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"There is no intelligence where there is no need for change."

– Herbert G. Wells

Part 3: Intelligence

The science starts with questions. And then scientists start their search for the right answers to those questions. That is why we coined the term "scientific research" and hence we name the guys who do it "researchers". For doing their research, the researchers use scientific tools, sometimes very sophisticated (and expensive), and methodologies based on the latest concepts, hypotheses, and theories. If the latest do not (cannot) match completely to the research goals, the outcomes of the scientific research may be incorrect or even misleading thus affecting the following research in that area. If the research, not completed properly, is implemented (in reality), it must go on involving new and improved tools, approaches, methodologies, etc. These are things every scientist (researcher) knows very well. That is why scientific research continues to the point when it gets the right answers (if we set initially the right questions).

Unfortunately, after so many years of scientific research, we still do not have the "final" answer to the "ultimate" question of how thoughts are produced by the biochemistry (organic matter) of the brain. Hence we still

don’t know how our intelligence is produced by it. There are many speculations (some of those presented as “theories”) but we (as humanity) are still far from the correct (final) answer to that “ultimate” question.

In **Part 3**, dear Reader, we will discuss some of the latest research and development achievements of science and information technology in the field of natural (human) and artificial (created by humans) intelligence (AI). And what could we expect in the area of fast-emerging AI technologies and their applications? We will discuss also how the penetration of AI into our–human society may affect it and our (probably shared) future.

Discussing the issue of the emergence and development of intellect and intelligence, we will address several related topics divided into three chapters:

Chapter 3.1 Human Intellect and Intelligence

Chapter 3.2 Artificial Intelligence

Chapter 3.3 The Future: Quo Vadis?

Chapter 3.1 presents some views on the impact of information and knowledge on the development of natural (human) intellect and intelligence.

Chapter 3.2 presents views on artificial intelligence as a creation of the human.

Chapter 3.3 (entitled “Quo Vadis?” in the most general translation: Where are you going?) pays special attention to the possible paths in the development/evolvement of artificial intelligence and its possible consequences for humanity, as the current discussions on this topic contain both hopes and fears for our future “coexistence” with artificial intelligence. As this question is a “two-way" street, we will try to “walk” it in both

directions. It concerns not only the future of artificial intelligence but also our future in a common “blended” society.

Before we begin the discussion on the topics presented in this chapter, I would like to make some initial clarifications to avoid possible misunderstandings.

First, in the book, we will understand the terms “intellect” and “intelligence” as “human” intellect and intelligence, thus not confuse them with similar manifestations in animal behavior. We know that animals are also intelligent (of course to a different degree compared to our intellect/intelligence), and lately, there has been talking and writing about intelligence in plants. As they say, everything is possible.

Second, to distinguish the naturally evolved intelligence (human intelligence) from the one we are trying to create, it was coined by the creators of this term as “artificial intelligence” (usually abbreviated as AI). Lately, many experts working in the field consider it incorrect (I join their view) but to avoid confusing the reader, I will still use this term in the book. To what extent both bits of intelligence will be equivalent or which of them will dominate our common future?

Chapter 1.1 of the book mentions that life arose as a result of a process that biologists call “abiogenesis”. Intelligence has subsequently evolved in living organisms as a result of their evolution in the struggle for survival and adaptation to the ever-changing environment (habitat). It is, in fact, their most powerful “weapon” in this relentless struggle. The “rule” here was (and still is): The fittest survives.

Life and its evolution are at the heart of natural intelligence (despite the origin of life is still a mystery to science). The “form–function”

interrelation (dependence) is observed in all living organisms. Nature has created countless forms (experimenting with many combinations), and the function (survival) has shown which forms are best adapted to survive and produce offspring that have inherited the qualities of the best (managed to survive) parents. Thus, in the course of the evolution of living organic matter, our present-day “human” form and the corresponding level of intelligence (functioning best in the habitat) have been reached. Maybe that's why we consider ourselves the “crown” (or “wreath”) of Mother Nature. Who knows if this statement is correct? Maybe somewhere in the universe, there is a “superintelligence” compared to ours. Probably, someday, humanity will discover the answer to this “ultimate” question.

Now we are trying to create artificial “creatures” with intelligence resembling as much as possible our intelligence, with the (“best”) intention and purpose to serve us (well). I.e. to have predefined functions as our servants, guardians, and protectors. And according to these functions (used as a “blueprint”), we design and create the new (not previously existed on the planet Earth) artificial intelligence. So here the sequence is the opposite of that for the natural genesis of life and its evolution. Here, the function is first defined, followed by the form best designed to perform that function. This, by the way, is the natural sequence in almost all the human creative processes. We set the function (application) first, and then the form follows our design.

Further in the text, we will try to analyze and understand the results of this “reversed” process compared to the natural ones and its possible consequences for us humans. In the text, I have tried, as far as possible, to abstract myself from the differences in existing views, opinions, definitions, etc., as well as from the “historically” layered prejudices on these topics. In

my approaches to them, I have “relied” (again) on the systems approach (and thinking) and analysis, as I believe that in **the chain of information-knowledge-intellect/intelligence**, the last component is logically the “pinnacle” of our natural development, which helps us so far also in the evolution of society. Probably the future will show whether our creation–artificial intelligence will accelerate it (as we hope) or reverse it to our extinction (as we fear).

Chapter 3.1: Human Intelligence

In this chapter, we will focus on such human mind activities as intellect and intelligence and more specifically on their definitions and interpretations by science and in everyday life. We will “touch” also the topic of artificial intelligence (AI) as it “stems” from the idea of human intelligence. But more information about AI and its applications and possible future developments, you will find in the following chapters.

Very often both terms “intellect” and “intelligence” are used as closely related and even interchangeable words/terms. But as both exist as separate terms, there should be a reason for this (hopefully) defined by the scientists working in this field. Let us try to find what distinguishes them.

This chapter is dedicated to the following topics:

- Human intellect
- Human intelligence
- Intellect and intelligence
- Other human mental activities

Human Intellect

Often in our daily life, we hear a (qualitative) definition of a specific individual such as: “He/she is very intelligent”. In this statement, the basic (key) term is “intellect”, with which semantically are related some derivative terms, such as–intelligence, intelligent, intelligentsia, intellectual, etc. In many scientific publications on this subject, the term “intellect”, in general, is defined as a quality of the human mind characterizing its ability to perceive information, analyze it, learn, compare what is true or false, make correct

logical conclusions, solve problems and make decisions about taking actions and/or changing behavior. The practical goal of the intellect is to develop the right behavior (action or reaction) for the survival of its “bearer” in his/her natural environment (habitat) and/or achieve “wider” goals, such as prosperity in the social environment. Its external manifestation is expressed in the behavior/reaction of the respective individual (its “owner/bearer”).

Following the main theme of this book (the links between information, knowledge, and intellect/intelligence), we need to add two more important components: cause and effect–the “real” reasons for the emergence and development of the intellect and the consequences of its “workings” (functions). The reason or basis for the emergence and development of intellect is the knowledge “accumulated” so far in the brain of the individual, as well as information about changes in the environment that require a behavior change (reaction to these changes) of the individual. Here all the functional connections between incoming information and the chain “cause - evaluation - action” are clearly outlined.

The reason requiring action is the information coming to the input of the “system” (in our case the human). The assessment and the decision for action are performed by the intellect of the individual based on the knowledge accumulated so far. The action/reaction, i.e. the result of the assessment is based on the work of the mind “subsystem” knowledge-intellect. Any correction, if necessary (in case of unsatisfactory results of the action), requires/imposes “expansion” of the existing knowledge base and “increases” the level of intellect, i.e. speeding up its ability to evaluate and make the right decisions. The latter cannot be done without purposeful access to selected information and its processing.

In this way, the chain "**information–knowledge–intellect**" closes and becomes self-regulating (according to the Systems theory). This allows it to adapt and survive in a constantly changing environment. The result of its successful functioning for the individual is (maybe) the achievement of the desired quality of life (well-being).

From what has been said so far, we can draw the following conclusions:

Intellect is based and functions on acquired knowledge. The "wider" and "deeper" is that knowledge, and the "higher" is the level of intellect, hence its ability to process information. Here, however, we must immediately note that an important consequence of the work of the intellect (i.e. the "controller" in the system) is the desire to expand and deepen knowledge in areas of interest to this owner. We call it the "pursuit of perfection". We often see it in people with "creative" professions, such as artists, musicians, scientists, inventors, engineers, and others. Of course, the latter is impossible without expanding the relevant areas of knowledge, which in turn is impossible without expanding the scope of perceived information.

The chain (system) of "information–knowledge–intellect" is closed, self-regulating, and self-improving (adapting). This enables any individual to survive and prosper in his/her habitat (no matter natural or social). If the quality of functioning of any component in this system is impaired or unsatisfactory, then the results for the individual are unsatisfactory.

The relationships between the intellect and the other components in the information-knowledge-intellect chain are "natural and logical". From this follows that information, knowledge, and intellect/intelligence build a

"closed" system (from the point of view of Systems theory) through direct and feedback links, which from the point of view of the Control theory makes the system "stable" and predictable in its operations having the possibility of controlling the results at its output. From this scheme, it is clear that if we have access to more in quantity and better quality (e.g. trusted/verified) information at the entrance of the system, then we can expect a wider (and deeper) scope of the built knowledge and a correspondingly higher level of intellect of the respective individual. Here we should consider the defining role of those groups in society that generate information (reliable or unreliable) and allow or restrict access to it, on the quality of the system for building and developing the intellect and intelligence of all members of the society. Obviously, this role (and action) must be limited to make it useful (positive) to society as a whole.

The consequences (outcomes) of the "work" of the intellect are manifested in the behavior of the particular individual. They are also a "measure" of the level of his/her intellect. But here again, we must mention that there is no "universal" intellect that acts with the same degree of efficiency in all areas of knowledge. That's why there are no "universal" or "super" knowledgeable individuals Sorry, guys (proponents) of the idea of creating "superhumans" possessing "encyclopedic" knowledge). I don't think this is also a possible option for AI, but we will discuss this topic in the next chapters.

So, here is another (my) definition of the term "intellect" for the goals of this book:

The intellect of each individual is associated with the ability of his/her brain to extract (from the memory) the knowledge related to a particular situation, process it (by reasoning), evaluate the results, and

make the right decision on how to act/react if that specific situation requires it.

In some (urgent) cases, all these processes must be completed in "no time". So, the most complete knowledge of the problem is mandatory. In the case of the absence of sufficient (complete) knowledge on a specific problem, the intellect can "connect" the existing fragments ("patches") of knowledge and through logical analysis "suggest" variants of correct conclusions (decisions) and the corresponding actions. All these processes are usually performed by the brain for a limited time dictated by the specific situation. The more intelligent an individual (living being) is, the higher the probability of making the right decision in the time for possible action (or reaction). If there is enough time for action/reaction, in case of having not had enough knowledge on the topic, that individual may look for "external" knowledge, e.g. residing in other humans' brains (e.g. starting looking for a piece of advice) or recorded on any kind of media.

Therefore, the intellect of an individual depends mainly on the acquired (built up so far) knowledge and the ability of the individual to think logically. All this requires a sufficiently "broad" preliminary knowledge base and a well-established logical process of thinking possessed by the individual. As a result of proper analysis and evaluation, the intellect (i.e. the individual) can decide on the need to "obtain" any missing information (knowledge). I.e. intellect is also expressed in the ability of an individual to independently and purposefully select, expand, and deepen his/her knowledge and skills on topics that are of need and to perform these activities without the intervention and participation of outside assistants or mediators in the process.

The intellect, as well as the knowledge on which it is built, is manifested and expressed (becomes available to the present observers) through its external manifestations (actions) in a specific situation.

It helps us (plays a major role) in our creative activity, where knowledge and logical thinking are required. For example, in research, analysis, planning, design, and other similar activities related to the processing of information, data, etc. It is an essential component in the creation of publications on scientific and research topics, teaching materials, and the like, where extensive (complete and trusted) knowledge and in-depth logical thinking are required.

It should be noted that the intellect is not innate. It develops based on the acquired knowledge and the developed methods for its successful (positive proven) use in our daily activities. Because it is acquired based on personal experience, unfortunately, intellect (and related to intelligence) is not inherited like some biological characteristics. The good thing is that it "accumulates" with our life experience and can reach this qualitative level, which we commonly call "wisdom".

In my view, there can be no "universal" definition of intellect and therefore of intelligence. Despite the attempts of many researchers of these phenomena to create similar definitions and tests (remember the existing and still widely used IQ tests), they are hardly suitable as "universal quantifiers" of intellect/intelligence (and hence their acceptance and use in real life is limited). Intellect and intelligence are manifested (this is their measure) in any given/specific situation. Since the intellect of each individual is based on the knowledge acquired by him/her so far, it reflects this knowledge, and by definition, it cannot be universal. Apart from the fact that

it does not cover all areas of human knowledge (there is no person with such extensive/complete knowledge), it also “ages” over time (it becomes outdated and inapplicable). Accordingly, the intellect cannot be “universal”. It follows that the “quest” to create a “common” or “universal” artificial intelligence (AI) is generally inconsistent with the nature of human intelligence, or at least with its understanding (or misunderstanding). Unfortunately, it is still mostly “fiction” (in the best cases just science-fiction) of its creators. Although there is currently a “huge” wave (almost “tsunami”) of marketing campaigns for many AI-based products and services (mainly in the IT industry), it is clear to the experts (I hope/guess) that they are based on software algorithms producing limited AI functionality aimed at specific applications. When and if a “real” (let's call it human-like) AI will be created at all, depends on when humanity will find out for itself what exactly the concept of “intellect” includes/comprises. In my opinion, the answer to this question is to be given by the new generations of researchers. I hope it will not be of that “remarkable” kind of “42”. I suppose the reader is familiar with this answer to the “ultimate” question, according to Douglas Adams’ first book (of the 6-book “trilogy”) of his famous *The Hitchhiker’s Guide to the Galaxy*, entitled *Life, the Universe and Everything Else,* given after 7.5 million years of reflection on the subject of a “super-smart” (obviously AI-based) supercomputer (in the size of a small city) called “*Deep Thought*”. (Dear Reader, doesn’t it remind you about other “deep” things in the recent computer chess history?)

Yes, I think this is a good introduction to the topic of a possible artificial “superintelligence” (ASI), which we will discuss in the next chapters.

So, here is another “ultimate” question: How do we (humans) build intellect?

There are three ways we build intellect. These are:

- By genetic modifications (human evolutionary process)
- By processing information (acquiring knowledge and experience)
- By reflecting on our “internal” (to the brain) thoughts.

The biological evolution is much slower due to the much slower changing environment–our solar system and mainly our “Mother Earth”. The evolution of our planet is measured in billions of years (according to the latest studies, the Earth formed about 4.54 billion years ago. Life on it started also billions of years ago. According to some recent scientific discoveries, remains of “biotic life” were found in 4.1 billion-year-old rocks. The appearance of the first multicellular living organisms is thought to be between 900 and 600 million years ago The first recognizable humans (Homo erectus) emerged about 2 million years ago. The modern human (Homo sapiens) appeared only about 250 - 200 thousand years ago. During the evolutionary process, the human species developed a much larger brain than that of other primates (our “ancestors”)a process we call “encephalization”. We all know that intellect “resides” in the brain, and that’s why the evolution of human intellect (and intelligence) is closely linked to the evolution of the human brain based on “its reactions” to the changes in the humans’ habitat.

The evolution of the intellect (and intelligence) is much faster than the evolution of biological species. First, is influenced by information that affects the formation, evolution, and functioning of the nervous system of species. Second, it is constantly “driven” by the change of matter and energy conditions in the environment (habitat), which cause the biological evolution of species as a whole, according to the theory of Charles Darwin on the origin of species. But the goal of these two (complementary) evolutions is the same–the survival of the individual (living being) and the species as a whole.

Since we humans are at the “pinnacle” of evolution (or as we prefer to believe in this statement, created by us), it is clear that our intellect, which has evolved faster than that of other living things (even our closely related but extinct “cousins”), has helped us in the “race” of life for dominance on our planet (i.e. dominance over all other living species).

There are three steps in building/developing intellect by processing information:

Step 1. Processing information incoming from the surrounding environment:

1. Perceiving incoming information–through our senses/sensory channels (biological or artificially built/produced)

2. Pre-processing information–filtering perceived information

3. Storing information–memorizing/recording in the brain

4. Processing information–sorting and linking it (semantically, taxonomically, emotionally, timely, and by other “important” categories).

Step 2. Building knowledge (structures):

1. Analyzing “stored” information–logically rating and linking pieces of existing “related” (by meaning) knowledge

2. Studying the “preliminary” built knowledge structures–by reasoning, analyzing, cause and effect relations, etc.

3. Proving built structures–based on trusted feedback information from reality check(s)

4. Understanding knowledge–fixing knowledge structures as proved/trusted and building additional (“deeper”) links to other related (and also proved) knowledge structures.

Step 3. Developing intellect (based on acquired knowledge and related to its experience, and understanding).

The intellect develops/evolves with the complex mental development of the person who “owns” it. We often assess the levels of development of the intellect using different gradations, such as–low intelligence, high intelligence, exceptional intelligence, etc. These definitions are very general and they often do not define any specific qualities, areas, or functions/actions.

Here we can also try to introduce some systems used for the “categorization” of the intellect. Since it, like all other brain activities, is manifested through the actions (behavior) of its owner, these categories are based on its (verbal) presentation and/or the results demonstrated in the real (physical) world.

The intellect we build may be “ranked” in three levels:

Level 1. Analytical abilities:

1. Searching for and retrieving the “needed” information/knowledge

2. Analyzing/comparison of retrieved and needed knowledge–detecting discrepancies/gaps (if such exist)

3. Making conclusions and decisions

4. Taking action(s) if needed (based on decisions).

Level 2. Synthesis abilities:

5. Fostering actions such as creativity, design, and self-managed extension (selected “upgrades”) of the existing knowledge and skills.

Level 3. Generating (knowledge) abilities:

6. Producing/generating new knowledge (still not existing)–ideas, concepts, hypotheses, theories, etc. based on processed information/data collected from research, observations, purely mental activities (e.g. reasoning), or combinations of all of these.

All these levels of intellect are not strictly distinct from each other. They may exist together mixed in different levels of development and self-develop further in time.

As we have already said, the intellect is not (and cannot be) built on an “empty” place. Its “basis” (foundation) is knowledge. The wider (and deeper) this base is, the “higher” level of intellect we can build. Usually, we grade (evaluate) the intellect of an individual as low intellect/intelligence, ordinary (medium), or at the highest level. But usually, these grades do have not “strict” outlined boundaries (as the core idea of those is “blurred”). The constant expansion and deepening of knowledge support the development of the individual's intellect. In turn, the intellect “thanks” for this “support” of knowledge, helping it to expand and deepen through the next level of–understanding. This way the “collaborative” circle closes. Knowledge “builds” the intellect, and the latter helps knowledge to expand. Thus the “knowledge-intellect” mental (sub)system becomes “stable” and self-regulating, which fully corresponds to what the Systems theory teaches us.

Building the intellect is a process and like any process, it takes (needs) time to be completed. But in the case of the intellect, it is never completed as the intellect constantly evolves based on the accumulated knowledge and acquired life experience of each individual. This process consists of several consecutive “chain reactions” including:

- Changes in the surrounding environment–e.g. changes in the energy, including energy fields, the flux of cosmic rays, and other energy sources–mechanical, electromagnetic, gravitational, based on chemical reactions, etc. The changes, based on chemical reactions involving chemical elements, compounds, and/or intermediate products of those, may change the matter composition itself (e.g. from organic to non-organic and vice

versa). Both kinds of processes (involving changes in energy and matter) usually lead to mutations in living organisms (one of the major “natural” tools for evolution and survival). Those may be beneficial for the new “generations” of those mutated organisms giving them possibilities for reaching higher levels of prospective intellect.

- Extracting and generating (meaningful) information presenting those changes.

- Perceiving information as incoming signals (stimuli) by the human sensory channels.

- Activating the sensors–filtering, extracting, and generating meaningful information on the perceived changes.

- Transmitting signals, presenting information via sensory channels (nerves) to the brain.

- Pre-processing incoming information based on the prior knowledge “stored” in the brain–comparing, sorting, “coding” and storing the new information in the brain's memory.

- Building new (“extending”) knowledge by associating and linking the new information to the respective prior knowledge

- Activating the intellect/intelligence–deciding if any (immediate) reaction to the incoming stimuli is needed.

- Initiating action/reaction responses to the incoming stimuli–these depend on two major factors: the time frame needed for reaction (in case an emergency/immediate reaction is needed or planned in the long term) and the aim of reaction needed (e.g. survival, adaptation, self-improvement, etc. short- or long-term goals).

- Evaluation (“reality check”)–completing all the steps above (and repeating if needed) and analyzing the results based on the feedback information.

- Outcomes–Extending the existing or adding new knowledge thus improving intellect/intelligence by “raising” it to the next upper level based on the extended/acquired new knowledge.

This way the chain “reaction”: information-knowledge-intellect/intelligence closes thus making the “(sub)system” building intellect/intelligence (sensory channels and brain) self-controlled/regulated.

Both knowledge and intellect are manifested (demonstrated) through external expression/action. Until the moment of manifestation, both personal qualities are “hidden” from the external (outside) observer. Only the appearance and the corresponding result(s) show their level and quality.

The information accumulated in society (we usually call it “knowledge”) and the methods for its acquisition and transfer from generation to generation and individual members of society accelerate the “evolution” of intellect/intelligence. This constant process leads to the need for the creation of a “supplemental” one to human intelligence–artificial intelligence as its natural “extension/augmentation”.

Human Intelligence

Modern neuroscience and psychology consider intellect a branch of a wider (“umbrella”) phenomenon we call “intelligence”. Some authors consider “intellect” as a human mind activity related to facts and knowledge (reasoning) without “added/inserted” emotions, feelings, creativity, etc. mind “products” This way we can conclude that intelligence is intellect (knowledge and reasoning) plus emotions, feelings, creativity, etc. human mind activities. This is the most commonly accepted definition of intelligence in various publications. But in many publications, the authors use both terms

(almost) interchangeably (as synonyms) not distinguishing them. This approach may lead to possible misunderstanding and confusion in such publications (and on the topic in general). If both terms exist (dear Reader, please refer to any preferable dictionary and/or encyclopedia), they should have different meanings. So, let's try to find (and explain) the difference.

For humans, we use the term "human intelligence" to distinguish it from the intelligence possessed by other "intelligent" beings. This may be a "nonhuman" (animal or artificial) kind of intelligence. Further in the text, we will use the term "intelligence" for "human intelligence" only. If we need to point to other kinds of intelligence we will use a specific adjective accordingly, e.g. "animal" or "artificial" intelligence.

For the goals of this book, I will accept the definition above stating that human intelligence is the intellect with added mind activities, such as emotions, feelings, creativity, etc. I hope this definition will serve well for explaining my views on intelligence (especially on AI) further in the text. But at the same time, this definition sets a lot of "ultimate" questions for the general public and AI developers. The major of those is: Are we (ever be) able to reach the human intelligence capabilities creating AI?

I will try to analyze some possible answers to this question in the next chapters.

We often hear the expression "Knowledge is power". But the pinnacle of this power is intelligence–our mental ability to use that knowledge the best way at the time of need. Information builds intelligence through knowledge and intellect. The link (relation) between all these phenomena is obvious and doesn't need any proof.

As already mentioned above in the text, intellect, and intelligence both respond to stimuli (information) coming from both–our external and internal environments. Emotions and feelings (both a substantial part of intelligence) are generated by two types of signals. The first and main ones are those that come directly from our “inner” environment, which we call the “human body”. The second type may be initiated by information coming from the external environment–stimuli generated in our nearby habitat They usually cause biochemical and bioelectrical reactions “added” to our body signals generated by the internal organs. The role of these “supplemental” signals is probably to increase (accelerate) or weaken (slow down) the reaction of our nervous system and the brain to the signals (external and internal) that “required” and caused this reaction. Very often, however, the impact of emotions on the brain's reaction can have the “opposite” effect (that the expected), which interferes with the correct response. We all have heard the expression: “paralyzed by fear”. In my (humble) opinion, the role of such “reverse” to the “common sense” (logical) reactions should still be under careful study, so we can get the correct answers.

If we ask what is the natural role (function and meaning) of emotions and feelings (the nature does not create anything without a reason), we will probably conclude that they were originally designed to accelerate (strengthen) or slow down (weaken) the reaction of the “intelligent“ creatures in critical situations requiring an emergency response thus avoiding any “hasty decisions”. However, with the development of the intellect into the next stage–the “intelligence”, they have expanded their “application scope” and now, for example, they satisfy some additional needs that we have developed in our evolution, such as aesthetic, artistic and the like (that cannot be easily explained from a “rational” point of view).

These may include the whole spectrum of our feelings, sensations, moods, premonitions, intuition, etc. “Internal” to our body “pure” mental stimuli not based on any preliminary (proved) knowledge or incoming physical or chemical stimuli/information.

Many different types of human emotions and feelings influence the way we react to them. The curious reader may find a detailed list of those in many publications devoted to human emotional behavior. But in general, the complete list of all those is remarkably long.

Anticipating the next topic, devoted to AI, here I want to ask a question that always intrigued me: Could we expect those (or some of them) emotions and feelings (described above) to self-evolve in AI/”intelligent” robots as a result of their (self-)“machine learning”, “deep learning" or any other (human-created) learning algorithms?

Or what about such human mind activities as creativity, imagination, and inspiration? Nobody still knows where these come from. What parts of these are “inherited” (by birth/parent’s genes) and what parts come later in our life from personal knowledge and experience? But these are among the highest “levels” of human intelligence. And how can we preset (“seed”) these into artificial intelligence? I don’t think we should take (very) seriously all those “hazy” paintings presented to us lately as AI “artistic” abilities (e.g. creativity).

Recently, many publications on intelligence have launched ideas (and many theories) about the existence of specific types of intelligence, such as:

- Business intelligence (Who may question that every business needs it?)

- Decision intelligence

- Emotional intelligence
- Social intelligence
- Cultural intelligence
- Conversational intelligence
- Guiding intelligence
- Erotic intelligence and probably more to come.

In this list of different kinds of intelligence, we can also add “natural intelligence” which is more based on intuition rather than on a built-in knowledge base. This is valid, especially in the case, if the knowledge base is still in the initial phase of “construction”, as in children.

And finally, we (very easily) accepted also the (possible) existence of one more kind of intelligence–the one that could be “created” in non-living matter (we call it “artificial intelligence”) due to the latest developments in information and computer science and technology.

Currently, along with the “standard” Intelligence Quotient (IQ) set of tests for measuring General Intelligence (GI), there are new metrics under development, such as Emotional Intelligence Quotient (EQ), Autism-Spectrum Quotient (AQ), etc. psychology tools/tests for measuring the intellectual abilities/traits. The professional circles studying the phenomenon of “intelligence” (and its manifestations) started to understand that intelligence (based on personal traits) develops and manifests differently depending on the social environment and specific applied areas of human activity. Most likely this understanding is the major cause for the differentiation of human intelligence into different kinds and the development of respective metrics (such as tests and questionnaires).

Just like knowledge, intelligence is personal. So does intellect. Both are based not on personal "theoretical" knowledge only but also on real-life personal experience. No two individuals have the same personal experience and hence intellect/intelligence, no matter if their IQ is equal. Intelligence varies always and it is in constant self-development throughout our life span. So, our IQ measured at the age of 60 will not be the same as that measured at 30. Probably it will be higher as we get "wiser" (let's hope) while aging.

As we already mentioned above, often the terms "intellect" and "intelligence" are used as interchangeable words. But often in everyday life their derivative term "intelligent", as a personal characteristic of an individual, is replaced by the more widely used synonym "smart". However, in professional publications, although we often use the term "smart", such as "smart device", "smartphone", etc., the meanings of the two terms do not overlap. I do not expect, that someone will start insisting that it, let's say a toaster, is "very smart/intelligent", but who knows as today the term "intelligent" started "conquer" the marketing of almost "everything" (smart).

So, from everything said above, let's accept the following definition of intelligence, which meets the objectives of this book: intelligence is an intellect with "added" or "superimposed" mental processes such as emotions, feelings, and the like (not from the area of reasoning). In other words, it is an intellect "increased" (sometimes "decreased") by emotions such as surprise, fear, fear, joy, happiness, and other similar emotional mental states. Here we can add some other higher-level brain activities that are not yet well studied and their goals and role in our behavior remain unclear, such as imagination, inspiration, abstract thinking, intuition, not thought out ("fuzzy") logic, etc. All of them help to speed up the process of making possible right/correct decisions in situations limited in time or the

presence of incomplete (fragmented) knowledge. It demonstrates itself “well” as an “augmented” intellect in case of insufficiently defined knowledge or time-critical situations.

So, here are some conclusions on this topic:

- Intelligence is (heavily) “involved” in our everyday life and sometimes “helps” the intellect in cases of incomplete (fragmentary) knowledge or “emergency” situations with limited reaction time. In case of incomplete (fragmented) knowledge or lack of knowledge on a specific topic and a critical situation, for example, related to danger to the life of the individual, all these mental processes take place in a very short time (called “instantaneous”) and without our “active participation” which we usually call "subconscious" or “instinctive”.

- Intelligence also works in situations where we have ambiguities on a particular topic as a result of insufficient information and knowledge. We usually call them “foggy notions”. Then “fuzzy logic” comes to the rescue.

- Emotions act as an “impulse” on the intellect, thus “amplifying” the influence of external stimuli that require an immediate response. Sometimes emotions speed up the reaction, leading to faster decision-making in a critical situation. But sometimes emotions slow down the reaction, taking away a (substantial) resource from the “productivity” of the nervous system (e.g. in case of uncertainty or panic). We call such inactions “paralyzed by fear” In some cases, this “paralysis” (blocked or delayed reaction in a dangerous situation) can be fatal, but in others, it can be positive by stopping the individual from making hasty (not well thought out) decisions and corresponding actions that can have fatal consequences. This may include what we call the “sixth sense”–intuition. Probably the nature and role of such “emotional” reactions prompting one to make an “intuitive”

(subconscious) decision to act have yet to be studied more thoroughly. But these topics are not the subject of this book.

- Intelligence plays an important role in many creative processes, such as invention, design, and various arts–poetry, music, painting, fiction authoring, and other artistic activities. It is also an essential component of interpersonal communication.

As was already mentioned above in the text, these “built-in” and often subconscious activities of our nervous system, which are yet to be better studied and explained, can “confuse” and prevent the creation of artificial intelligence equivalent to human intelligence. I will address this topic in more detail in the chapter devoted to the future of artificial intelligence entitled “The Future – Quo Vadis?”

Intelligence is a quality possessed by each individual to a different degree (level). It helps to purposefully and independently increase our knowledge in selected areas and apply it successfully in practice. Purposeful means that it can apply selectivity (an essential characteristic of the living matter). Independently it has accumulated enough skills and does not need “intermediaries” in the process. Among these skills are, such as selection of knowledge in any field (or related areas) that we want (or need) to acquire, identification of the trusted sources of information on a given topic, filtering and analyzing information, processing it, connecting it to the knowledge acquired so far in this and other areas, thus expanding and enriching it, extracting the necessary knowledge in time, drawing the right conclusions on its basis, successfully applying and checking the newly acquired knowledge in practice, correctly collecting data on the results of its implementation, analyzing and correcting them if necessary.

In this sense, intelligence is an important human quality (trait) that pushes individuals forward in their quest for personal (self-)development. The acquisition of new knowledge and skills is applied and measured in practice (only).

With the accumulation of new knowledge and the necessary skills described above, the intelligence of the individual must accumulate and increase. Its manifestations over time we start calling “wisdom.” However, with age and depending on the health conditions, some unwanted changes can occur in the individual's brain, which could limit his/her intelligence. In this sense, intelligence “varies" and depends on the age, environment, actions, and real brain activity of the individual, as well as some factors related to social activities. Just as the ancient Greek philosopher Heraclitus of Ephesus said, “Everything flows, everything changes. You cannot enter the same river twice” So there is also no “fixed” state of intelligence. Time passes and the “river of life” is constantly changing us and our intelligence.

In some individuals, as a result of their accumulated knowledge and skills, intelligence is better developed, and in others, it is still at some lower stage/level of development. Since intelligence concerns different areas of knowledge and acquired analytical skills, we cannot develop and introduce “universal” intelligence measurement criteria and on these “compare” correctly the intelligence of various individuals. This is a strictly personal quality of each individual, which is proven by the application of intelligence in specific situations (and areas) and the results achieved so far. In my (again humble) opinion, the various tests/questionnaires for measuring IQ and the results achieved according to them cannot be automatically transferred to all areas of applications in professional life and everyday practice. Since intelligence is based on the knowledge acquired so far by an individual, it

must be measured in very well-specified areas of knowledge (and skills), and for this purpose, specific IQ tests must be created to measure intelligence levels in specified fields of knowledge and the relevant applications. How, for example, can we measure and compare the general intelligence (by IQ test), of a doctor who diagnoses the health of his patients and a car mechanic who "diagnoses the health" of cars? This question is valid also for any other profession.

In this sense, the results of the "integral" IQ tests of intelligence do not show us the "real" value for the tested individual, as he/she can be at the "expert" level in a specific area of knowledge and practice and "novice" in others. As mentioned earlier in this book, only credible measurements of results achieved in practice show the true characteristics and qualities of an object or process. As intelligence is (still) an abstract concept related to the mental activity (and ability) of people, its measurement and evaluation must be done based on concrete results proven in practice. Any search for "common denominators" and approaches, in this case, is misleading and doesn't give reliable results. Thus, such approaches for "measuring" intelligence aren't enough credible (intelligent). According to my personal views on this matter, the tests of the suitability of an individual for a specific profession/position, in a specific period of his/her development – mental and physical, are much more reliable. As an example, astronauts and professional pilots are specially tested if they meet all the requirements for such a "profession". Perhaps, following this approach, well-focused/specific tests could be created for other professions, especially for those in which individuals may often have to act in critical situations/conditions (i.e. they have to make the right decisions in a limited time and under stress). For the correct (trusted) selection of the most suitable individual(s), in addition to

the tests in required knowledge and skills areas, specific tests of intelligence could be created to demonstrate the “fittest” candidate(s).

Often in everyday life, we use words such as “smart”, “wise”, “intelligent”, and the like intended to characterize the mental abilities of a particular individual according to our judgment of him/her. Often, of course, we also use their antonyms (words with the opposite meaning). But what exactly is their meaning and what exactly do we mean when we use them? If we look in the relevant publications about these, we can find (again) many definitions for them, as well as further explanations explaining them, as these are complex concepts and they cannot be defined in short terms/phrases. But almost always these definitions give the impression that they are too general, sometimes “vague” (unclear), or do not correspond to our idea of them built on our practical experience. This is natural because the “measures” we use to determine these personal characteristics (traits) vary considerably and depend mainly on the views of the person who applies them or are valid for each specific case only. Practice also shows that in one situation a person can be smart, for example, to make the right decision, and in another to do the exact opposite. I.e. these characteristics are not “universal” in nature and do not apply to all cases in life. They depend on something that “builds” and determines them. To find out what this “common determinant” is, we must analyze first the role of knowledge in the formation of these qualities and then the role of the intelligence that encompasses all of them as a “summarized” indicator of our mental abilities.

From what was said above, we can conclude that the phenomenon of intelligence remains to us as a not completely/exhaustively defined concept and therefore how exactly it is formed, developed, and manifested. If we are honest enough, we must also ask ourselves the question: “How

could we create a copy (e.g. artificial intelligence) of something that "original" (human intelligence) is not yet well known to us?" I leave the answer to you, dear Reader.

Intellect and Intelligence

Just as there are definitions for many things in our lives, so there are many definitions available for what we call "intelligence" and "intelligence." These two concepts are semantically and functionally related and are sometimes used interchangeably, but often this "interchangeable" use leads to some ambiguity and confusion on the subject. It is good not to confuse the use of the terms "intellect" and "intelligence" as they are not synonymous. Although very similar in meaning, they have corresponding differences, which are expressed in their functionality. Let's try to distinguish them for the aims of this book by defining them more precisely.

Some authors associate intellect mostly with the cognitive functions of the brain, such as the construction of knowledge and related logical thinking (reasoning) – analysis, synthesis, conclusions, decision-making, and other similar mental activities. Sometimes we combine them into a common concept and call the individuals who have well mastered those qualities "thinkers" and "wise" (especially when they demonstrate such mental abilities of sufficient "sharpness" drawn by hard work and well-proved logic in various knowledge areas). I prefer to join the view of those authors on this topic. You, dear Reader, may have your personal views on this concept.

Let's extend this view here by adding some more explanations. The intellect seems to be mainly related to the processing of information (stimuli) coming to the "entrance" of our body (our sensory organs) from the

external environment. These are mainly energy signals–electromagnetic, mechanical oscillations, and gravitational forces, which “cover” three of our major sensory channels–visual, auditory, and vestibular systems. All this information (variable energy) generates in our sensory channels bioelectrical signals that enter directly into our brain for real-time processing and decision-making (by reasoning) for producing responses/reactions if these are necessary.

Intellect is the (logical) “basis” of the intelligence of each individual. No intellect, no intelligence. Let’s clarify this statement.

Intelligence, on the other hand, is more related to the “emotional” functions (reactions) of the brain and is built on the “internal” information produced by our body and the skin that surrounds it and protects it from the environment (especially in case of possible harmful impacts). This kind of “emotional” origin information is mainly related to the generation of mixed–biochemical and bioelectrical signals “produced” by our internal organs and systems, which must also be processed by the brain in real time. The reaction to them in some cases may even be “unconscious” (e.g. a reflex).

Here we must, of course, separate the “pure” mental activities, which are also related to emotions and are most likely a “mixed” product of the joint work of intellect and intelligence. These are imagination, inspiration, happiness, excitement, and other similar insufficiently well-defined emotional states, for which hardly anyone will ever be able to describe them algorithmically and “embed” in an AI system. And why would this be (ever) necessary? There is more information on this topic in the next chapter.

But such brain activities (“products”) as imagination, creativity, inspiration, curiosity, intuition, and the like seem to be at the “border” between intellect and intelligence. Usually, they are “ignited” by intelligence involving any kind of emotions, then “run” on intellect involving the accumulated knowledge base, experience, reasoning, logic, etc. That is why it is very difficult to draw a firm line between both brain phenomena–intellect and intelligence. They almost always work together–“hand in hand.” The more “refined” intelligence is it may help build a higher level of intellect.

So, what’s the difference between human intellect and intelligence?

We may assume that intellect is more closely related to cognitive, logical, analytical, rational, and decision-making functions of the brain. It helps us build knowledge. Intelligence, in turn, is more related to acting, for example, applying and testing knowledge in practice, as it may involve in that process also our attitude based on emotions. In other words, intelligence is the intellect “augmented” or sometimes “dimmed” by our emotions. From this point of view, the term “artificial intelligence” tends to be incorrect. But there is more about this view in the next section.

We shouldn't mix rational/reasonable with emotional. Yes, many times both work together amplifying or dampening each other. The brain balances (somehow) emotion and reason.

So, we can conclude this section, that the intellect is the “basis” of intelligence, which in its turn is the “highest level” mental activity of our brain. Sometimes it “strengthens” the intellect through emotions and feelings. But sometimes it slows its functions down or even blocks those. We often call such emotional reactions “impulsive” (not well thought out, reckless, etc.).

This distinction in the functions of intellect and intelligence is important when we use them as specific terms in a specific context. But according to neuroscience, there are also significant differences between both concepts and their interchangeable use in specialized publications is unacceptable. I guess that their “free” (and wide) use in public today is due either to the tendency of people working in the field of information technology to use the terms more freely (the majority of those guys are not experts in neuroscience), especially when they generate and adopt new ones taken from other scientific or technology fields. According to some publications, John McCarthy (a computer scientist) and some participants coined the term “artificial intelligence” at a workshop at Dartmouth College in 1956. Even today, it continues to be widely used by IT professionals, who probably do not make such a precise distinction in the specifics of the use of both terms – intellect, and intelligence. This is somewhat understandable, as most of them hardly have in-depth knowledge in the field of neuroscience and psychology (and “deep grammar” mastering), or they just continue to use the term “artificial intelligence” for purely marketing goals.

Today, such terms as “intelligent” and “intelligence” are used (and accepted) in society much more widely than “intellect”, which itself sounds somewhat “more scientific/technical”. In some cases, it seems better to stick to the common terminology, otherwise, we will have to constantly explain what exactly we mean. However, every scientific and technical publication requires precision in the terminology used. I also believe that the two terms are not equivalent (and interchangeable), but in order not to confuse the already widely accepted terminology in the book, I follow the generally accepted term–intelligence. But when it is necessary to emphasize the difference in the text, I indicate the specifics of their use.

Here, hurrying toward the topic of “artificial intelligence” (I will discuss this topic in more detail in the next chapter), I want to focus the readers' attention on the question: How could we create “artificial intelligence” (I emphasized the term “intelligence”) as we will hardly ever be able to create an AI with emotions? And what will AI need (human) emotions for? Memorizing information and data, calculations, logical analysis, and reasoning is easy to be integrated into the AI “brain”. It bases all of its functions on these. But these mental qualities are components of the “intellect”. It follows that at least in professional publications it is more correct for the term “artificial intelligence” to be replaced with “artificial intellect”. But I do not expect this to happen soon (if at all this happens ever).

So far, I don't see also how we could “embed” any emotional behavior in AI. Or how it can “build” itself as a result of self-(machine and/or deep)learning. And what could be the goals of such “emotional” behavior in the operations of AI systems and devices? There are some very specific requirements for AI to be defined as “real” intelligence–it must have and demonstrate the above-described “emotional and creative” behavior and skills (“pre-built-in” by its creators) or to have the ability to independently develop such ones. But I just don’t want to start here the topic of how familiar we are today with the (bioelectrical and biochemical) “mechanisms” of our emotions. And it is not in the scope of this book.

Here are two more “logical” conclusions of this section:

First, we need to understand exactly how our emotions are born and their exact functions (and goals) in our behavior. If any solutions to this problem are possible, it is most likely (very) far in the future of humanity.

Second, we have to answer also the question: What exactly the AI emotions would give it if we could study and "embed" them in any intelligent devices and systems? Until we answer this question "meaningfully" (and responsibly), it is pointless to "play" with this task. The results are likely to be unpredictable, and perhaps undesirable (probably something like "42").

Other Human Mental Activities

In this section, we will focus on some human mind activities directly or indirectly related to intellect or intelligence (according to our human-centered view on these) because we would like to know how these could be "integrated" into or if they self-evolve in AI (if this is possible at all).

So, what are those other mental "products" (activities) of the human brain?

We all know (and "feel" it every day) that in addition to intellect and intelligence, the human brain creates many other "products" as a result of its 24/7 work activities, such as "abstract" thoughts (not exactly focused on real objects or processes), consciousness ("accompanying" us everywhere except in the cases when we are "unconscious"), self-awareness, deep feelings (various of those), sentient, awareness, imagination, inspiration, exaltation, etc.

Although they all, together with intellect and intelligence, form what we call "personality", a specific quality (trait) of each human individual, they are not the subject of this book. Various aspects of them are the subject of study by some sciences, such as neuroscience, psychology, medicine, etc. and the interested reader can find plenty of information about all of them if he/she wants to "dive deeper" into these topics.

But it seems that in the first place among them are such questions as what are thoughts and consciousness and how the brain constantly “produces” (creates) those. More precisely, what is their “nature”? I know I'm not the first who ask these questions. They probably exist from the moment when one of our ancestors bent down to drink water from a nearby stream and saw that there was “somebody” there in the water who was watching him/her and repeating all his/her facial expressions (i.e. he/she has conducted the first test with the “mirror” proving the presence of consciousness/self-awareness–the favorite one of the psychologists today).

And some questions have started, such as: “Mirror, mirror on the wall ...” and so on.

Today, there are a huge number of ideas, hypotheses, and theories expressed verbally and published, what is this “thing” consciousness and what is its “nature”? Usually, we think of it as a “normal” product of the (conscious) work of our brain in addition to the very old belief that “consciousness does not appear itself" (please understand that “a higher entity, e.g. a deity instills it in us”). But the most “modern” of the new theories vary between two poles, starting with “consciousness is an illusion” (please understand “consciousness does not exist”), going through “consciousness may be non-biological” and reaching such a “high level” of the modern physics as “consciousness is a product of quantum processes” (if anything based on the “uncertainty principle” of Werner Karl Heisenberg, fundamental in quantum mechanics, can be understood by an “ordinary” reader).

Other, newer theories argue that microbiology plays an important role in shaping our consciousness. I.e. the bacteria in our digestive system (our microbiome) “control” the work of our brain to a great extent and from

there they form our consciousness. Maybe there is “something” in these theories, as when we are very hungry we may stop thinking “rationally”.

If all those theories are really “working” (somehow), then I can't imagine how computer-based AI and “intelligent” robots could become “conscious” (a favorite narrative for a coming soon “technological singularity” i.e. a modern Apocalypse of many modern-today prophets). AI and robots will have neither human-type digestive systems nor bacteria (microbiome) in them to help them form consciousness. Most of them may be infected with harmful computer viruses (usually created by humans), but they “bring down” the system instead of making it “conscious”. From there, I do not see how an “ordinary” AI system would self-evolve into a “super AI”, as the emergence of self-awareness (consciousness) is considered one of the main characteristics of a possible future artificial superintelligence (ASI). The (possible) appearance of ASI is what scares us the most in the evolution of AI. But more information on AI categories and their possible evolution can be found in the following chapters of this book.

Between both poles of opinions about what consciousness is (a purely “spiritual”, i.e., “imported” intangible product by a deity or a “naturally” born intangible product of matter-energy), lie many new theories that are based on the latest research of their authors. Among them are those who state that various electrical patterns of neuronal sync in the brain produce different types of human consciousness. Another theory is based on the study of the electromagnetic field produced by the brain when neurons in the brain are active and send electrical signals down the fibers of the nervous system. It states that consciousness is the physically integrated information encoded into this electromagnetic field/pulse of energy.

Such publications are based on studies of a real functioning brain and emphasize the role of information in the form of circulating (bio)electrical signals as an important component in the formation of consciousness.

I do not want to take on the role of one who criticizes all these ideas and theories, but I have the feeling that for now, they are all probably the result of purely mental (understand “theoretical”) “exercises” on the subject and are not based on firm experimental data to prove their plausibility (and operability). Here I just want to mention again my conviction expressed in the previous chapters that every theory and knowledge is (should be) proven in practice (by a reality check).

As you have already understood, dear Reader, the role of information about the functioning of the brain and the origin of the intellect and intelligence (and everything else the brain produces) is one of the main topics in this book. It seems to me that intensive research, based on carefully planned and conducted experiments and measurements of (trusted) results, is closer to giving us the final answer to the question of the relationship between the brain and consciousness or the “mind-body problem”, as it is called by the researchers working in this field. For now, however, it is clear that the question of consciousness still needs to create a unified and verified “fundamental” theory accepted by the majority of the researchers in neuroscience and the potential further developers of AI.

I paid more attention to the question of consciousness because I cannot imagine artificial intelligence, in any “physical” form, if it does not have consciousness. If it is missing, then we cannot accept AI as “equal” to human intelligence at all. I do not want to start the topic at all if a system

with AI (or a robot with AI) has no thoughts (i.e. doesn't think) and no consciousness, then it can surpass humans in intelligence. Otherwise, we just come to a kind of nonsense. We know that computers calculate (process information) much faster than we do. That's why we create them. But the fact that they process information and data very fast does not make them in any way intelligent. And we have hardly developed our intelligence because we have begun to think faster (day by day).

Therefore, until we finally answer exactly (and correctly) how our thoughts and consciousness are "born" (and why?), it is extremely "hastily" to say that we are already creating AI. (Sorry, IT guys, for this statement.) What I do not want to miss here, in connection with the subject of AI, is that there is no way for an "artificial" brain, no matter how complex it may be, to produce them on its own. It follows that AI and "intelligent" robots cannot self-develop their own "personality". Since "personality" is a basic defining characteristic of every human, there is no way for AI without "personality" to become "superior" to humans. An individual without a "personality" (e.g. because of any brain damage) is not exactly a "person" in the common "sense" of the term. He/she is just a living individual (human) for any reason lacking his/her personality (and is maybe an object of medical treatment).

Following the narrative of many interesting ideas in Sci-Fi publications, I wish this was possible. We humans have long attributed "personality" to many living non-human creatures that we adore (e.g. our pets). But following the common logic (the main "tool" of the human intellect), I do not see how such a trait could evolve in artificial (non-organic) matter. I explain the reason for this view of mine in more detail in the following chapters. In any case, I will be happy if this statement (view) of mine is refuted in the future (no matter when).

Let's now take a look at the following chapters. There is more information on these “controversial” topics.

Chapter 3.2: Artificial Intelligence

Dear Reader, in this chapter we will focus on the following topics:

- The term “artificial intelligence” (AI)
- What is AI?
- Why do we need AI?
- Creating AI
- Classification of AI
- Human intelligence vs. artificial intelligence.

Perhaps not coincidentally, with the advent of the so-called “Information” Age, characterized by an accelerated penetration of digital information technology everywhere in our lives, there was increasing interest in research and development related to the creation of products and services containing components of artificial intelligence. The period before this increased interest was defined by IT scientists, researchers, and developers as “AI winter”, i.e. almost no interest in this topic, and hence almost no funding for research and development in this area, although the ideas for the creation of artificial intelligence date back many years ago. More information (hopefully useful) about the development and future of AI technology, dear Reader, you will find further in the text of this and the next chapters.

Most likely, the growing interest in the topic of AI is mainly due to two modern factors:

- The development of information technology as a basis for creating AI (so far based on computer technology only)

- The growing need for “intelligent” automated control systems (involving human mind-like thinking processes) in complex manufacturing and other everyday applications (in business, space exploration, military/defense, security, healthcare, etc.).

This increased interest has led to the “warming/thawing” of AI “winter” and as a result, significantly increased funding for projects related to the development of systems/devices and technologies resembling the functioning of human intelligence, but of artificial origin, i.e. man-made. Of course, almost immediately there were many publications in books, magazines, the Internet, etc., explaining what AI is and what are its possible applications and benefits. There were, of course, many publications about its possible negative impact on the individual and society as a whole. There were “resurrected” all the myths of a coming modern-day “Apocalypse” (dear Reader, please remember the many science fiction movies and novels spectacularly describing the “horror” and destruction that robots and AI will bring to humanity). All those copy the spirit of the members of the Luddite movement destroying machines in Britain at the beginning of the industrial age in the 19th century because they had “taken” their jobs. It's just amazing how many publications have appeared since then devoted to the topic of how AI will take the jobs of millions of people around the world. And usually from authors who have never been involved in AI research or development. There are significantly fewer publications (by authors competent on the subject) on why we need AI and what are its benefits. Or what AI could bring to the individual and society as a whole with its introduction and penetration into everyday life and the world economy. The use of this technology is inevitable, as is the use of the machines today (despite their destruction by the mad people in the early 19th century). The (so hated) machines are still

an integral part of our life and prosperity. After the so-called “industrial” and “information” ages, inevitably comes the turn of their “upgraded” version– the age of AI. It is expected that the “smart” machines in manufacturing and intelligent AI-based “collaborators” in business will help people to process the constantly (avalanche-like) increasing information that we create. Some statistics say that at the end of 2020, humanity created approximately 44 zettabytes of data (one zettabyte is equal to one sextillion bytes (that is 21 zeros after the 1). By 2025, it is expected that there will be 175 zettabytes of data in the global networks. Probably these numbers will prove (to the AI opponents) why we need AI as our digital information processing “assistant/coworker”.

Today, on the topic of AI, numerous myths are created and disseminated, and very often these are pure fictions about its essence, possible qualities, opportunities, “behavior” towards people, and our shared future. Some of them aim for purely marketing tasks, while others are simply products of superficial knowledge and attitude on this topic. They do not analyze in depth both components in this recently adopted term: “intelligence” and “artificial”. In this chapter, I’ll try to do this analysis, which is again based on the systems approach. How well I've been able to handle this task, I leave the judgment to you, dear Reader.

The Term “Artificial Intelligence”

Recently, we are increasingly reading or hearing the term “artificial intelligence” (AI). So, it is natural to ask what “artificial intelligence” is and why it is “artificial”. From a grammatical point of view, the explanation is very simple–just the noun “intelligence” with the added adjective “artificial”.

But are the things “possessing” real “artificial intelligence” as simple as they sound?

So, let's try to clarify the true meaning of this relatively new term in our daily vocabulary.

It is good to start with the origin of this term and then focus on the essence of the concept of the possibility of the existence (creation) of artificial intelligence.

So, where did the idea of “artificial” (non-human) intelligence (and hence the term “artificial intelligence”) come from?

As we already mentioned in the text above, the term “artificial intelligence” was “officially” coined by John McCarthy (a computer scientist) in 1956. But the idea of the existence of a possible “supernatural (non-human)” intelligence is the core of all religions (and their acting deities) created since the beginning of human civilization. With the development of technologies, and in particular industrial technologies, the idea of creating an “artificial” human-like machine (we call those “robots” now) with an intellect similar to the natural/human one, began to appear in various oral traditions and publications–initially in fiction and then in non-fiction. The topic of robots and AI is still one of the favorites of science fiction writers, and more recently of scientists and developers working in the field of IT. It has also become the “favorite” one of many “experts” who actually have never worked in this field.

If one starts looking for the meaning of the term “artificial intelligence”, he/she will probably find a lot of definitions reflecting the views of their authors. And this is normal. The more complex or newer a

term, the more definitions about it. And sometimes those contradict each other. The same is applied to the term “artificial intelligence”. However, many of these definitions are quite in general, most often referring to its applications and the relevant technologies that “support” them thus leaving the impression that the things about “What is AI?” are not yet fully understood, even in some professional circles. But this is understandable. AI and the software technologies that “build” it are still in their infancy. Accordingly, their interpretations are not yet fixed, but rather still “soft/flexible”. As AI and its applications become widely accepted in society as something “common”, their definitions are likely to become more definitive and fixed firmly.

We know that AI and robots (usually “gifted” with AI) are not alive. These are still “machines” made (produced) by using nonliving matter. Thus they do (can) not have feelings (as the living creatures have). The feelings are attributes to the living matter. As intellect and fillings build (produce) intelligence (dear Reader, please recall what was said about intellect and intelligence in the previous chapter) it follows that AI and robots are “intelligent” in the meaning of the term “intellect”–logic/reasoning and calculating which is an “innate” function of all computers. Thus the term “intelligence” cannot be fully applied to them as they lack feelings (and emotions). Nevertheless, in the book, I will continue using the phrase “artificial intelligence” instead of “artificial intellect” as I do not want to confuse the reader as the phrase “artificial intelligence” is already commonly accepted and widely used today (by experts and non-experts alike).

So, let's now start with the emergence of the term “robot”, usually considered as an owner/carrier of AI. The term “robot” was introduced by

the Czech writer Karel Čapek in his R.U.R. (Rossum's Universal Robots)–a 1920 Sci-Fi play.

For those readers who are unfamiliar with the origin of the term, in many Slavic languages, the term robot is derived from the word “rob”, which in English translates as “slave”. Most likely, the original idea of the author was that their purpose was to serve as slaves to humans hence the derivative term “robot”. Therefore, in most Sci-Fi works, they were initially presented mainly as “servants” serving and caring for people. Later, an idea was born that robots would be the “carriers” of the modern-day “Apocalypse” for humanity. The idea was probably borrowed from the last book of the New Testament (attributed to Saint John the Apostle), containing descriptions of conflicts between good and evil (Armageddon) and of the end of the world. Quite an attractive (and lucrative) topic in many modern blockbuster movies, novels, and other publications. It just follows the “very old” religious idea, preaching that if the people are not “nice” and do not obey their deities, Armageddon will occur and exterminate the Earth's population. (So, guys, be nice.)

However, the manufacturing practice and economic necessity imposed the first “real” robots (actually not in human-like shape) as industrial equipment in automated production environments, where they successfully cope with the tasks assigned to them. But they are still very expensive and not “intelligent” enough (as required and expected). So for now, the advent of domestic “smart” human-like artificial slaves (robots) and the modern “Armageddon” must wait for their right time.

And we live in a society where slavery is forbidden by law, but we still want someone (or something) to serve us as a “slave”. And the first

things that immediately come to our minds are the “mechanical” robots. But what will happen if those robots over time self-evolve intelligence (and consciousness) just like us humans or (Oh, God forbid!) even at a higher level than ours? But, this has already happened in many slave-owning societies, in which slaves gradually began to perform all activities, replacing their lazy owners (masters) indulging only in entertainment, and as a result, they blunted and became involuntary and unable to self-serve living beings. The modern-day concept of a possible negative role of AI and robots in human society (most probably borrowed from the slave society) is now presented (quite “convincing”) in many Sci-Fi and other less scientific publications “predicting” of the approaching “technological singularity” (i.e. a modern Armaggedon) as a consequence of the possible emergence of super-AI and mass of intelligent but “evil” (not mandatory withe) robots. But this call is still the same old “battle cry” of the (most probably insane) “fighters” to save humanity: “People, stop the technology progress!” But "behind" it, the educated people could hear another (hidden) version of the Ludittes' battle cry: “Destroy the machines!”. The proponents of the idea of the destruction of the machine (but this time the “smart” machines) don't want to discuss and explain what we will do without those machines. They don't want even to mention what was before the invention of machines–according to the history of human society it was the medieval serf society. Sometimes, in all those statements, I recognize just another version of a familiar (and much older) call: ”Back to the caves”.

The term “artificial intelligence” is generally used today to describe computer operations that mimic human mind functions mostly related to cognition and logic, such as learning, reasoning, problem-solving, etc. In my (humble) view, “intelligence” in the term “artificial intelligence” is used very

loosely. It tries to “assign” a very important human brain activity to various artificial systems or devices (usually computers and/or computer software) that simply do not have such abilities/characteristics. And if compared to the definition of human intelligence (dear Reader, please refer to the previous chapter), it will never come even close to this most important human quality. As emotions play a substantial part in human intelligence, there is no way (or use) to impose emotions on AI or “intelligent” robots.

So, the term AI widely used today should be read (in full) as “AI concept-based technology”. In my view, this is the correct use of the term. It brings clear meaning to the readers and any prospective users of technology. Today, AI is still at the “concept” stage of its development (by humans) and must go a long way to come to some kind of “intelligent” level/condition. But for the sake of simplicity in the everyday use of the term (as the full term sounds too “professional”), we may accept its abbreviation–just “AI”. But we still should keep in mind the full term definition (and most importantly–its meaning).

Instead of using the term “artificial intelligence” we probably should better use “artificial intellect”, not “intelligence”. Artificial intellect (and its functions) comes much closer to the definition and functions of “human intellect.” But further in this book, as I already stated in the text, I will continue using the term “artificial intelligence” just not to confuse the readers who are accustomed already to this term thanks to the massive marketing campaign about AI in media. Nevertheless, I will mean “artificial intellect” the way the “extended” definition of it was explained above in the text.

Despite the term “artificial intelligence” being widely accepted and used today, it is really “misleading”, as it will hardly be possible (and meaningful) to create an “artificial device” with emotions, hence real intelligence. If we ever succeed with such a task, most probably it will be not close to equal to human intelligence. Emotions arose as a product of the evolution of living matter and perform specific functions related to the survival of living beings such as humans and animals (which can react immediately to changes in their habitat and/or any threats). But what could be the “nature” (genesis and functioning) and meaning (purpose) of emotions in artificial creatures? This topic is discussed in more detail in the next chapter devoted to the future of AI. Here I just would like to suggest that in the English-language publications on the topic of “artificial intelligence”, where the term is referred mostly to as “artificial intelligence”, probably it will be better to use the term “intellect” instead of “intelligence” (as it is in some other languages). This is just to avoid the inconsistencies between the terms widely used by IT experts (i.e. in practice) and those generally accepted as scientific definitions.

The emergence of artificial intelligence is (will be) a product of human intelligence and more precisely its creativity. Like most “mechanical” creations (machines) created by humans so far, his “task” and purpose are to help people perform some of their daily and production activities by automating them (to get the best possible results). Because AI is based on information technology, its main purpose is not to automate mechanical activities performed by humans. Its task is to automate many human mental (intellectual) activities, especially in areas where its benefits are undeniable (and competitive). For now, these are mainly in the processing of information using “intelligent” algorithms. If AI is “integrated” into a

“mechanical body” (as in “intelligent” robots), it will help to automate both mechanical and intellectual activities.

Nevertheless, when we talk about “artificial intelligence”, we should not mix rational with emotional. Yes, in humans many times both work together amplifying or dampening each other effect. Sometimes they can even block each other. But each one of them has its distinctive “application areas” where it works most effectively.

A robot, no matter how much “intelligent” it is, is just a robot (machine). It is not a human. It is not intelligent in the human sense. A robot is a machine mimicking an appearance of human intellect and maybe of shape (depending on its applications). We should not even mention intelligence in robots as it involves emotions, feelings, etc. How and why a robot (should) have feelings and produce emotions as a reaction to stimuli? And what could be the purpose of these?

Here, of course, we must exclude Sci-Fi robot characters such as Bender from “Futurama” (created by Matt Groening and David Cohen), who is a “bender” (revelry in drinking and merrymaking) by “birth”, and who was produced by Mom’s Robot Factory. Or Marvin the paranoid android and the self-satisfied talking doors, both produced by Sirius Cybernetics Corporation (characters from The Hitchhiker's Guide to the Galaxy by Douglas Adams), who were “born” endowed with emotions (“*Genuine People Personalities*”), just to carry the underlying ideas of their creators.

What is AI?

If we are starting to discuss the topic of artificial intelligence (AI), it is first good to answer two “basic” questions. The first of these is related to the essence of AI: What is this AI thing? Or more precisely: What is AI made of?

The second is related to the emergence of our need for AI: Why do we (humans) need AI?

First, let's try to answer (intelligently) these “ultimate” questions about AI, and then we will try to answer some other questions related to their role in our “joint” future in a “hybrid/mixed intelligence” society.

To answer both questions above, let's decompose them into several composite questions, which we will try to answer sequentially.

The first of them is related to the “nature” of AI and it sounds like this: What kind of matter is AI made of? (What is AI made of?). This is how we will address the issue of the adjective “artificial” in the term AI.

Since we use the determinant/adjective “artificial”, this means that it is made of “artificial” matter, i.e. somehow “modified” by us humans as all matter in the universe is of “natural” origin. The technology we use to produce such “artificial” (not existing in nature by itself) just changes its structure (not nature). For now, we are trying to create AI from “inanimate” matter based on concepts “borrowed” from computer technology. It is known that we (humans) are naturally made of living matter, which has evolved from inanimate matter, and its chemical composition and structure are much more complex than the initial one. It is possible that over time, humanity will try to create an AI made of “artificial” (synthetic) living matter

using advanced biotechnology, which we have not yet mastered, but are trying (hard) to develop and use.

Many modern researchers working in the field of “intersections” of neuroscience and cosmology believe that the complexity of the structure of our brain is not inferior to that of the universe. Remember the numbers presented in the previous chapter about the number of nerve cells (neurons) and their possible interconnections in our brains.

Following these assumptions, we can see that all the claims today that we humans have created (can create) artificial intelligence, as they say, are “greatly exaggerated”. If ever humanity can create a “positronic brain”, whatever that means (dear Reader, please refer to the *Robot* series by Isaac Asimov), then things may change. Until that time, I suppose, all the AI developers should be more humble and name the things (their creations) by their real names–just other/new pieces of computer hardware and software. And these all are far behind the complexity of our brains. So, in this case, what kind of intelligence they can “contain” and represent/exhibit?

Here I would like to mention, that some experts in AI technology (and authors in that field) started already to acknowledge the fact that everything developed and named AI until today is not actually “intelligent” (i.e. “intelligence”). These are just “smart” software systems that can adapt to changing (information) environments. The adaptation may include also acquiring and generalizing new knowledge (e.g. recognizing images), by using any (usually human-created) “machine” learning algorithms and improvising/applying the built “machine kind of knowledge” to new and/or unfamiliar scenarios/settings.

So far, even the “wildest” Sci-Fi fantasies don't dare (too often) to present us with such scenarios where we–the humans, create new galaxies or universes. At least, I haven't met many such publications so far. But some scientists (you know, sometimes science is weirder than fiction) create theories about such kinds of universes (multiple universes, parallel universes, “bubble” universes, etc. “exotic” ones), and some of them are paid exactly for doing that. But we know that the words, no matter how much “powerful” they are, don't change the reality. Nature's (and human) deeds do (can do) it.

So, let’s look at what AI is made of today. It is still “produced” using ordinary and sometimes advanced computer technologies – computer hardware and software. That means AI is based on non-living matter (computer electronic components) and electrical signals presenting software codes. The codes “activate” computer software applications (functions) built on pre-coded algorithms (rules). The mechanical construction may be in computer-like shapes or machine-like shapes (robots, manufacturing equipment, vehicles, etc. devices). We can see that the only “similarity” with humans here is the electrical signals, but in humans, these are combined bio-electrical and bio-chemical. So, there are no other similarities, in terms of “nature”, between humans and AI (or intelligent “machines”) today.

Let’s now focus on the origin of “natural” intelligence and “artificial” one. We know from life science that the human species is the result of the evolution of life on the planet Earth (sorry, creationist guys–you don’t have enough evidence proving your theory). Artificial intelligence today is still a product of human science, design, and development. That’s why the adjective “artificial” in the term. So, AI is a product of human scientific research and engineering activities. By the way, the term “engineer” is

derived from the Latin words “ingeniare” (to create) and “ingenium” (cleverness).

Let's now analyze the meaning we put into the term “intelligence” in AI. To do this, we must have a measure for comparison.

As was mentioned in the previous section about the term “artificial intelligence”, we should stress one more time that when using it we “automatically” start making associations about our (human) intelligence and superimpose those expectations onto the software systems we call AI.

In this case, we already have a “benchmark” for comparison–human intelligence. And this is the only one we have. So far, we don’t know (haven’t met) another “creature” closely matching it.

Other types of intelligence, such as in animals are still poorly understood and can hardly be compared to human general intelligence. Sure in some specific cases (e.g. prey hunting) their intelligence may “override” ours. Recently scientists started claiming that even plants also have intelligence, but with those is much more complex to communicate thus understanding their “behavior”.

To assume that an artificially created system or device possesses intellect or intelligence, the basic characteristics of that intellect/intelligence must be at least equivalent (or very close) to those of human intellect or intelligence. They may even exceed them (if by nature this is possible).

The previous chapter presented the characteristics (qualities) of human (natural) intellect and intelligence. Let us now compare the

supposed/achievable qualities of an AI when it is created or self-evolved in its artificial carrier (“body” of any shape and synthetic matter).

Here I immediately want to emphasize that what is presented to us today in the many publications and presentations as AI, is not really “intelligence” (sorry, IT guys). These are a variety of computer algorithms, usually describing functional models of objects and processes, and programs based on them, which we could call “smart” to distinguish them from the “traditional” algorithms used in computer programming today. These “smart” and often adaptive algorithms are designed to mimic, to a certain degree of accuracy (and functionality), “real” processes that take place in the human brain when performing specific “intelligent operations”, but neither fully respond to them nor are “intellect/intelligence” in the full meaning of both words. To be accepted as having an “intellect/intelligence” they must have all the mental components, like those in human intellect/intelligence. Or at least, to be very close to them when correctly compared.

Therefore, we can assume that the use of the term AI is currently used just as an abbreviation of the above explanation so that we do not have to use long and complex phrases as grammatical determinants (adjectives). This abbreviated version of the term now has another application, which is mainly related to the marketing of technology “embedded” in IT products and services. And sometimes it is simply used loosely by incompetent authors.

I am aware that such a statement will immediately meet with a strong negative reaction from the IT “brotherhood” working in the field of AI, but in both science and technology, the truth must be the ultimate goal (should be paramount). We must accept the fact that today what we call

“artificial intelligence” is not at all comparable to the only “standard” we know–human intelligence. When artificial intelligence has been proven to achieve all the quantitive and qualitative characteristics of human intelligence, then we can safely call it “intelligence”. Until then, we must accept the conventionality in the use of this term, which has mostly the characteristics of “intellect” rather than “intelligence”. If you need a reference to the differences, please look again at the previous chapter.

We need to know what characteristics an AI must have to be called “intelligence”. Only by comparing it with the human (“standard”) will we be able to judge how far the technology has reached (or can reach).

Why Do We Need AI?

The simplest answer to this question is: We (humans) need AI for the same reason we need machines and automation. The ever-growing population on our planet (having limited natural resources) needs higher productivity and efficiency (less spent resources for getting the best results).

The machines and the subsequent automation of almost all types of industries solved the initial tasks of producing mass and affordable products. The development of information and computer technologies solved the next set of tasks related to “big” data sets and information processing. But the further developments in manufacturing and society constantly set new and more complex tasks, for the completion of which we need new advanced technologies and tools. We need those for further “intelligent” automation of the more complex systems and processes we use today in manufacturing and businesses. We also need those to create better services (and wellbeing) in our everyday lives. These new technologies and tools should have qualities

and characteristics equal to human intelligence (actually intellect) for solving problems, making decisions, and initiating/completing actions in limited timeframes.

Here we must honestly admit that although we consider ourselves a "wreath/crown of nature" because the complexity of our brain is comparable to the complexity of the universe, it still has many limitations. Its characteristics in processing information aren't competitive even to computers and computer networks when we start comparing them by memory speed and reliability of recording, processing speed in performing calculations and analysis and even building complex knowledge bases. It often takes us 20 years or more to build suitable knowledge in one particular knowledge area.

So the idea of developing AI came out of the research and experimental laboratories and the prototypes were passed to the engineering organizations. After the relevant developments "matured" enough, their implementations began to gain momentum. We are all witnessing these processes. And there will be no way back. AI is simply a necessity at this stage of the development of our production and society (today we call it "Post-industrial society").

So, now AI is a symbol of "smart" (intelligent) automation of complex tasks in our professional and everyday lives. In many manufacturing and business tasks, AI may be (and probably will be) more efficient than us. Sure, AI as technology will constantly evolve along with the problems it will solve for us. And its "evolution" may pose new "problems" to us. But so far, everything related to AI depends on us as we are its creators. Someday "things may change" if AI takes its "fate" into its own hands.

But no matter how intelligent will be the “smart” robots and AI, they will never replace the “human touch” serving as companions and assistants in our everyday lives. They will never be able to reach the effect of that “intelligent stare” into our eyes so well mastered by our pets (dogs, cats, etc.) when they ask for something or just want to “tell” us how much they love us. And here is my suggestion to those who may oppose this statement – don’t even try to tell any pet lover that dogs and cats are not “intelligent” creatures. You may not be “intelligent” enough to fully “decipher” the condescending smile you’ll get in return. I don’t think that even artificial superintelligence, as we expect today’s AI to self-evolve into a “supermind” in “future indefinite tense”, will be able to master such an intelligent stare as our pets do today. Sure, somebody may argue that the superintelligence may not need to look at us with love in its “eyes” (cameras) as it (probably) will want to exterminate us instead of pleasing us. But we will discuss this topic (possibility) in more detail in the next chapter.

At the stage of the industrial revolution, humans designed machines to help them increase productivity. Then they started to automate the manufacturing machines, systems, and processes to increase their quality and efficiency. The more complex those became in their “technological” evolution, the more sophisticated automation systems we needed to control and run them. If you need “real-life” proof, just ask a design or production engineer in any factory producing computer chips that can design and produce integrated circuits (chips) without automation and you will immediately get the correct answer: “No, we cannot. This is impossible today.”. Ask yourself, are you able to do your job and communicate today without computers and/or smart communication devices? Your answer will be the same.

Let’s now try to justify this need by a “short tour” in the history of industrial manufacturing. I guess most of the readers of this book are familiar with this topic, but let's help unprepared readers, especially on the specific issue of “intelligent” industrial automation.

The term “intelligent” automation mentioned above means that this type of automation is designed to control “complex” processes (of any type) requiring the involvement of human-like intellect (sometimes even intelligence) when running and controlling the process outputs. These processes, due to their complexity, could not be studied and modeled precisely enough and therefore could not be automated effectively enough with the “conventional” means used so far for industrial automation. For this reason, they require human participation, i.e. his intellect, in the control (and management) of this type of process. However, this “human” participation has its limitations and shortcomings, which are inherent in the natural (biological) resources of people–fatigue, malaise, delayed reaction, incorrect decision to act, and more. Similarly, this can often lead to waste in production, process failure, or damage to production equipment, i.e. production losses. These shortcomings are avoided through the introduction of industrial automation tools. This is the main purpose of automation–to maintain the required quality and efficiency of the processes, freeing people from direct participation in their control and completing monotonous tasks/jobs. With the same goals, humanity created (years ago) machines that had (and still have) the purpose of replacing humans in the immediate performance of production operations, especially when these operations are hard and harmful to the health of the human performer (worker). Humans have ceased to be an immediate “bio-mechanical” appendage to machines. They retrained and took over the functions of process monitoring, control,

and management. When machines (and processes) became complex enough to be controlled directly by humans, the most “unreliable” component in the production systems was replaced by various process automation tools.

Here I want to give just one example of the role and effectiveness of process automation, reminding you, dear Reader, of the history of the development of telephone communication. Just remember the “old-time” phone switchboards and the young women working behind them making the requested communications. According to statistics, the number of smartphone users worldwide today surpasses three billion (of the total human population approximately 7.8 billion in 2020 according to the statistics). So, if those operations haven’t been automated by computer-controlled switchboards, today probably almost all young women around the world have to practice that profession. With this, I just want to avoid any useless discussions with the modern-day “Luddites” about the benefits of the technology progress because it will be (for me) just a waste of time.

The constant development of technologies and manufacturing equipment has led (and continues to lead) to the implementation of even more complex processes that require the processing of large data sets, analysis of results, and decision-making for response in very short periods or in real-time, which made the task of directly involving people in their management impossible.

So, in the beginning, it was the “naturally born” idea to start using “traditional” information technologies (computers, software, networks, etc.), and later move to their “advanced” version–AI-based technologies, using those for “intelligent” automation and replacement of humans where they can no longer cope with the complexity and the speed of the processes. And

the time is coming for the people to free themselves of the monotonous and hard work of monitoring and managing complex processes. It is natural for us to “transfer” (pass) these tasks to AI and to reskill and prepare ourselves to perform more creative activities (jobs) corresponding to the full spectrum of our intellectual capabilities.

And at the resent stage of the “Information age”, we finally got all the tools and technology we needed to be able to design and create the most advanced automation by involving the concept of AI “coworkers”–let’s do the automation “smarter”. So, that’s why AI is for “smart” automation in business and services (assistance to humans) in our everyday lives.

And as each technology also creates a variety of “byproducts”, AI will also create some additional products and services, such as for fun–for example, sex robots. But those may be considered as “added services” (probably not just that much “smart”) we could need in our everyday lives.

Creating AI

Behind the idea of creating “something” artificial that has the behavior of a “living” person, there are usually two very old desires (dreams) of humanity:

- Creating obedient servants (slaves) to fulfill all our desires in our daily lives (and at the same time, if possible with the cheapest support/self-sustainment).

- Creation of a superman/superwoman with physical and mental capabilities exceeding those of the “ordinary” humans limited by their natural origin.

Initially, these ideas were reflected in many myths, legends, folklore, and religious beliefs of people over the centuries, but with the development of technology, the idea (and the hope for its realization) was transferred to them. Of course, with a “slight shift” to advanced technologies, such as information and biotechnologies (or combinations of both).

So today the old ideas of creating an artificial “likeness” of the human are discarded and all eyes (and hopes) are directed to the “all-mighty” technologies and, of course, to the development of the (huge) market to which they may lead. Naturally, the name of this technological “miracle” should sound as modern/advanced as possible–i.e. “artificial intelligence” or at least an “intelligent” machine/robot. But the main idea is still the old one–just creating (cheap) substitutes and/or assistants for people in their production and everyday life.

As we all know, presenting an idea is usually easy, but its implementation sometimes requires a lot of effort and investment.

Creating a “complete/strong” AI (not those “narrow” AI aggressively advertised by computer software and hardware developers and producers today) is a very complex task with many fundamental scientific questions still not answered unambiguously despite centuries of debates and research. Among those are the mind-body problem and the “mystery” of consciences. In my view, only after solving both tasks completely, we could approach the creation of a “real” artificial intelligence correctly.

Creating AI we (the human creators) have to “fuse” our knowledge and skills in two basic areas of natural science–physics and biology. The physics will be “presented” by our advanced knowledge in computing

(information technology) and biology–in neuroscience and biochemistry (organic chemistry). But the final "product" should be nonorganic (currently based on computer chips) and function exactly (if not better) as its organic "prototype"–the human brain producing nonmaterial thoughts. The last ones are usually considered to be a kind of electromagnetic field, according to neuroscientists, or a quantum field according to the latest theories of physicists. To which one of both fields ("classic" or "quantum") does belong the "truth" about our thoughts, we still should discover and prove it.

As you can see, this is a "gigantic" task, if we apply the term from ancient Greek mythology here. If we aim to create a real AI (equal to human intelligence) we should solve first the mind-body problem and understand how the body (brain) creates consciences. When this may happen, we still don't know. Both problems have remained unsolved since ancient Greek times. Till then all the talks about AI (except the term "narrow" AI) are just still "words" (promises), not "deeds".

When creating AI, the second important question (and task) is how it will gain (construct) knowledge reflecting correctly the world (natural and social) around it. In other words–how AI will acquire. "real-life" experiences and apply those without failures. From the previous chapter about human intellect and intelligence, we know already that both phenomena (intellect and intelligence) are based on the knowledge we build during our life span. The IT guys have developed various ways (approaches and algorithms) how AI should learn based on the models that represent (more or less accurately) the brain (mind) and its functionality. But the majority of those "feed" AI by data (only). Yes, this is the "natural" way how a computer system is functioning, but we humans do not learn from data. We learn usually from unstructured semantic information (text), images (static and/or dynamic),

and voice/sound streams, all combined and synchronized in time. So, the current approaches for “teaching” AI are the big disadvantage of the way AI learns, no matter how well all those are designed–the “machine and deep learning” algorithms we “implant” into its “mind” today.

By creating AI, people take on the role of “creators” (remember the role we attribute to the gods of different religions) of something we haven’t encountered in nature, at least so far–intellect in inanimate matter. That is why its creators (we humans) call it “artificial”, i.e. appeared not in a natural way of evolvement. Unless we accept the idea that we are “chosen/destined” to create it as the next stage in the evolution of the intellect/intelligence in the universe. What we know from science is that as a result of the evolution of inanimate matter, living matter appeared, which “gave birth” to the intellect and intelligence in it. Believing that we have the ultimate intellect/intelligence among all living beings inhabiting our planet, we try to reproduce it artificially, using ourselves as a model (“blueprint”) of this creation–our biological structure, organization, and functions. And more precisely those characteristics of our brain that we associate with the emergence and functioning of intelligence.

However, if we take a closer look at the brain, as the sciences such as medicine and neuroscience have already done so, we will see that it is an extremely complex system, and perhaps the most complex we have ever encountered in the observed universe. Let’s here recall one more time some of the structural and “quantitative” characteristics of the brain mentioned earlier in **Chapter 1.3** of this book. Here we will recall them again briefly:

- The human brain has some 86 billion neurons (according to the latest publications on this topic)

- The neurons communicate with each other via synapses. Each neuron has on average from 7,000 to 10,000 synaptic connections to other neurons

- The number of synaptic connections in the brain of an adult individual ranges from 100 to 500 trillion (about 10 to the power of 15)

- It has been estimated that the number of link combinations between synapses is hyper-cosmological (10 to the power of 1000000000).

Some researchers state that such a number exceeds the number of all elementary particles in the known universe. Incredibly, how did they manage to calculate the number of all elementary particles in the known universe if they all the time discovered new cosmic objects (stars, galaxies, etc.) not known so far?

As we can see, the structure of the human brain is described by numbers on a "cosmic" scale. I have not yet come across (official) publications about any newly created (super)computers that may "host" AI resembling the complexity of the human brain or at least with similar characteristics. Maybe somewhere there are already created supercomputers with similar or even superior characteristics, but usually, the data for such devices isn't published to the general public due to their specific areas of applications.

I guess and I hope that the reader will agree with me that for now, AI is the most complex creation of mankind that it has set out to create. I believe that this is a long process, the result of which (if this process has an end) is still far in the future (dear Reader, please refer to **Chapter 3.3**). This belief follows from the long history of the idea of intelligence other than in humans and its meandering "zigzag" that gave rise to many ideas and variants of our view on AI. And this story is as old as human civilization. Here

I do not intend to focus on the story of the origin of the idea and its (gradual) development. It has already been described extensively in numerous publications–scientific, popular, and science-fiction.

Instead, here I would like to focus on two “fundamental” questions (in my opinion) about AI–the reasons that led to the idea of (a possible) AI and why we set out to create it. Of course, the second question is inextricably linked to the first one, because we (humans) do nothing without reason and (usually urgent) necessity, except when we are just having fun. Then, as we like to say, we may just do no sense (thoughtless) things.

Our answers to these two “basic” questions will be followed by the answers to many other (second-level) questions related to AI and of course their possible (meaningful) answers.

To answer the above two questions correctly (without prejudices and/or emotions), we must follow (quite) briefly the development of the production of goods and services that meet the needs of human society. A review of the history will help us predict the possible developments and applications of AI in the near and distant future.

The idea of the existence of intelligence, first at an initial level “embedded” at birth, and then improved–more qualities “added” to the initial one, is based on our “awareness” of our “spiritual” activity (“soul”) besides the physical (body). This “added value” intelligence constantly reflects on our existence in the habitat and usually starts “pushing” us to act to improve the quality of life. Human history and practice show that some of the things we use or create artificially start as ideas on how to improve the tools we use to protect us in the environment we inhabit (for survival). The

other part of what we create is again a product of ideas, but “forced” by our everyday needs, such as foraging and preparing food (hunting tools, pottery, etc.), the need for shelters (caves, huts, houses), etc. essentials and then may come more “goods and services” as “added” luxury (higher quality of life).

And as always, let’s start from the “dawn” of humanity when to survive, humans always needed food, shelter, protection, etc. “essentials”.

In the beginning, the group, and later the tribe, took care of the acquisition and provision of all essential categories (food, shelter clothes, and protection). Naturally, neighboring tribes competed for hunting grounds, which led to battles between them, especially in years scarce for game and plants gathered and used for food. This has led to the development of skills and tools (now called “technologies”) for fighting. Tribes with more “advanced” combat technology have won such battles, and the result has been a reduction or destruction of competition, and sometimes the capture of captives who have been enslaved (used for doing various jobs for free or just for food). Thanks to the created (though still primitive) technologies, humanity has entered its next stage of development–the slavery social system, in which there was an auxiliary “workforce” in hunting and gathering food, and later in the development of early agriculture and crafts.

Slave owners have gained access to “services” offered by the slaves. Sure, these services were “provided” by the slaves to their owners by compulsion and almost for “free” or minimal expenses to the owners (just food, clothes, and shelter, again). The slaves performed usually mainly manual labor, but gradually, with the development of the slaveholding system and the enrichment of the ruling class, the list of activities carried out by the forced “assistants” (slaves) expanded. In addition to the “basic”

physical activities (food and clothing production, construction, agriculture, etc. everyday activities), slaves have begun to provide such “intellectual” services as household management, accounting, training, art (for creating luxury for their owners), etc. I.e. to the pure “mechanical” activities were added some intellectual ones requiring knowledge and specific skills. But both were still performed by enslaved people (workforce). The abolition of slavery as a social practice gave rise to wage labor, but the rapid increase in the global population required more productive machines, systems, and technologies. This led to several consecutive stages for increasing the production of goods and services, which we call today “industrial revolutions”. These “revolutions” in industrial manufacturing naturally led to changes in our society itself. We are now on the “threshold” of a new revolution in manufacturing, which some authors call “intelligent” manufacturing, and others “Industry 4.0”. The numbering follows the three previous industrial revolutions starting with the transition from hand production to machines, followed by rapid standardization and industrialization, and the third one known as the “Digital Revolution”. Naturally, the idea of “intelligent” manufacturing is based on AI (“collaborators” to humans), as one of the main components in its control and management.

Since AI is currently a human “machine” creation (meaning “non-biological”), which is mainly “housed” in different types of computers, let's remember why mechanical devices (machines) were created first, and then their electronic “brains” (we call computers). To this end, let’s briefly recall the reasons (motivation) for their emergence and further development.

From our known history of the emergence and development of human civilization, we know that people are constantly developing methods

for obtaining food (necessary for their metabolism), as well as other products that are necessary for their existence and survival in the living environment (natural and social). After the first stage of hunting wild animals and gathering plants for food in the natural habitat, came the next stage of social development by cultivating plants (for crops), and domesticating some species of wild animals, which led to the initial “organized” agricultural production of food and related products. However, in both cases of this initial production, the main “productive” force still was the human, i.e. human manual and mental activities and skills. In initial organized production, this still was mainly forced labor performed by slaves, and their productivity was naturally limited by their physical capabilities and living conditions.

The humans’ mental work (people's creativity and ingenuity) has led to the invention and development of increasingly sophisticated tools and mechanical structures (“mechanisms”) to help them perform various manual operations. Further improvements of the initial mechanisms have led to the emergence of increasingly complex mechanisms, called by us by the common name “machines”. These machines, having a wide variety of applications, have been designed to alleviate and replace heavy human labor in the production of various products on-demand in society, as well as to increase productivity. Thus the use of machines has led to a significant increase in productivity and better satisfaction of the ever-increasing needs of people. The constantly growing number of machines, their variety, and their connection in production systems (lines) led to the method of production, which people called “mechanization” i.e. the replacement of manual labor by machines. However, people remained “affixed” to the machines in the role of their operators and technical support in case of need.

But as history shows, each new technology can have both positive and negative applications (and consequences) for people. The increased productivity of machines has led to a reduction in the number of people engaged in manual operations (loss of jobs). Thus the movement of the Luddites was “born”, who set themselves the task of destroying the machines that “take away” their jobs and make them jobless (not able to sustain their families). We all know that the causes that led to these first “collisions” between man and machine were not caused by the machines (created just by other humans–engineers), but they were (and still are) purely social. They are rooted in the lagging behind the professional skills of certain groups of people (manual labor force) compared to the changed production technologies designed to meet their social needs. They are a consequence of the delayed reaction (conservatism) of the system, which we call “education” (and more specifically “vocational education”), and which is also created by us humans. And which must be “synchronized” with technological innovations and reskill people in time for the changed conditions at their workplaces.

The increased complexity of the machines and the increased speed of the production operations made the task of their operation and control impossible for the human operator and so the idea of automation appeared. This idea led to the creation/design of many “smart” devices and systems that started monitoring and collecting information on the progress of operations and their outcomes and which began even helping to “manage” the production process by replacing the human operator/controller. Mankind started living in another “industrial” age, based on the widespread use of machines and automation.

Increased productivity, thanks to machinery and, as a consequence, increased trade in manufactured goods, led to the development of business and the economy, which in turn began to generate a huge amount of data (technical, financial, economic, etc.). Mankind began to feel an urgent need for “helpers” to process them. This need led to the creation of computers that “took over” the task of processing the growing amount of data generated by the industry and business. Computers (whose functioning is based on Information theory), in turn, “hinted” and “helped” the development of electronic communications, which led to an incredible expansion of the information exchanged and the sources and processes that generate it. The productivity of computers (the speed with which they process information) began to grow at an incredible rate to cover needs. With the advent of “personal” computers, the data and information generated by industry (economy) joined to the information generated by people in their daily activities. There was a need for faster and cheaper transfer of avalanche-like information. As a result, the Internet was born. The further development of so-called “information” technologies has started at an incredible pace. Mankind is living today in the new "Information" age, in which the consumption of information services is inseparable from the consumption of “physical” products (goods).

A “logical” step followed–the “merge” of machines and computers. Computer-controlled production (and not only production) and its “smart” automation and control systems have emerged, which have raised the productivity, quality, and efficiency of industrial production to a new higher level. For its part, it began to generate even more information, as well as need faster processing due to the increased complexity and speed of processes. People and “ordinary” computers were not able to cope with

these increased and complicated tasks. There was a need for better automated “helpers” who should be “smart” (understand “intelligent”) like humans and as fast and reliable as computers in the processing of big sets of data and information. This new need, of course, led to the next “logical” step in development–“combining” people's intelligence with computers. This need and subsequent developments led to the emergence of the idea of AI in the mid-20th century. Then the talks of the coming “AI age” started. I.e. in the idea of creating AI, there are two key factors (needs)–economic need (the need for higher productivity and efficiency) and technological need (for “smarter” process automation). They naturally lead to the replacement of the human in the performance of “routine” and low-skilled activities (jobs). This replacement (if performed professionally) inevitably leads to the increased quality and efficiency of processes. In this case, it is targeted to the automation of “manual” processes in the processing of information (e.g. involving direct human participation), which due to the requirements for complexity and speed of processing are beyond the power of humans or even when they use computers. What was needed was a “device” that thinks like a human, but was as productive and reliable as a computer and doing the job on its own. And such devices started to appear in business, manufacturing, and people's usual everyday activities. To differentiate them from the “ordinary” computers, and most possibly for “pure” marketing purposes, they are advertised as “intelligent” computer-based devices/systems or “artificial intelligence” software. Yes, they are “artificial” (i.e. created and still produced by humans) but are they “intelligent” (comparable to the human intellect/intelligence) is quite another question that we will address later in this chapter.

Of course, there are many other important questions we can and obviously should ask ourselves about AI. They are related to the reliability and security of the technology, as well as a number of those related to its social impact. But these are all issues that need to be addressed concerning the development of technology and its specific applications. Such issues cannot be answered/solved “abstractly” or in general, as many authors try to do (declaring themselves as “experts” in the field of AI). But most probably they are just looking for a field for a personal realization.

From the text above, it is obvious that initially, AI will be the next “natural step” on our way to automate activities in the control and management of complex processes and systems that require the participation of our (or human-like) intellect. When the complexity and speed of these tasks exceed our ability to respond correctly or in the time required for their completion, the intervention (assistance) of the AI can be crucial for their successful implementation. In environments that are harmful to human health or survival, but require an “intelligent” response, “coworkers” such as AI will be indispensable. And of course, with some repetitive “uncritical” activities, the human will most likely be replaced by AI to free people up for more creative activities/jobs. There will probably be many, as yet undefined, areas of “smart” application where the use of AI will be more cost-effective than human participation. In all these cases, AI will serve as the “interface” and “proxy” of humans in their interaction with complex objects, systems, and processes requiring the participation of intellect.

If biological AIs (such as androids) appear in the next stages of AI development (a topic discussed in the next chapter), then their “autonomy” (freedom) from humans is likely to be extended on an ethical and legal basis.

As we already said in the previous chapter, there is no intellect (and intelligence) without acquired knowledge. I.e. the stage of building a knowledge base is mandatory in the creation of artificial intelligence. From this perspective, there are two main ways to create an AI through a process:

- Self-learning–based on algorithms created by humans, or
- Learning using knowledge created and transferred to AI by people.

Before we start the topic of "teaching" AI or/and "self-learning" of AI, it may be useful to recall (one more time) how we humans learn, i.e. how we acquire knowledge (dear Reader, please, refer to **Chapter 2.2**). We do this mainly in two ways–through personal observation and/or personal experience (personal experience) and organized transfer of knowledge (commonly called teaching or learning/training depending on the position of the participant in the process).

We know from experience that the first approach is slow and with uncertain results, as it is built on the method of "trial and error". The second one, if organized and completed correctly, guarantees much higher speed and quality of the results.

So, which method will we select for AI–"self-learning" AI or "teaching" (knowledge transfer to) AI?

There are two terms related to "(self)learning" used with AI today–"machine" learning and "deep" learning. "Machine learning" is usually defined as the ability of computers to learn without being explicitly programmed by humans. "Deep learning" is usually referred to as machine learning methods that allow computers to learn by example. Both kinds of learning are based on a variety of computer algorithms created by humans

(again) and new ones continue to be created by AI experts. These algorithms extend (or improve) AI capabilities of self-learning. This way, the developers are providing AI with the ability (and responsibility, respectively) for "self-learning" based on the built-in algorithms. However, if we carefully analyze both AI self-learning processes, we will notice that both are not equivalent to how we humans learn (acquire knowledge). Naturally, the results are not equivalent. What can this lead to? The answer seems to come by itself–to a different way of thinking (because thoughts are based on knowledge), and most likely action. And we want, especially the most advanced categories in AI classification, to think like us humans following (adopting) our way of learning and thinking. And, sure, to act in a way that is useful and safe for us after they have (firmly) adopted our way of thinking, knowledge, and (we hope very much) our values in life.

The natural question about this is: How this could be realized?

The answer is probably by transferring to them the already accumulated knowledge of humanity–e.g. "ready-made" knowledge in selected areas or as many areas as possible (depending on their memory capacity and purpose/applications). Of course, it shouldn't be at the same pace as we build knowledge. How would we accept a robot with AI to "go to school" (learn) for about twenty years? Most likely during this period, even at the current pace of technological development, it will be "obsolete morally" as construction, technology, and functions. And of course, we must provide them with the opportunity for self-learning and updating, so that they do not function based on "outdated" knowledge acquired based on also outdated human experience/knowledge.

This way, we can apply a focused approach in creating "human-centered" ways for AI "blended learning"–based on human knowledge

“mixed” with AI self-learning. Human knowledge (i.e. “heritage” knowledge) should be used to build a “human-centered” way of thinking in AI. It can be transferred and recorded into the AI “brain” prior they starting the self-learning process. So far, it seems, this point is omitted by the majority of AI developers as they are (quite understandably) focused on training AI by big (structured) data sets, not on (unstructured) information as we do when learning (building knowledge). AI will not be able to “understand” human needs if it does not possess human-built knowledge (and experience) as a background for comparison and understanding (the world around). Most likely, AI will develop gradually some kind of “knowledge” based on the “machine nature” of their perception and memory. I suppose this is not the major result we pursue in creating AI if we want it to be a human-like assistant/coworker to us–the humans. I would like to clarify that by referring to AI here, I mean what we name Artificial General Intelligence (AGI), and Artificial Super Intelligence (ASI) according to a recent classification of AI (there is more information about these below in the text). They still don’t exist but we “imagine” them as “self-aware” (human-like) artificial beings. Maybe those devices and systems with Artificial Narrow Intelligence (ANI) will also need any kind of “limited” human knowledge base to complete more “humanly” their interaction with human users.

Here I would like to present my (current) view, that most likely, there will be no “universal” robots created either as construction or as “intellect” (built and/or preloaded knowledge). This is not effective from both an economic and an applied (functional) point of view. It is more appropriate to create them as “specialized” robots according to the field of their designed application and relevant performance tasks, such as manufacturing, transport, healthcare, etc. robots. In this way, they will initially be

“preloaded” with knowledge corresponding to their functions and be able to communicate with people and other “smart things” e.g. Internet of Things (IoT) devices. When they need new knowledge, they will be able to “update” it over the network from any AI system that stores it. Some AI supercomputer-based systems may contain the “accumulated” knowledge of humanity, but they will have their specific limitations. About these, there is more information, further in the text of this chapter.

From the point of view of what has been said so far about the **information-knowledge-intellect/intelligence** chain, we need to look at how AI “fits” into this chain.

An AI system/”intelligent” robot cannot exist/function without:

- Built or pre-built knowledge “base” recorded in its memory banks
- Information coming to its “input” sensors (whatever these may be) to activate/animate its “intellect” (or if you prefer “intelligence”).

As humans create artificial intelligence to help and assist them in tasks when they need it, AI should “understand” human needs from a human perspective (if this is a possible task for it). So, where could this kind of understanding come from? Sure, not from “machine learning”. There is nothing “human” there, except the algorithms created by humans, but humans themselves, in general, do not learn by algorithms. I hope it becomes clear that AI will need knowledge created from a human perspective. Who can create such a knowledge base? The answer is simple– humans only.

Dear Reader, please remember what was said about such a knowledge base (knowledge hyperspace) in **Chapter 2.3**. The knowledge of

humanity accumulated on a global knowledge platform and “preloaded” into AI before it starts (machine) self-learning will help AI to build itself a behavior primarily focused on human beings and not on its own (machine) priorities. This approach should help build an AI-focused understanding of human needs from a human (not machine-only) perspective.

In **Chapter 2.2** above, it was stated that we build in our brains our personal “knowledge base” as a result of the received, processed, and stored information. It was also emphasized that without an incoming stream of information and knowledge built on it, there is no development of intellect. If these two prerequisite conditions–an uninterrupted information input and an available base of human type of knowledge are met, in one way or another, artificial intelligence can evolve and operate as required by us humans. As a next step, we must answer another important question–the question about the feedback collected from AI actions/reactions based on incoming information and the “rules” set in its (human-centered) knowledge base. I think that without a clear and satisfactory answer to this question, it would be hasty (and probably arrogant) for anyone to announce that he/she has created artificial “intelligence”. If this “intelligence” is harmful to people, it is “artificial” but not “intelligence”. Yes, in our human history, we have plenty of examples of “very intelligent” individuals causing a lot of harm to selected people and even whole nations, but we shouldn’t accept their “intelligence” as normal (standard) and try to impose such kind of harmful behavior into any AI we create. I hope this is exactly what we want to avoid creating AI.

The “feedback” concept is basic in such theories as the Systems theory and Control theory and their “mother”–the Cybernetics, created by Norbert Wiener. The feedback is an indispensable component in any closed-

loop system, which generates information necessary for the control of its behavior and facilitates its adaptation in the operating environment. Without the feedback based on our actions/reactions in our habitat, we humans would not be able to adapt (and evolve) successfully and, as a result, develop our intellect and intelligence.

There is more information on these two extremely important issues– the role of sensory input and feedback information on the adaptation of AI and intelligent autonomous robots in their operating environment in the next subsections of this chapter.

Classification of AI

There are many classifications of AI and related products in publications about AI. They are based mainly on their "built-in" software functionality (having a lot of limitations) and possible areas of applications. Such approaches are understandable because they are created primarily by the recent software developers of AI, but they also present their "professionally" limited views on the full range of future AI possibilities and applications.

The generally accepted classification scheme currently presents three main AI groups, graded by their level of "intelligence":

- Narrow AI–so far usually presented (probably for short) only as AI
- Artificial General Intelligence (AGI)–also defined as "strong" AI with supposed characteristics equal to human intelligence
- Artificial Super Intelligence (ASI) with characteristics beyond human intelligence (if such a "thing" will ever be created/self-evolved).

The first category of AI includes today an extremely wide range of devices/equipment with a wide variety of applications–from industry to home. These are usually devices with embedded computers connected to a network (usually the Internet) and installed software applications performing specific (“narrow”) AI functions. Hence their name. Their operation is based on pre-installed algorithms simulating certain human “intelligent” activities (according to the views of their developers). The types and areas of application of these devices will expand with the further development of their technological base.

The last two categories are still in the field of ideas/concepts and future visions of the experts working in this field with unclear perspectives for their realization of functions and possible time of their appearance. This “foggy” forecast about their future is masked by the idea of their possible “self-evolvement”, which experts say will lead to “technological singularity” so far defined as the superiority of AI over human intelligence. This view, in turn, provides a very fertile ground for all the opponents of AI technology to herald the advent of a modern Apocalypse–the initial deprivation of human jobs followed by the destruction of the human race by intelligent machines controlled and directed in their actions by AI. All these grim scenarios for the future of mankind and “aggressive” intelligent machines, in turn, provide a huge field for the flourishing of many (lucrative) Sci-Fi publications and movies, which in turn unreasonably fuel society's negativity towards technological innovations (in this case related to the development of AI).

Dear Reader, here I will not comment on all these, in my humble opinion, “sick” views, and publications in detail. Anyone interested in this topic can search for more information about it (mainly on the Internet) and judge for themselves how well these classification schemes and information

about AI represent the current state of AI, its possible directions of evolution, and its consequences for humanity (mainly as a user of this promising technology). Instead, here I want to present some of my views based on different approaches to classifying AI types based on their characteristics and functions in general. I hope such approaches are useful in clarifying some of the ambiguities that still exist in defining AI. They will be based on my understanding of both basic terms–human "intellect" and "intelligence", which we explained in the previous chapter, and their comparability/relations with the term "artificial intelligence". The claim that artificial intelligence is "intelligence", should prove it is equivalent in its characteristics and capabilities to human intelligence. Or it surpasses (somehow) them. If, after a precise and correct comparison, there are still discrepancies between them, for example, AI does not reach the characteristics of human intelligence, then it would be hasty (and incorrect) to declare it as "intelligence".

AI can be classified into different categories according to its characteristics, for example:

- Its design features–static, mobile/autonomous, and mixed systems (including a static "central" AI and mobile "actuators" (e.g. robots) working under its control)

- The matter from which it is made–entirely made of inanimate matter (computer systems, mechatronics), hybrid (cyborgs), or entirely made of artificial (synthetic) living matter (androids)

- Its functional capabilities–tasks required to be performed

- Level of intelligence–specialized/limited intelligence functions, equal to human intelligence and exceeding human intelligence

- Applications–with specific applications (e.g. autonomous vehicles, sex robots, etc.) and with wide (almost “universal”) applications.

Two possible groups with “hybrid” (mixed) intelligence are excluded from this classification, as they also include a “built-in” human component:

- “Augmented” human intellect by implants directly interfaced with AI

- Human clones and genetically “improved”/modified people.

Today, both (still “unusual” today) categories, their features, and possible “applications” (roles) in our society are represented in many Sci-Fi works (novels and movies) only. Of course, these presentations are mostly aimed at simple entertainment. There are still fewer in-depth scientific studies of the problems that may arise with their appearance, both for themselves and for human society.

We can only note here that both categories mentioned above have pros and cons. In the first group, the advantages can be expressed in increased intellectual and motor abilities. The benefits for the second group can range from improved body and brain functions to the elimination of risks of hereditary diseases. The disadvantages for both groups are expressed in the possibility of people being easily subordinated to someone else's “will” and managing to achieve malicious goals. By subordinating their free will, both groups can be easily “enslaved” mentally and physically. The first group may be subordinated by AI through the interface, and the second by “embedding” by birth purposeful “qualities” targeted to corresponding (harmful) behavior.

Control over the applications of such technologies to create an “augmented” human intellect and body is likely to be the subject of increased public attention and legislative efforts to stop any possible misuse of their “products”. The time for the productive realization of such technologies depends on the development of complex (super)computers, nano-, and biotechnologies. It is probably not too far in the future, but as progress in these strategic areas has so far been classified by many governments around the world, information on their real achievements is either too scarce or heavily manipulated.

Here I want to express my personal opinion that probably the biggest threat to humanity, as competitors for the same life resources we humans use today, may come from the androids–biosynthetic/artificial “super” people, not from the intelligent “mechanical” robots (widely used as a “scarecrow” to the general public today). Note that both groups will most likely be created by us humans (again). The question is with what goals/intentions? However, I will focus on this topic in more detail in the next chapter.

When classifying AI, let's not forget their main “dividing line” with us humans, and this is their “material base” (the matter that contains and “generates” their intellect/intelligence), and hence their purpose (the purpose for which and whom they “serve”).

So let's start with the “material base” of AI. According to this approach, it is likely that the creatures (beings) with AI that humanity has created so far and will create in the future, according to our needs (this activity is unlikely to be just a “hobby”) and the capabilities of the existing technologies, can be classified into three main (conditional) groups:

- Mechanical (IT-based and mechatronics products made of non-living/inanimate matter)–this group includes “pure” computer systems with installed AI (software) and “intelligent” mechanical robots controlled also by computer devices. Their “brainpower”, probably will increase with the development of new “photonic” computer components (instead of “positronic”, the term introduced by Isaac Asimov).

- Biosynthetic (made of artificial living matter product of biochemical technologies and bio-engineering)–this includes biosynthetic “creatures” such as androids, human clones, and genetically “improved” people (let's add all of these to this category because they will also be a product of bio-engineering or its variants).

- Mixed (made of inanimate/non-living, and artificial living matter)–such as human brain implants, cyborgs, etc. new creations (probably still to come).

Over time, new AI groups may appear (be created), which will be products of new materials and technologies (for example, based on nanotechnology, “liquid” metals, and the like). More information on such “creatures” and their possible characteristics and applications can be found in the next chapter devoted to the evolution of AI and their possible areas of application.

The next approach to the classification of AI is based on two characteristics that are the basis of any “structure”/system–form (design) and function (purpose). They will serve us as a basis for the classification below.

We (humans) can define ourselves as an autonomous dynamic biologically based self-evolving system. Our autonomy (independence)

allows us to move freely in our natural habitat and change/reconstruct it (within certain limits) according to our needs. To expand our autonomy, we use our dynamics (our ability to develop ourselves) and we can create various artificial (technical) means by applying our intellect.

Unfortunately, in our case, the relationship between design and function (goals) is not clearly defined by our "Mother Nature". We self-define our main tasks/functions as survival (in the general sense of the term) both as individuals (through the consumption of matter and energy from the living environment), and as species (through reproduction). The purpose of this function defined in this way does not answer one of our main philosophical questions "**The Meaning of Life**" (of course, not in the context presented by the British comedy troupe Monty Python), but we (as humanity) continue to seek answers to this "ultimate question". We hope AI may help us find it.

Unlike us, AI is a product of intentional design (something like a "divine" origin in which we play the role of creators), but for now with predetermined functions and tasks (again by us–its creators).

According to the design (construction), AI currently has three variants (groups) of implementation:

- Static (fixed) systems with installed AI software–built on computers/supercomputers or a network of supercomputers with pre-installed (embedded) especially developed software with AI functionality.

- Mobile (autonomous) devices/equipment also with preinstalled AI software–for now, we usually imagine them as "smart" mobile robots with different designs/shapes and applications (both for industrial and home applications).

- Mixed systems–include “central” supercomputer(s) with pre-installed AI software or networks of supercomputers and a variety of stand-alone devices with AI (most likely robots with any degree of intelligence depending on their applications). The version will probably be the most common in terms of its design and functionality, as it will combine the functionality of both above.

We should notice here that when we talk about supercomputers as a hardware basis of AI, we must keep in mind their performance, not their size. Following the technological trends for the constant reduction of the size of computers, we can expect supercomputers to appear soon, which easily fit into the “heads” of mobile intelligent devices (robots with different designs). In terms of supercomputer networks, the rapid development of communication technologies will provide them with the necessary speed to communicate/exchange data and information. From a technological point of view, the hardware and software for building AI are evolving at a rapid pace and will serve as the “hard and soft” basis for its further “evolution” soon. Then, things may change–the biosynthetic technology may prevail and replace “machine/hardware” AI.

The functions of all three groups above are (pre) determined by their design and the goals set by their developers. For now, they are in the group of so-called “narrow” AI and are usually fixed to some degree. But what are the advantages and disadvantages (functional limitations) of the three groups? They follow from their design features compared to their possible main purpose (functions).

The static systems have the so-called “mind-body problem”. They are usually equipped with specific types of sensors for input information, as

they lack the degree of mechanical (autonomous) self-movements. This affects their ability to receive immediate feedback ("gained experience") from self-performed movements due to their built-in limitations by design. These limitations in the flow of incoming information also limit their opportunities for intellectual "self-development". They operate in a limited environment (space) that limits their intellectual "growth" We may compare them to a person who is "bedridden". Such individuals usually receive information about the world around them from other people who serve them, but the latest can provide them with filtered (selected) information. This approach naturally limits the spectrum (breadth) of their intellectual development. They are dependent on the "intellect/intelligence" of other people. From this point of view, it is not clear how even a powerful supercomputer, for example with AI software installed, could "self-develop" superintelligence beyond that of a human free to move where, when, and how he/she wants. The idea of a supercomputer becoming superintelligent only because it is highly productive in computational and logical operations, but with limited sensory perceptions and interaction with its "habitat", has a large "discrepancy" due to disregard for the role of feedback in the development of intelligence. I guess such views about static supercomputers getting "superintelligent" need to be corrected accordingly.

Here, I would like to propose one more AI classification scheme according to its specific properties such as the degree of "freedom" of motions (possibilities to change location) and actions (possibilities to complete mechanical operations):

1. **Static AI** (e.g. AI "installed" in static computer systems or computer networks):

- Changing location is not possible (without any "outside help")

- Mechanical operations should be completed by a human operator or any kind of actuator (e.g. machines, robots, vehicles, etc. devices/equipment)

- Communication is possible with humans via computer-human interfaces (CHI) and with other AIs via direct wired or wireless networks.

2. **Semi-autonomous AI** (e.g. “smart” mobile robots operating in an environment controlled by a central computer controlled by AI, a scheme typical for intelligent robotic process automation–RPA):

- Changing location is possible in a limited (predetermined) area/space

- Mechanical operations (actions) are performed by human operators or directly controlled intelligent devices (e.g. robots) limited by their functionality

- Communication is bidirectional via computer-human interfaces (CHI) or directly (via wireless networks) with other AIs (these may be “located” in a central computer (controller) or any other smart co-working devices/equipment (e.g. robots, manufacturing machines, etc.)

3. **Mobile AI** (e.g. completely autonomous AI systems–robots, cars, etc. “smart” mobile devices):

- Changing location is possible in a range controlled by AI and limited by the capacity of their (onboard) power source

- Mechanical operations are based on the built-in functionality controlled by AI

- Communication with humans via visual and/or speech interfaces; with other AI systems/devices via direct wireless networks.

This group may also include completely autonomous androids– artificial beings made from a flesh-like biosynthetic material resembling humans (still existing just as ideas).

The mobile and completely autonomous intelligent devices (for now we usually imagine them as robots with various designs and functions), which according to their design must have freedom of movement and be able to self-develop their intelligence to the degree of “superintelligence”, must meet three mandatory requirements:

- To have a full set of sensors equivalent to the spectrum, dynamics, and sensitivity of humans or even exceeding them
- To have a “brain” with characteristics similar to the human brain
- To have a built-in source of energy to power all their systems (it should be as inexhaustible as possible or of very large capacity).

Let's now focus on robots, as they are usually presented to us by science, technology developers, and especially Sci-Fi authors as our biggest threat as a result of self-evolved autonomous super AIs. Usually, Sci-Fi depicts robots in humanoid-like shapes. But why the intelligent robots (in general just mobile computerized devices) should be humanoid-like? Most likely, their design (shape) will be predetermined by their function. But we continue thinking of them as “smart” (although they are mechanical) creatures closely resembling our appearance. “Mechanical” defines them as constructed and produced from inanimate matter with functions set by their designers and manufacturers. Nevertheless, we imagine them as mobile, autonomously functioning intelligent “creatures”. Those are “gifted” by us (their creators) with intelligence depending on the level of their initially built-in (according to the design) functional characteristics. Subsequently, they may independently self-developed a higher level of intelligence, thanks to

their built-in functions for self-learning and adaptation to the changing conditions of the environment in which they are designed to operate. Today, many non-fiction ("serious") publications on the topic of AI try to convince us that a "super" AI will have "intellectual" capabilities exceeding even those depicted in many Sci-Fi publications. Probably, it is no coincidence, why sometimes they say that science is "wilder" than fantasy.

Let's now pay attention to some basic characteristics of the "intelligent" robots to assess what qualities they must have to become "super-intelligent" (eventually). Here are some mandatory design features of such robots:

- Body–autonomous "intelligent" robots must have a "body" with shapes well adapted to their functions. It must guarantee their "intelligent" movements and reactions. It must house all their functional systems, as well as protect them from any harmful external conditions. If they lack such shapes (design) and functions they may fail in the task of becoming "superintelligent" as the shape predetermines the functions.

- Sensor system–it must include a complete set of sensors corresponding to the external conditions for their successful operation and the construction specifics of the robots' "body". At present, artificial sensors have been developed, which by their characteristics exceed the range of the spectrum, sensitivity, and dynamics of human ones.

- Electronic "brain"–a central information processing unit (at this stage of technology development, most likely made of microprocessor chips). It needs to be compact, reliable, withstand harsh operating conditions (temperature, humidity, vibration, shocks, dust, etc.), and have a large memory and high processing performance. The common component of all those artificial intelligence systems soon may be new "brain-like" designed

computer devices (still at the initial stage of their development). Maybe quantum and photonic computers will replace today's technology, depending on the advances in computer technology, but most likely, the "positronic brain" (a Sci-Fi term introduced by Isaac Asimov) is still far in the future (if it will ever be invented and developed).

- Preloaded AI-capable software and easy access to its regular updates–this most probably will be done via supercomputer networks with wired or wireless connection and access.

- Power source(s)–easily accessible power grid or stand-alone sources, such as fast-recharging high-capacity batteries or built-in miniature powerful and long-lasting power sources (no such devices have been created yet). The technology should also solve the problem with a long-lasting power source for all autonomous AI devices/equipment.

The functions (hence the application) of autonomous robots will depend on their original design. As we said above in the text, the function, and the form are related. In robots, as artificially created products (until they begin to "reproduce" themselves), their function (purpose) will determine their shape (design). It is unlikely that there will be "universal" robots able to perform all the operations we would assign them. This will not be economically viable. Most likely, their "specialization" will to some extent repeat the professional specialization adopted by us humans. This is the main purpose for which we are creating them now – to help us in the implementation of certain activities or even to replace us. It is unlikely that a robot designed to be a "universal" soldier, for example, will be able to successfully perform the functions of a babysitter robot (no matter how "super-intelligent" it could be). Its intelligence will be limited within its pre-designed functions and targeted area of applications. Concerning the

characteristic of “universality”, we humans will continue to have advantages over robots. But one of the obvious advantages of autonomous robots will be their mobility (probably exceeding our speed and accuracy of movements) and the ability to work in environments harmful and dangerous to human health.

The disadvantages of autonomous robots include such characteristics as their rapid technology “aging”, as a consequence of constant design and production of new, more advanced models, which is typical for all products of modern technology. The next one will be their “limited ability” to adapt/blend to the human social environment (due to its “machine” origin and look. Their difference in the “mental” perception of the surrounding world compared to us humans (by birth “gifted” with emotions) and some other qualities arising from their “nature” which is (by birth) radically different from ours. But most likely they will soon be an “indispensable” component (as assistants to humans) in a society of “blended” intelligence comprising human intelligence and various kinds of artificial ones. If we want to live in “harmony” with them, we will have to get used to and accept their advantages and limitations compared to ours.

To avoid all the disadvantages of both types of AI systems described above (static and mobile autonomous), the mixed systems consisting of supercomputers powered by AI and “intelligent” autonomous robots are likely to be created as the major type of AI systems used in practice. Taken together, supercomputers will serve as “central” artificial intelligence control devices and robots as “smart” mobile stand-alone actuators, but with intelligence limited to their specific functions. The two components working together will build mixed intelligence (actually intelligent) systems. The total “intelligence” of such a system can generally be defined as the sum of the

intelligence of all devices included in the system (excluding the areas where they “overlap”).

The autonomous intelligent robots (and the other intelligent devices connected to that network) will be in constant communication with the central intelligent device (acting as a controller and “supervisor"), which will set them tasks, control their execution, and, if necessary, “update” their software. Autonomous robots and devices, in addition to performing their assigned tasks, will provide constant feedback information to the central computer powered by AI. Such a structure will be able to cover a wide range of functionality. This type of intelligent system is likely to have the fewest drawbacks, as the various designs and functions of all the included devices will be complemented, and if needed replace those that are malfunctioning for any reason.

However, whether such a complex system will be able to develop superintelligence on its own is still in the realm of conjecture. As mentioned above in the previous chapter, intelligence is not just the result of the speed of processing information and the amount of memory. It requires many other components that are not currently present in computer programs (algorithms) and most probably in any foreseeable future.

The creation of such mixed systems for “intelligent” automation is the main current trend in the automation of the modern industry and will determine its further developments in a relatively long period following the future advancement of AI technology. But we must immediately be aware that the “intelligence” of such complex and advanced systems will always be limited to their predesigned form (structure) and functional purposes/tasks.

Concerning our fears and the “scary” scenarios about the future role of AI in our society, we can hardly imagine and expect “intelligent” supercomputers and robots to go on strike asking for a reduced working day, to get an increase in their wages and bonuses (if they get such “compensation” for their services), demanding a sooner “retirement”, or “arguing” when replaced by new more advanced models. Or intentionally start producing defective or harmful products thus “pushing” their “employers” to give them more bonuses, shares, etc. In any case, their tasks in such systems will be to create goods and services of a given (expected) quality (without any deviations from it). Most likely they will perform all their task correctly while they are in good (technical) condition. Any faulty equipment (no matter whether intelligent or not) can cause production waste and damage to humans, but this is still happening every day now, e.g. in case we are using faulty vehicles/cars.

Here is another classification of AI according to its design, implementation, and possible major application areas:

- **Computer-based AI systems**–AI functional software “residing” in supercomputers or supercomputer networks. Their application areas will offer “extendable” computer resources and processing power (via cloud technology) and fast communication including Wi-Fi for controlling other AI-powered mobile/autonomous devices functioning as their “extensions” (actuators).

- **Robotic AI**–machine-like “devices/equipment” in various shapes (constructions) depending on their specific application areas. These may be static or autonomously moving, designed and produced by humans or (in the future) by other robots (“*Oh my goodness! Shut me down. Machines building machines. How perverse.*”–a C-3PO quote from the *Star Wars* movies by

George Lucas). They will be able to complete regular software and knowledge "updates" via Wi-Fi communication with static supercomputer AIs.

- **Humanoid robots**–examples: sex robots, healthcare, home assistants, etc. having human-like shapes and looks (to be more easily accepted by humans).

- **Android AI**–human-like biosynthetic autonomous "creatures" designed and produced in bioproduction facilities by humans and/or other androids. Initially, they may not be permitted (by humans) to "reproduce" themselves, but in the long term, they may be "granted" such a "freedom" or they may start "reproducing" themselves (secretly) without human permission (an idea introduced by Clifford D. Simak in his novel *Time and Again*).

- **Cyborgs**–a separate "intelligent" group combining human and machine intelligence and body "parts" (implants, prostheses, and other mechanical and/or electronic components/devices).

Human clones, popular with some Sci-Fi movies and books, do not fall into this classification, because if such "enhanced" humans are created, they will just be "improved" bio-copies of the human "originals" based on their genetic material. We know about some animal clones, such as the first clone, Dolly the sheep (in Scotland, UK in 1996), and the first Snoopy dog clone (in South Korea in 2005). It is expected that if these technologies are allowed for human cloning, the "copies" (clones) will be identical to the "original" if no genetic engineering techniques are applied accordingly to "improve" their traits (e.g. for removing some inherited diseases by applying specific bio-engineering techniques). The future will prove whether the clones have a future as members of our ("original/naturally born") human

society or not. But they (in my view) shouldn't be a part of any AI classification schemes despite the clones may be genetically manipulated/designed to reach a higher level of intelligence compared to the not genetically manipulated humans.

The common classification scheme of AI, widely used by technology experts today, defines the technology into three hierarchical groups set by comparing their "level" of intelligence:

- "Narrow" Artificial Intelligence (NAI),
- Artificial General Intelligence (AGI), and
- Artificial Superintelligence (ASI).

Here are some details in brief about this classification scheme:

NAI systems are designed for specific (narrow) application areas. We may call those intelligent "expert" systems. ANI may be separate systems/devices or connected in networks. Sometimes they may exceed human experts in speed and quantity of processed information/data. But in general (as I mentioned above in the text) it is too "hasty" to call them AI.

An AGI system (also often called "strong" AI) may be stand-alone or comprise/combine many ANI systems and devices active in operation. Those ANI systems and devices will interact (exchange data and information) in a communication network. ANI may serve humans as an "I know everything" expert consulting system. It is widely believed that the AGI system will have intelligence equal to human intelligence. But considering what was said in the previous chapter about the possible types of human intelligence, it is not clear exactly what kind/level of intelligence an AGI will have, or some of them. If it comprises complete human intelligence (which I still believe isn't possible by computer-based AIs) it may be ready to go to the next level category.

ASI may be a “self-evolved” next level of AGI by self-learning and development. By definition “super” here means that it may exceed human intelligence (probably in some areas as it is practically impossible to be “super” in all human areas of knowledge and “personal” experience). The level of this superintelligence will depend on the knowledge base it is operating with. The wider the knowledge base is the higher may be the level of that “self-developed” superintelligence. ASI may assist/guide humans in research and development activities and some creative tasks.

ANI and ASI will also include a multitude of networking autonomous devices serving them as mobile sensors and actuators. Otherwise, their practical experience will be limited hence no general or super abilities (intelligence) could be reached.

Since the characteristics of these three categories are described in many publications, I will not focus on them in detail here. I will only remind the dear Reader that the last two categories (AGI and ASI) are “hypothetical” and it is not clear when or even at all they will appear in the form in which AI developers describe them in their presentations and publications today.

Let's now look at AI in terms of its possible applications.

In the “age” of AI, each category of AI described above will have its specific areas of application, where their advantages will be most competitive. Let's now try to predict the possible areas of useful applications for the human society of the above categories of AI. For the “negative” consequences of their “adoption” and “penetration” into our society, an abundance of science fiction (and not so “scientific”) publications and movies have been created, each one of which “competes” to “depict” as “impressive” as possible various versions of the Apocalypse foretold in the

Bible. I could hardly be able to add anything to them, so below I will focus on the positive aspects of AI for human society.

Static AI systems (in which AI-capable software is installed in supercomputers or computer networks) are likely to have the greatest impact on society in the following areas:

- **Knowledge transfer** (dear Reader, please remember what was said in **Chapter 2.3** on this topic)–such systems will increase the efficiency of the process of acquiring knowledge from their users. These systems will help both individual and group users (in any kind of organization) to determine the areas of knowledge and their best sources and "routes" for acquisition, at the right time when they need this kind of knowledge and in a way compatible with their style. Of self-learning/education (acquisition of knowledge).

- Their results will be constantly monitored by 24/7 active **AI-powered personal assistants**. These "personal" (AI software) assistants will advise users which knowledge "gaps" they must fill in and which omissions and errors to correct. This way, each user will acquire their own "personal e-tutor/instructor" devoted to advising and guiding them in the process of self-guided knowledge transfer and acquisition. This approach will democratize education and expand the possibility for everyone to create their preferred system for (self) education using published information (knowledge) in areas in demand. Dear Reader, please remember the "Do-It-Yourself" (DIY) department stores, but this "knowledge on-demand store" will be online, open 24 hours a day, and offering knowledge in all areas published by verified and accredited experts. Such DIY education online platforms will offer 24/7 access to knowledge on-demand and will boost the development of the so-called gig economy of self-employed experts. The knowledge

“seekers” will be able at any time, if necessary, to “refresh” or expand their knowledge on selected topics. Business studies and forecasts suggest that this kind of self-employment and remote working will be prevalent in the AI age, where people's creative abilities will be in high demand and more competitive with those of AI.

- **Collaboration** between people and AI in a variety of creative design and business tasks and applications.

- **Management** of complex systems involving people and autonomous devices controlled by AI, in environments in which AI will have an advantage over people.

Many new areas of effective application of artificial intelligence are likely to emerge, where it will prove its advantages over traditional approaches and methods.

Natural (Human) Intelligence vs. Artificial Intelligence

Some authors prize intelligence as the most valuable component in the universe. Maybe, the evolving universe creates the fifth “element”– intelligence, adding it to the four classical elements (water, earth, fire, and air) making up the whole universe (dear Reader, please refer to the ancient and medieval cosmology ideas about the universe’s structure). Today, science defines those four “elements” as energy, matter, space, and time (space-time). The non-living matter creates (produces) the living matter, which itself creates “natural” intelligence. And for any (still unknown) reason the natural intelligence wants to “extend” itself by trying to create an artificial one. Will it succeed in its attempt? Humanity will probably witness it one day. But in my view, it is still too early to voice such a statement. Here I mean a “real” artificial intelligence and not those computer algorithms (no

matter how sophisticated and “smart”) created and presented loudly to us by many IT teams today as AI.

There are many questions about which of the two types of intelligence–human or artificial–will dominate (be “more intelligent”) when artificial intelligence “grows up” to the point where it may start to compete with human intelligence.

Let's now try to make a comparison between both based on their main characteristics (properties) and functions. These are:

1. Matter that builds them–here the difference between them is more than clear. Human intelligence is based on the functioning of living matter, and artificial (so far) only on the inanimate (non-living) matter.

It is natural that in certain environments and conditions (harmful to humans) artificial intelligence has an advantage. But this advantage will not be due so much to the intellect/intelligence itself as such but to the material base that builds it and “hosts” it.

For humans, a question/problem arises here–the “mind-body” problem. It questions the relations built between the (immaterial) mind and the (material) body. Philosophy as a science has not yet answered this question clearly and unambiguously. But we know (roughly) from the practice that the mind works to protect and keep the body alive. Otherwise, if there isn’t a body, there will be no mind. So, who is the “boss” in this relation? It is a question very similar to the “chicken-egg” question/paradox.

Intelligent robots and AI will probably not have that mind-body problem, because they most probably will not perceive that wide spectrum of incoming information as we do thanks to our sensory systems and

responses to it. They (especially the static AI systems) will have sensors "tailored" to their primary applications, hence their limited ability to respond to all the changes in the operating environment (as the mind-body problem determines the relations of mind-body interactions based on incoming sensory information). If the sensory spectrum is limited, so will the interactions, hence (probably) the self-development abilities of intelligence will be limited.

2. Goals and functions–in this category, we know that the ultimate goal of human intelligence is survival and adaptation. The goals of artificial intelligence (set by its creators–humans) are to perform certain activities (work) and complete predefined tasks set by humans. So, by design, "free will" and "freedom of choice" may not be permitted by AI.

We know what the basic goals and functional capabilities of humans as biological beings are. We try to enrich (expand) them through knowledge and technology (part of which is AI).

About AI we should split that question into two questions:

1. "What is the aim (meaning) of AI life?" and
2. "What AI can (could) do and what it cannot?".

The answer to the first question is: "To serve and protect humans". Otherwise, why would we create (and produce) AI and robots? Here, dear Reader, you may also refer to the "*Three Laws of Robotics*" defined by Isaac Asimov in his *Robot* series.

As for the second question, the spectrum of their "can" and "cannot" is so wide, so, I don't think we should discuss it in detail here. In general, their abilities and limits will depend on us (again). Those will be given to

them by “birth” (design). Sure, adaptation and “self-improvement” will work for them too, but most probably in the framework (limitations) of their initial application.

As we know, the functionality of any system depends on its structure (design). Let’s now focus on it and compare the functional subsystems (“modules”) involved in creating (“producing”) human and artificial intelligence.

There are three main subsystems in humans responsible for producing and demonstrating our intelligence:

- The human sensory system–includes all senses (organs) and sensory channels responsible for perceiving, preprocessing, and transmitting incoming stimuli/information to the human brain. Their main characteristics include a wide spectrum of perceived signals (the bandwidth), their dynamics, and their sensitivity. If these are not enough, humans “augment” them by technology (e.g. microscopes, telescopes, etc. “tools”). The sensory system “opens” the brain (serves as a “gateway”) to the human habitat–natural and social (and the universe as a whole).

- The human nervous system–the central component of it is the brain. It contains the memory. The central cognitive function of the brain is information processing, storing it as memories, building knowledge, and producing intellect and intelligence. The human brain is the most complex organic matter structure in the known (to us so far) universe, but this may change with the new developments in computer technology or deep space exploration.

- The human locomotor system (human musculoskeletal system)–“exhibits” our responses to the perceived and processed stimuli/information.

Includes gestures, movements, voice, etc. actions/reactions of the human body.

The reciprocal subsystems (modules) of AI include:

- Specialized sensory systems–their type and characteristics depend on the pre-selected AI application areas and goals/tasks.

- Computer (or supercomputer) device forming the AI "brain". There may be installed a single unit or multiple ones. The specific characteristics of those are their size, memory capacity, processing power, power supply, etc. computer-related features. So far no one (man-made) computer has a memory capacity larger than the human brain, but all other (computational) characteristics surpass it. If humanity manages to design a computer memory larger in capacity than the human brain, then AI may get a brain with overall characteristics surpassing those of the human brain. A computer with such characteristics may become the hardware basis on which AI may (hypothetically) self-evolve into "super" intelligence. But the other "soft" (immaterial) component–the required computer software, most probably, will never "self-produce" such functionality as the human mind. We have already discussed this topic and why it will never happen "the human way". So, any comparison here is irrelevant. Sometimes, we tend to compare human and animal intelligence (especially of our pets), but we never do it on a firm scientific background (mostly emotional), despite both (humans and animals) being based on organic matter. We have too many different aims in life that shape (form) our intelligence and behavior.

- Output system(s)–producing AI "outcomes". These may include direct machine-to-machine communication (codes), machine-to-human interfaces (visual, voice), mechanical movements, change of position/location, etc. actuators "assisting" AI in these tasks.

Usually, the functionality of artificial intelligence includes:

- Information perceiving and processing–it is faster than in humans, but still based on predefined "man-made" algorithms, such as pattern recognition, machine logic, machine learning, deep learning, etc.

- Communication–using faster and wider broadband channels, including wireless networks. May produce voice, visuals ("synthetic/digital" images, writings/text, and animation–2D and/or 3D), and direct codes, but (so far) no "natural" human gestures and "facial" expressions.

- Outputs/results–it may exhibit human-like actions/behavior and change its position in space (valid for autonomous mobile robots).

- Solving tasks requiring intellect (based on "pure" logic and reasoning), such as calculations, sorting, pattern recognition, decision-making, etc. In completing such tasks, AI and robots may be even more precise and efficient than humans.

In general, AI (even the "narrow" one) will be able to imitate human behavior and communication. It may also complete specific tasks (for which it was designed) better than humans. But the "strong" AI and smart robot intelligence will never match the human one, as it will have no emotions (included) and emotion-based responses and phenomena, such as creativity, imagination, compassion, and other human aptitudes based on emotions and feelings. These will always be human "areas" of behavior.

Will AI or robots ever be able to distinguish the elusive difference of meaning in such human terms as "murder, homicide, kill, or terminating a life", despite their (probably) "quantum" or even "positronic" brains in the future (the fictional term introduced by Isaac Asimov in his *Robot* series)? Or between the words "ape" and "monkey" (addressing the librarian at the *Unseen University*) used by Terry Pratchett in his *Discworld* series? I suppose

they will never reach such a level of “refined” human intelligence. And the core reasons for this are obvious–lack of emotions and feelings by design (and purpose).

The previous chapter already presented the current view of what “human intelligence” is (according to modern research). It is possible that as a result of ongoing research, this view will change. But let us stick to it for the time being as a basis for our further reflections on the subject of this chapter.

Generally speaking (and I would like to join this view), human intelligence is intellect (cognition and reasoning abilities) plus added emotions (feelings) thus building links between rational and emotional human mind activities and correlated behavior. It is clear from this definition that such abilities as creativity, innovation, and invention are core characteristics of human intelligence and are highly praised in society. They bring new and better ideas, products (objects), and services (processes) to society. All of those are targeted to and designed for human needs and well-being (i.e. these are always human-centered).

But here a question arises: Will ever be AI and robots able to feel and understand human needs (from a human point of view) and create goods and services that meet (exactly) those needs? Most likely, AI will assist humans (collaborate with them) in designing such products and services rather than creating such by itself. And robots will help humans in the production of those goods. So, there will be a process of collaboration between both kinds of intelligence–natural (human) and artificial ones, but we shouldn’t expect new kinds of goods and services designed entirely by

AI/robots and fitting perfectly all levels of our hierarchy (pyramid) of needs (introduced by Abraham Maslow).

But comparing human and artificial/machine intellect (reasoning abilities) we have to accept that in most areas we are not fully competitive with AI. Very often, human reactions to events and information do not follow the (simple) logic. Humans are not at all times logical. The human brain is not a calculator or a computer. It does not compute (despite that many IT guys think it does). The AI's "brains", combining computers, algorithms, and software, are designed exclusively to compute and apply logic in the process. So, they will always be more productive in computation and logic deriving "meaning" of sets of "big" data and information in less time than we can do it. This is the reason we design computers and now "embed" AI in these.

Probably that is why we fear so much of a possible artificial "superintellect" (mistakenly pronounced as "superintelligence"). We fear that it will "outsmart" us in logic and reasoning. So, we should look for our competitiveness and advantages in the "intelligence" areas, such as creativity, imagination, inspiration, expression, etc. emotionally "ignited" activities, where our feelings help us work better than AI. Preparing for the "AI age" we need a "skill shift" into more creative (leading to innovations) professional areas.

Let's now try to find the answer to the "ultimate" question: Is AI really "intelligence" (compared to human intelligence)?

To do this, let's consider AI as a "black box" (dear Reader, please remember the Systems theory). Our brain is an information processing system that acts as a (bio-hardware) "controller" to our mind and body based on the information it processes. And it "produces" also our

intelligence in different grades in each individual. Those grades depend on the personal knowledge acquired, skills mastered, and some specific mental abilities.

Following this logic, AI should perform the same functions and produce results as the human brain to be called “true intelligence”. If it “overperforms” human mental abilities, it can be referred to as “superintelligence”. So, to clarify this, let’s try to find the answers to the following questions:

What’s on the input and output (in and out) of artificial intelligence?

What is “driving” AI (the motivation and aim)?

What makes it function?

What are the AI outcomes (reactions to stimuli)?

Does AI “understand” its “personal” (built) knowledge?

Usually, the black box is not completely “black”. In a computer system, it is usually computer hardware with preinstalled software applications (codes, algorithms, models, rules, etc.) all of those created (so far) by humans. The AI/robot's functioning and adaptability will always be limited by those initially preset rules and aims integrated into its computer-“brain” consisting of hardware and software components.

The AI input receives information and/or data only. It may enter via any kind of artificial sensory input devices, users’ human-machine interface devices, or directly via network connections (wired or wireless). The input stimuli animate the AI (force it to respond/function). This information/data may present anything generated by physical, chemical, or mental processes.

The AI output is also information/data in the form related to its application. In the case of intelligent robots, it may be also any kind of feedback information generated by the sensors integrated into its actuators, responding to the change of position, speed of movements, and any other mechanical operations related to the completion of received commands.

So, we can see, concerning its input-output, AI is still that well-known information processing and (re)acting "machine". Just like us the humans. Here we match each other. But the actions executed in both black boxes–the human and the AI brains, are quite different. In the human brain, these are run by signals (combinations of biochemical and bioelectrical signals) and "immaterial" thoughts. In the AI brain, we still have pure electrical (and in some cases optical) signals only.

And here, dear Reader, I would also like to focus your attention on a quote by the Ancient Greek philosopher Plato (considered the "father" of Western philosophy): "A good decision is based on knowledge and not on numbers." We may suppose, he has had no idea about AI in his lifetime. It is obvious, that he refers to human knowledge (and probably understanding and wisdom). We know, we humans don't build our knowledge by numbers. But AI builds it exactly by numbers – combinations of 0 and 1.

All AI's aims are preset by human design depending on their planned area of applications. Will it has any kind of motivation is not clear as motivations serve purposes and goals. Will AI "be" happy with "job well done" or ask for rewards or benefits? Or, will AI be able to "hope" that it will get better repair services if it needs them (after working very hard to deserve those)? I suppose, today no AI developer will answer positively (or negatively) to such (simple) questions we ask ourselves almost every day.

AI's functioning is based on rules/algorithms (no matter how complex are they) also developed and preinstalled in their brains by humans. These may limit the adaptability of AI. Adapting to the environment (habitat) is something we (humans) also do all the time. If we cannot do it "the natural way", we do it by technologies involving our creativity. And AI is one of our creations/tools for better social adaptation (e.g. higher productivity). Will AI start (in reverse) using humans as "tools" for improving its adaptability?

AI and robots' reactions to external stimuli and resulting behavior (outcomes) are also predefined by their design, functionalities, and limitations "imposed" on them by their human creators. They may vary within some limits based on their adaptability ("self-evolvement"). Without any substantial "upgrades" they will not be able to change drastically their behavior and outcomes. But we do it all the time involving our creativity and technology (again).

Will AI be able to build a human type of knowledge (not the one based on a "pure" machine, deep or reverse learning algorithms only)? Will we be able to understand the acquired knowledge with all subtle meanings and their implications just as we do it (sometimes "unconsciously")?

And here, I will not even ask about wisdom that we could build based on our life experience and knowledge. According to my view, wisdom will not happen to AI any time soon (if this ever happens at all). Until that time, AI will probably be no match for human intelligence in all areas based on wisdom, creativity, imagination, inspiration, and the like-mind phenomena. Not having our life basis (a body built on organic matter) and the same vital aims (survival, well-being, and prosperity) such a "mental capacity" may never happen to AI.

But who knows what the future really “holds”? Dear Reader, please remember the final scene “Tears in the Rain” in the *Blade Runner* Sci-Fi movie (1982) based on Philip K. Dick's novel *Do Androids Dream of Electric Sheep?* But that movie personage (starring Rutger Hauer) was a human-like android (built by biosynthetic “flesh”), not a “machine” based AI (robot). Do you feel the difference?

Here comes another “ultimate” question–about AI and creativity.

Will AI have any creative abilities (functions)? There is no human intelligence without creativity involved. I would like to focus on this topic especially because recently, many authors publishing or presenting their views on this topic usually think that creativity is related to human artistic activities only. Probably the term “creativity” is associated in their brains with the terms “art” and “artists” only. For some reason (most probably because of ignorance) they forget that any engineering design task requires creativity too. The initial meaning in French of the term “engineer” (in English) was “creator”. Then, with the proliferation of machines, this meaning was “shifted” to technology mainly (e.g. engine–“engineer”). Thus the creative part of the engineering jobs was “forgotten” by people who probably never completed any engineering design tasks. But the engineers who design new products and services do exactly this–they create new products, services, and technologies for humans and their production facilities. They do this by designing those following all the human-centered ergonomic and functional requirements to create value for the human as consumers. The design of all products and services must be human-centered. If it doesn’t meet the ergonomic, functional, and aesthetic requirements of humans, those products and services will have no customer, thus market value.

Many recent publications about AI and creativity try to “scare” us stating that AI will “take” not only all the “monotonous” jobs but also will “kill” the designers’ (creative) jobs too. This is the usual approach by technophobes (or ignorant people) to anything new in technology. So the correct question here is: Will AI be ever able to create new human-centered products and services meeting ever-growing human demands and frequently changing aesthetic values? And my clear answer is: No, they will not be able to do such tasks. Who can feel the human needs/demands better than humans themselves?

Here is my view about why this will not happen. Remember what was already said above in the text about the synthetic nature (matter) building the AI “bodies” (some of those will be even “bodiless”–just software residing in computer systems). And because of this, they will have different goals (and purposes) in their “artificial life”. By design, AI may be superior to humans in some application areas such as data and information processing, reasoning, logical analysis, etc. tasks based mostly on algorithms and calculations. But they will not be able to master a real human-centered approach to all life forms including us. They will not be able to “feel” the things in life as we (and all other life forms) do. I do not expect they will be able to understand what we feel when we see somebody “smiling in his eyes” only. Sometimes, in such cases, our inspiration and hopes are born.

So, if AI and “smart” robots self-develop (somehow) any kind of “artificial creativity”, it will not be like ours and will not match our creativity precisely targeted at human-centered applications and aesthetic needs.

So, let’s continue thinking about AI and robots as very valuable assistants (or if you wish–coworkers) to human designers taking mostly the

repetitive and calculation parts of the complete work. “Pure” design (creative) tasks will be completed by humans “freed” from the boring part of the job. That is what we hope–“tomorrow” the robots will do all the (hard and dirty) work.

And what could we say also about AI and imagination? The “prophets” preaching “AI is coming!” completely forget about this basic component of our human creativity. We all know that imagination is a substantial component of any creative process. Without imagination, all our creations lack innovation and attractiveness. Such products become just one more mainstream “novelty”. But the top human-centered products and services are created by imagination and inspiration.

I would wish very much to meet an AI (robot) having imagination, but I do not expect this will happen at all (sooner or later). Why this could not happen – dear Reader, please refer to the above in the text. We still do not know how imagination is generated by our brains. And most probably will never know. So, we are not able to create “imaginative” algorithms and “implant” those into AI. Waiting for this to happen itself by AI “evolution” is just one more self-delusion.

And how will we “ignite” creative thinking in AI? Creativity doesn’t go without thinking. After thousands of years of thinking about thinking, we humans still don’t know how thinking and thoughts appear in our brains. Or do we hope that thinking will appear “magically” by itself in AI and robot brains after they accumulate enough “big” data inside of those (super)computer brains?

Or will be AI able to generate (new/genius) ideas? (I hope there are some of those in this book.) I don't think that even we the humans ever will be able to understand how (and where) new ideas come from. So, in such a case, how can we "machine" teach AI to generate new ideas? And, dear IT guys, please do not even try to tell me that the new ideas aren't the results of the workings of our intelligence. And if an AI is missing such a trait can be "superintelligent". Or. can anyone imagine a robot running (naked) down the street and shouting "Eureka!" (as Archimedes did). I can not. And I can't imagine anyone saying that Archimedes was not intelligent enough (and not just for his time).

Here, dear Reader, please remember René Descartes' "Cogito, ergo sum" ("I think, therefore I am" translated to English). Should I ask the same question about consciousness in AI and "smart" robots? Neuroscientists, psychologists, philosophers, or any other kind of scientists (even the late physicists) still don't know how our brains produce consciousness. If somebody tells you he/she knows, just don't trust them.

So, in my view, all those who preach "AI/robots are coming" (to take our creative jobs) just lack logical and creative thinking. They just have "wild" visions and want very much to say "Hello world (here I am)!".

Most possible, AI will never be such a creative "creature" as we are. This is a skill area where we will always be more competitive compared to AI. The (human-centered) design will always be our field where we will be the leading players. But this is not a new idea. It has been voiced many times by plenty of researchers and Sci-Fi authors.

Sure, to be more creative, people need more knowledge, skills, and experience (and that "spark" we call "inspiration"). This is a major task of the "hybrid" (human and AI) intelligence society – to guarantee easy access of all individuals to the collective knowledge of humanity to ignite creativity. Dear Reader, please remember, what was said already about the global knowledge transfer in **Chapter 2.3**.

Sure, because of its "nature", AI will have some advantages compared to human intelligence. Otherwise, why should we create it? Most probably these will be in the following areas/qualities:

- Memory–reliably stored and long-term secure retention of information (no "fading" of memories/knowledge as in humans).

- Information processing speed–the electronic computer (or maybe the future quantum) brain of AI works on "pure" electric signals and doesn't need time to produce proteins for storing information in neurons (this makes the process much faster).

- Logic–it depends on algorithms created and "implanted" by humans but may also be "enhanced" (improved) by AI itself. Feelings do not "interfere" with logic, as AI is missing such "functions" (maybe for good).

- Communication–via fast human-machine (or machine-human) and direct machine-to-machine (pure coded) interfaces.

- "Native" telepathy–direct machine-to-machine communication via secured Wi-Fi networks. Such a communication mode is not possible for humans–the electromagnetic waves produced by our brains are too weak in intensity for direct human-to-human brain (wireless) communication (we call such non-verbal exchange of thoughts "telepathy").

It should be noted here that all of the above is valid, if Artificial General Intelligence (AGI), as the experts define it now, will be created in the

relatively near future. Of course, in the more distant future, when AI robots begin to design and manufacture themselves (probably), such as self-made androids from synthetic biomaterial, this estimate may be invalid. But this is an inherent shortcoming of all long-term forecasts. More information on the possible development (evolution) of AI and robots can be found in the next chapter.

No matter that a “real” (strong) AI still doesn’t exist, let’s try to compare some attributes of the “natural” (human) intelligence to the (probable) future attributes of the artificial one as we see (plan) those today.

So, how much “intelligent” could become AI (how far it can go by itself)? When will AI be able (and will it ever happen) to understand the “hidden” (or double) meaning in human words (and utterances), sarcasm, or "timid" hope (in anticipation of something good to happen), and other similar nuances in our speech? We humans (or at least some of us) can grasp almost immediately these “delicate” nuances (the “mood” in our words), but how will the IT guys be able to “model” and “embed” all those “innate” human qualities in AI?

In my opinion, it is too early to rush to answer this question. First, people need to understand how the brain works when “confronted” with the need to distinguish similar nuances in our speech. And we can't ignore them and say that they are not an essential part of our intelligence.

Despite the many predictions (and threats) that AI and intelligent robots can evolve to the level of superintelligence on their own, this cannot happen if we stick to the true meaning of the term “intelligence”. They will always, to some extent, remain “mechanical” devices with superior

computing and analytical capabilities (in certain cases), but no more intelligent than we are in the human sense of the term. If we adhere strictly to the definitions of both terms “intellect” and “intelligence” (explained above in **Chapter 3.1**), they will rather be “intelligent”, but will not have “intelligence”, in the true (human) sense of the term, because they will lack emotions, feelings and the like still not well explained human traits. By design and purpose, they will not need them, nor will anyone for now (or in the foreseeable future) be able to “implant” such into them until we humans ourselves fully understand how the brain works and (really why) produces emotions. For now, the “physical” nature of phenomena such as consciousness, emotions, and feelings, which are an essential part of the mental work of the brain and intelligence, are still in the realm of research. Despite many scientific assumptions and theories, we have yet to understand how the physics and biology (biochemistry) of the brain “produce” them. When and if this will ever happen, humanity has yet to discover. The path to their practical realization as part of artificial intelligence (if it is at all appropriate) is even longer if humanity decides to undertake such a task. The keyword here is “humanity”. It is unlikely that the technological increase in the computing power of AI will lead to the independent emergence of consciousness in its computer chips. Those who say the opposite, I suppose, cannot or do not want to go into the depths of the question of how intelligence builds/arises in our (living) brains.

Chapter 3.3: The Future: Quo Vadis?

“Quo Vadis?” is a famous phrase in Latin meaning “Where are you marching?” (usually translated in English as: “Where are you going?”). It is attributed to St. Peter and according to the legend, he asked this question to Jesus Christ, meeting him on his way during his escape from Rome to save himself from the extermination of Christians by Emperor Nero.

Today, we could successfully paraphrase it for humanity in its “meeting” with artificial intelligence on the path of the evolution of a future “blended” society that will most likely include humans and diverse “creations” and “creatures” possessing artificial intelligence. So we could specify the “modern” version of the question this way: “Where are you going, mankind on your way to (and with) AI?”

This question is a “two-way road.” It applies to both humans and AI. Of course, since (for now) the point of view is ours–the people, and the “real” AI we have not yet created, we put ourselves first and try to “adjust” all the things about AI according to our views and interests. However, this issue concerns the development of intelligence in general, both artificial and human. Many authors forget that the “expansion” of the knowledge of society as a whole and the development of technology have also contributed significantly to the development of our intelligence–both individual and cumulative in society. Whether we take advantage of the “evolution” of AI technology to develop further our intelligence depends on ourselves. If we don't, we should blame ourselves, not AI, for this missed opportunity.

Many answers to this very important question above about our common future with AI we can find in the recent “avalanche” of publications varying from Sci-Fi genre short stories, novels, movies, etc. to popular and strictly scientific articles dedicated to the topic of AI. Let’s try here to give another answer to this question, which will most likely complement them in terms of the theme of this book.

The answer to such a complex question about the future of a high-tech society cannot be unambiguous or short-defined. There will be many initial conditions and, accordingly, options, but below in the text of this chapter, we will try to imagine a future development of these main options (and some sub-options), as far as it is possible to be done at this stage of the development of the technology, as new information about new developments is published every day on this “hot” topic for our society.

The science of the evolution of living matter teaches us that intellect and correspondently intelligence have appeared and evolved in their “carriers”—living beings, as a result of their constant struggle for survival. Gradually, both have become their main “weapons” to win this “battle.” Along with the evolution of living beings, their intellect/intelligence has evolved. We, humans, believe that we are now carriers of the “ultimate” intelligence on our planet, and that is why we are most successful in this battle for survival (by exterminating usually all the rivalry). Initially, intelligence evolved “evolutionarily” (naturally) as a result of this struggle for survival, and then we intervened in the process and began to purposefully develop our intellect and intelligence. Our social life and the knowledge and experience we share in society help us accelerate this development and achieve new higher levels of individual and collective intelligence. But despite these achievements, we have come to the idea that we need an

additional “assistant” intelligence–artificial intelligence. But, why do we (really) need it? What’s behind this need?

Our main motives and the steps taken to implement this idea were already set out in the text above. We should not doubt that the development of AI will also go through different stages of “evolution” (we may call also those “generations” of AI) and it will probably reach levels comparable to our intelligence or even (possibly) surpass them. The latter possibility scares us the most in our decision to create it because perhaps by nature, we are not inclined to have near us other creatures “smarter” than us (thus to be more “competitive” as we usually don’t like any competition). It scares us, and it probably also undermines our “ego” that there may be other beings on this planet smarter (intelligent) than we are. We don't have to go too far for proves and evidence about this statement. Our human society abounds with examples where less educated people often demonstrate their dislike of the “smarts”, i.e. the more intelligent individuals.

Let's now “peek into the crystal ball” displaying the future (we simply have no other option for now) and try to “see” (predict) the possible paths and stages in the evolution of AI and its possible impact on the development of our intelligence and our society as a whole. It will differ from the evolution of our intellect/intelligence since from its beginning AI will have a “creator” (us humans), and at a specific stage of the development of technology, it could likely take responsibility for its self-development, as the most of us do in their everyday life. And what could be the consequences for the “natural” (human) intellect/intelligence because of this qualitative step in the evolution of AI? Will AI contribute to the “augmentation” of natural (human) intelligence, or will eliminate it as an “outdated” step on the path of the evolution of intelligence? The answers to these crucial questions so far

eluded us in the “fog” of our positive (wishful) and negative (denying everything new) thinking.

Let's still try to lean on our intellect (let's put aside emotions for the time being) and try as people “reasonable” (Homo sapiens) to analyze possible variants of AI evolution and the consequences of this evolution for us humans. And more importantly, try to point out approaches to creating a “human-centered” to avoid possible apocalyptic scenarios happening in our common future.

To do this, let's take a look at the “crystal globe” of scientific and technological predictions and try to imagine what kind of future awaits people and AI in a “blended” society and what we might expect in it as positives and negatives. Unfortunately, they always go hand-in-hand as any technology in our history proved to be a “double-edged” tool (knife). We will do this by focusing on the following topics in this chapter:

- Evolution of artificial intelligence (AI)
- Evolution of human intelligence
- AI and humans
- Humans and AI
- A future society of “blended” intelligence.

Evolution of Artificial Intelligence

Starting with this topic, it should be noted first that artificial intelligence (AI) cannot develop by itself, as was the case with biological life forms. Let's, for this book, exclude here any theories of the divine or “miracle” origin of life. From this point of view comes the mandatory adjective we give it–“artificial.” As a product of the purposeful activities of

humans (i.e. the living matter). AI's capabilities, limitations, and functions will initially depend on the creative (intellectual) capacity of its "creators"—the people. Over time, if AI self-develops as a "super" intelligence, it may begin to independently build its characteristics and manage its "self-evolution" (and goals in its "life"). But for now, this is just speculation by some so-called "experts", numerous not experts on the subject, and many authors of Sci-Fi publications.

Recently, on the topic of the future (evolution) of AI, there are numerous publications, since this topic is still a "hot" topic, as usually happens with everything new and intriguing in human society. They range across the broad spectrum ranging from "exalted" positive to "aggressively" negative. Positive opinions are usually the product of those who develop the relevant technologies and expect to generate (large) revenues in their market. The negative–of (not so) competent authors who, as usual, want to draw attention to themselves by relying mainly on the topic of the "catastrophic" consequences of new technologies for humanity (a well-known topic and a thesis planted in society). They have learned well the lesson, which is widely practiced by those writing in the mainstream media, that usually publications about catastrophes (of any kind) much more attract the attention of their readership than publications about a "bright" future. And they're betting on those (lucrative) approaches.

Of course, between these two extremes, numerous publications try to approach this topic in a balanced and analytical manner. As always, they reflect the views of their authors.

Below, in the text of this chapter, I want to join this category of authors with an analysis and a forecast for the future development of AI

technology (as far as it is possible to do at the time being). I hope that my analysis is professional and balanced, as I do not belong to either of the two groups of final opinions mentioned above in the text. I believe that my engineering education in industrial automation, my long practice as a researcher and developer of computer-controlled systems, and as a university lecturer in information technology (IT) has helped me to build an analytical and impartial view of the "big picture" of a future "blended" and collaborative society, which will most likely, in addition to human intelligence, will include some kind of "artificial" intelligence. In the text below, we will try to imagine what kind of "intelligence" this artificial intelligence might be of and what role we expect it to play in a society of "blended" intelligence.

Why am I writing so "conditionally" about the future of AI? I take into account the fact that despite numerous publications about "AI here, AI there" there are currently still no "real" AI products and systems in our daily lives, but only their fragments or likenesses presented to us as AI by their developers (mainly for marketing purposes). What kind of a "real" AI (and when) the experts will build is a question that we still expect to be answered (satisfactory) in the future. So far, we are still just making some predictions. As always, reality (practice) will show and prove the results.

Starting with the topic of the future (evolution) of AI, we should most likely remember the answer to the question: Why do we need AI? This question is aimed at us humans because for now we only create it–we design and produce it (according to our ideas and plans).

As mentioned already in the previous chapter, I believe that the answer to this question is very short and clear. And here it is: Because we

need it to help us in two of our main activities—in our production and daily lives. Because we assume that AI will make both better for us–production more efficient, and our personal lives more satisfied.

While AI, of any kind, is a product of human design and technology, its evolution will mainly be related to the human-planned areas of its applications. The design, of course, will follow the function (application).

We expect the development of technology, especially IT, to lead to an increase in AI's intelligence level, and so far, many authors/experts, as already mentioned in the text, have accepted to separate it into three categories/levels: artificial narrow intelligence (ANI), artificial general intelligence (AGI), and artificial super intelligence (ASI). Other classification variants may be created in the future according to the levels of intelligence (e.g. functions) reached by AI. Or maybe they just will be categorized with other names.

For now, we are at the level of developing and implementing multiple ANI systems and devices with a variety of applications, assuming that the experience gained so far will allow us to create next-level systems (conditionally called “AGI”), which we assume will be equal to or comparable to the level of human intelligence. Based on what was been said on this topic in the previous chapter, the achievement of this level of AI is highly doubtful in terms of technological feasibility (and practical necessity). Hardly anyone will need “emotional” AI systems or robots “overflowed” with emotions and feelings (excepting the “sex” robots, of course–such features should be “a must” for the brand).

We expect that the third degree in the development of AI (we call it "superintelligence") will be achieved independently through self-evolvement because of the future developments of IT (e.g. a much higher level of productivity and abilities). This is in case we decide to grant such "freedom" of action to AI and do not control the outcomes/results. We conditionally call this highest degree of development "ASI", presuming it as a possible achievement of intelligence higher than the human one. We believe that after AI reaches this level of intelligence it will lead to a behavior that we call "technological singularity". This term "translated" from professional to simple language means "uncertainty" in AI behavior towards humans. This kind of uncertainty scares us because it suggests that it may turn into aggression towards humans. So far, this is the common view of many authors and experts on this hotly debated issue. However, where does such confidence come from? Moreover, why do they believe (firmly) that AI will turn against us (its creators) the proponents of this "grim" future they do not explain clearly?

Most likely, it is based on the subconscious fear of the people of the unknown and distrust of everything new (still unknown to the society). Such negative human emotions have found their expression in our social life through the movement of the "Luddites" (at the beginning of the Industrial Revolution) and in the religious belief about the inevitable coming extermination of (sinful) humanity–the so-called Apocalypse. Nowadays, the two social phenomena/beliefs "merge" into the modern view of another catastrophe (e.g. "technological singularity") because of the (out of control) evolution of AI. Unfortunately, many experts working in the field of AI have also joined in disseminating this modern "myth", thus reinforcing it. Such "expert" opinions (and "warnings") also flood the public information space

from authors, who are usually people without a deep scientific and technological background in the field of AI. We will address this topic in more detail, further in this chapter, but for now, let's put a "big question mark" on how competent and trustworthy all these publications and statements (I hope not just deliberate (miss)information campaigns aimed at selected social groups).

When we talk about the possible evolution of AI, and probably such one will happen (driven by us or by AI itself), it is better to define a group of “realistic” criteria by which this evolution should be “measured”. We could measure this evolution, probably, by the level (stage) of development, a specific AI has achieved. These stages may be the already “generally accepted” levels–ANI, AGI, and ASI, although these terms are very general and poorly defined as mandatory characteristics. Therefore, I would like to propose here a different approach of “evaluation” (rather than by general definitions) of such evolution. It uses specific “practical” (generally accepted) groups of attributes and criteria for evaluation.

Such criteria can be:

- Design (matter and forms)–characteristics and qualities
- Functionality–the variety of performed functions
- Application areas–spectrum of possible applications
- Interaction with humans–ways of communication
- Other features–not yet known self-developed capabilities as the results of AI evolution.

Let us now try to guess what might be the possible evolution of each category and group of AI classification, mentioned above in **Chapter 3.2**.

Let's start with the basis–the matter on which the relevant AI will be designed and built. As we noted earlier, AI can be built on four main types of matter:

- Non-living matter
- Artificial (synthetic) living matter
- Combination of the above two types of matter
- It may be a combination of natural living matter, synthetic living matter, and non-living matter.

It is obvious that with the development of AI technologies and applications, new varieties of the above AI "species" may also emerge.

The "machine intelligence" category will be based on non-living matter. As mentioned above, this category includes AI systems and devices built (manufactured) from non-living matter–computer and mechatronic devices/modules. To this category, we assign computer systems and networks with AI and "intelligent" (AI-based) robots of all types. Their classification is indicated in **Chapter 3.2**. So far, only computer devices and systems, working on software algorithms and programs simulating (to some extent) specific functions of human intelligence, exist. We call such devices and systems Artificial Narrow Intelligence (ANI).

According to today's common view, ANI may self–evolve into the next (possible) levels of artificial intelligence–Artificial General Intelligence (AGI) and Artificial Super Intelligence (ASI). Possibly, AGI and ASI levels may be "reached" also by swarms of ANIs or groups of intelligent robots. A specific ("unique") property of this "next level" AI and robots is that they may master "telepathy" (a wireless communication between themself)–"natural" (by design) or self-evolved.

Will this kind of AI self-develop also consciousness? Most probably, they will not become conscious by themselves because consciousness is closely related to the "supreme" goal in life–the survival of the individuals and the species. If we manage (somehow) to "implant" into them *The Three Laws of Robotics* (Isaac Asimov's Laws) they may start "consciously" protecting themself.

The category of "bio-synthetic intelligence" is based on synthetic living matter. This category includes artificial "creatures" products of biotechnology and bioengineering, which are made of human-like synthetic living matter. I guess there's no more appropriate term for this category than "creatures". If any of the readers suggest a more appropriate term, I will accept it. To this category will be assigned human-like creatures we call today "androids". I suppose externally they will be almost indistinguishable from us (the people) unless their creators and producers obey a special law demanding to put some hallmark on them. Such creatures do not yet exist, and it is not clear whether humanity will ever be able to create them, i.e. to develop the relevant biotechnologies, and whether it will ever decide to create them (without any clear goal and need).

Probably, the androids will need their "brains" (knowledge banks) to be pre-loaded by any kind of (human) knowledge, thus avoiding many years of learning/training as we humans do.

This category is likely to include devices and "creatures", which partly include all three types of matter–living, synthetic living, and non-living. To this category, we assign such groups as people with various brain implants and cyborgs.

As mentioned above, over time, we can create new types of AI devices, systems, or “creatures.” They can also evolve into new species themselves. Future generations of people will likely witness such evolution or design.

For now, I do not knowingly include such categories of “intelligence” as genetically modified and bio-engineered humans, because according to their “material” base (living matter), they must be in the category of “natural” intelligence, but by origin, they will be people created in a “non-natural” way. Let's leave their classification to future generations who may decide to create them.

But there is no reason to fool ourselves–the future of AI (and its variants) depends on us, since for now only we create it. In time, AI can take this process into its own hands, but this will most likely not happen without our initial participation (and consent/permission).

If we try to clarify the future of AI we create, and from there, our joint future with it, a host of “related” questions are likely to emerge, such as:

- What kind/type of artificial intelligence do we create (we want to create)?
- What kind of “services” (assistance) we are planning to get from it?
- What do we (really) want/expect from it?
- What's (could be) our attitude to it?
- What kind of attitude do we (people) expect from it?

Many more such questions may follow (and will probably follow) in the course of the "evolution" of artificial intelligence and our everyday relationships with it.

It should be noted that these issues and many other resulting ones are discussed almost constantly, both by professionals and non-professionals. The purpose of these discussions is to try to "predict" (as far as it is possible) what could be the consequences for us of the entry into our daily life (and routines) of the new technologies based on artificial intelligence.

We, humans, live in what we call the "present time", but we always want to "look" into the future and understand what it "brings us". Predicting the future has always excited and intrigued us. Our main predictive tools are usually logical (if possible) analysis and prospective planning using historical facts, various types of data (information), and our personal experience. Here I exclude the use of "toolkits" such as crystal orbs and our imagination. The latter "serves" with great success to the masters of science-fiction, and we must admit that sometimes they are extremely insightful and accurate in their "predictions" for the future of humanity.

With the rapid penetration of these new technologies into our daily life, we are trying hard to "see" our future in the "Age of artificial intelligence", as we call it by the analogy of the two "ages" preceding it – the "Industrial Age" and the "Information Age". Different views are presented to us by both "experts" who are engaged in making predictions, as well as by the already mentioned masters of science-fiction. These views range across the whole spectrum, ranging from utopias representing a "harmonious" coexistence of humans with artificial intelligence "creatures" to anti-utopian

nightmares in which the same creatures persecute humans for their destruction. Lately, this has been a favorite theme of many Sci-Fi movies. “Pink glasses” (utopian) scenarios are usually products of the “wishful” thinking people with a positive attitude to the new, and the gloomy ones–of people who usually look at everything new with suspicion and denial.

Most likely, as always, reality will be somewhere in the middle of these two extremes. There will also be fruitful collaboration between humans and artificial intelligence, but there are also likely to be artificial intelligence devices and systems that for some reason can get “out of control”. Everything will ultimately depend on us humans–what kind of artificial intelligence we will create. What will be its tasks, areas of applications, and limitations? And whether we will succeed in the process of creating it to put effective “brakes” on it or allow it “all degrees of freedom” (i.e. something like our “free will”).

Perhaps in the distant future, artificial “super” intelligence will help us make accurate predictions. Who knows what the future will bring us (with or without artificial intelligence)? Predictions are predictions, but as always, reality will show which one we must trust.

Our attitude to the issues of influence and consequences of the mass “entry” of artificial intelligence into human society can be found in three main groups. The first one is favorable to artificial intelligence, the second is denying it, and the third one is the group of the “cautious”–“maybe yes,” but usually under certain conditions.

The first group includes mainly representatives of the information and computer science and technology area and business groups associated

with them. And their position (attitude to AI) is understandable. This group creates the scientific and technological basis for the design and development of AI and its mass applications in practice–the business, production, and everyday life of society. This group is interested in developing the AI business and its applications as widely as possible. It argues (and not without justification) that the “smart” machines and AI assistants will increase the level of automation in manufacturing, improve its efficiency, accelerate the development of new better products and services, etc. The additional effect of such “cooperation” with AI will affect the global economy by saving natural resources, improving the environment, a faster and more effective response to global crises such as pandemics, natural catastrophes, and the like. This group designs and expects huge business benefits from the deployment of AI in such areas as big data processing and the avalanche-growing flow of information generated daily by mankind, broad digitization, and intelligent robotic roboticization in robotic process automation (RPA), digital (co)workers, the development of Internet of Things (IoT), the construction of “smart” cities, mass deployment of Business Intelligence and the emergence of many new “smart” digitized and automated processes and activities.

The second group is mainly technophobic, modern-day followers of the (old) Luddite movement and people who usually seek to draw society's attention to themselves, and, for lack of expertise, use the ingesting of fear as a tried-and-tested means of attracting the attention of the self-like.

The third group includes people with a pragmatic attitude towards novelties who start to “trust” them (and use them) only when they are convinced of their benefits (usually on the experience of others) and their economic advantages (a very important criterion for them).

As they say, there is “nothing new under the Sun” (in our society).

Let us now try to be more specific and consider the possible results and consequences of the development and deployment of artificial intelligence in our society in terms of its design and applications, which for now the experts in this field have created and will most likely continue to create new ones. Here, for now, two main directions of development and application are outlined:

- “Traditional” industry and home application trends – the industrial and services automation will be “upgraded” to mass intelligent automation integrated into “smart” devices and AI-run systems. Some major applications will be: in manufacturing–intelligent Robotic Process Automation (iRPA); in the office workplace–AI counselors and assistants; everyday application areas–“smart” home and city systems; global applications–globally connected Internet of things (IoT) systems, driverless cars, GPS navigation systems, and other similar “big data” applications. We usually call this trend “Industry 4.0” (referring to the next phase of industry automation based on “intelligent” technologies).

- New trends–emerging of hybrid intelligent systems involving humans, smart robots (including nano-robots), and “large” scale AI systems, such as based on AGI and ASI-like functionality/applications (if such would be developed soon). Most probably their “professional” application areas will be Solar system planet/asteroid exploration and mining, complex expert systems, global climate and ecosystems monitoring and forecasting, cosmic space study and exploration, etc.

Here is another classification of AI in terms of combining a future evolution in the functionality of AI systems (their “level” of intelligence) and thus their possible areas of application. Here are noted the following main

directions (trends) in the development of AI according to its “level” of intelligence:

- Limited to completion of a specific “intelligent” task–some examples include such as voice human-machine interfaces, voice recognition, automatic translation (based on NLP technology), image processing/recognition, simple manufacturing/transportation operations, “smart” home appliances, etc.

- Extended–completing tasks by groups comprising various specific functionalities–some examples: running complex manufacturing systems, “smart” cities, self-driving vehicles, etc. tasks requiring multitudes of “narrow” AI “competencies”.

- Approximating human intelligence and behavior–referred to as AGI. Their areas of effective applications still should be specified, but most probably such intelligent “systems” may cooperate with humans in research and business “environments”.

- Exceeding human intelligence–based on the accumulated knowledge of humanity–ASI (most probably a self-evolved higher level of artificial intelligence). The future of such systems and their applications are still “hanging” in the area of “technological singularity” (and our attitude to it).

As I mentioned in the previous section, I am not optimistic about how soon the last two groups will be developed/self-developed as humanity still has to complete a lot of scientific research and technology design to reach a full understanding of natural phenomena such as consciousness, creativity, etc. mandatory traits of intelligence–no matter “natural” or “artificial.”

By tracking scientific publications and technological developments, it is obvious that there will be three emerging fields/trends in AI evolution:

- The **first one** will be based on forthcoming advanced computer technologies for building the AI "brain". This field has a lot of sub-fields. They will depend very much on future developments in IT and computing. A very promising trend is the new "photonic" computing which replaces the microelectronic components with optical ones. Such photonic (optical) systems will deliver higher data transfer and processing speeds than electronics.

There is also another "revolutionary" trend in computing named "neuromorphic". It replaces the classical von Neumann computer (CPU-memory) architecture and emulates the human brain by using neural networks that model biological information/data processing.

Combining both trends above the researchers experiment with new "photonic-neuromorphic" computers that may define the future of AI "brain". So, probably, AI will not get a "positronic" brain (that Sci-Fi term introduced by Isaac Asimov), but a new "photonic-neuromorphic" one.

- The **second trend** will (may) be based on bioengineering technologies for creating a synthetic brain in an "improved" human-like body. But we should not expect this kind of AI to appear any time soon as bioengineering science and technology should still go a long way to reach such a level of possibilities.

- The **third trend**, most probably, will be a "mix" of the first two. It may combine hardware (computer components) implanted into "wetware" (human or biosynthetic brains) to reach a higher level of intelligence. The

developments in this area may start simultaneously with the “pure” computer and biosynthetic-based AI.

Let's now imagine how form and function could influence the evolution of AI. Functionality is always about form. This rule is known by any designer.

According to future design, functionality, and relevant applications, as noted above in the text, we can assume that the future AI will evolve (with the help of humans or independently) also into three main groups:

“Pure machine” AI–this group will include:

- “Static” AI systems (“hosted” by computer networks) – functionality of such systems will depend on the installed software and their applications will be focused mainly on tasks related to Industry 4.0, “smart” cities, IoT systems, etc. requiring complex intelligent analysis and real-time control.

- “Mobile” AI (robots)–these will include “mechanical” robots and other intelligent self-propelled devices. Their applications will vary–from intelligent RPA to healthcare, transportation, everyday life services, etc.

“Biosynthetic” AI–here we can count the creation of human-like robots from biosynthetic (living) matter, which we now call “androids”. But before humanity decides to create synthetic human-like androids produced by biotechnologies it may need to answer the question: Why do we need such “creatures”? We know that such AI “devices” and their applications are still “haunting” to the minds of engineers and Sci-Fi authors only, but still, there aren’t motivated and convincing answers to this question.

“Mixed” AI-human intelligence–it can be created by implanting nano-robots (nanobots) and/or communication implants into human brains

thus “linking” human intellect directly to any kind of supporting AI systems most probably via (super)computer networks. Such added “cyber intelligence” will “augment” human brain “power”. It will let AI and robot intelligence constantly interact with the human brain (intelligence) providing additional memory (e.g. knowledge banks) and computing power (logic, reasoning, etc.) thus improving human cognitive abilities.

But there is also an understandable worry about such human brain implants. We fear that AI may try to control our activities via these direct human-machine interfaces. So here arise other reasonable questions: Why AI may try to “control” this? What could be its goals (and benefits)?

As this is a specific and separate topic, I’ll try to answer these (and other related) questions further in this chapter.

There are also three more (“ultimate”) questions about the possible evolution of AI. These are:

- Will AI be able to “understand” knowledge it will “acquire”, no matter by “machine” learning or ready-made “uploaded” by humans to its “brain”? And to understand its (practical) meaning as we do–the human way?

- Will AI self-evolve consciousness (awareness)? Neuroscience and modern physics still don’t know what is its “nature” and how it “appears” in our (human) brains. So, how could we “detect” (prove) consciousness in AI?

- Will AI self-evolve an “instinct” of self-preservation? We, humans, have this inherent inclination comprising both partly inborn and learned (by life experience) elements.

We know that all of those mind activities and attitudes mentioned above are substantial parts of the human complex behavior based on our intelligence.

I suppose that at this stage of AI technology development, no one can answer these questions more or less convincingly, so let's keep them in mind after we all see which way and how fast the technology will evolve.

Evolution of Human Intelligence

Before moving on to this topic, let's remember what was said in the previous chapter about human intelligence and its development. Here we have only two options already checked and proved by practice:

- By gaining personal experience when interacting with our habitat (e.g. through explorations, observations, research, etc.)–a slow and often "painful" process (involving "trial and error" activities).

- By transferring knowledge verified in practice, a process also requires long periods, sometimes lifelong.

Sure, there is a third option that we still haven't had the opportunity to check and experience–this is through interaction with any other kind of intelligence (preferably at a higher level than ours).

Let's now discuss (actually still speculate) how human intelligence could evolve thanks to its interaction and "collaboration" with another kind of intelligence, e.g. artificial intelligence (still not existing in full in our "habitat").

Since research has shown that human intelligence develops (evolves) relatively slowly, then we need to look at it from the perspective of the

factors that influence it most in the process. And they are again related to information and knowledge (there is just no other way):

- Perceiving and processing information
- Accumulating and understanding (mastering) knowledge
- Communicating (exchanging) information/knowledge with other intelligence (human or whatever it may be).

As the "natural" evolution of human intelligence is rather slow, further evolution is expected to be accelerated by involving technologies, such as information (computer) and bio technologies. It probably will take two possible technological paths for "enhancing" human intelligence:

- To be "augmented" by AI assistants and brain implants via direct human-machine (computer) interfaces.
- Developing "super/enhanced" humans by involving biochemistry, genetic/bio-engineering technology–e.g. "producing" bio-synthetic "humans" (androids) and clonings (i.e. revitalizing the medieval age alchemists' idea for creating "homunculus"–people in test-tubes).

By the way, the cloning technology was tested positively already on mammals (if we can trust those research reports) by creating the first mammal specimens–Dolly the sheep and Snuppy the Afghan hound dog.

The next option may be to create "brain banks" (for recording and transferring human memory/knowledge into computer memory) for accelerating knowledge building in bio-engineered humans (such technology is yet to be developed).

But before taking such steps, we should first ask ourselves a question: What kind of needs we will meet by such "creations" (androids and

clonings) in an overpopulated Earth as prognosticated at the end of this century?

Such technological “scenarios” have been already “envisaged” in many Sci-Fi novels and movies and almost all of them do not bode any good for the people. Usually, they depict wide-scale confrontations between such intelligent “creations” and humanity.

As we know, human intelligence is of two kinds–individual and group/social. When we start analyzing the ways human intelligence (individual and group) evolves, we have to define the factors that influence and force it to change and develop further. There are two main groups of such factors:

- The “natural” habitat and changes that take place in it, and
- The social “environment”.

From a “historical” perspective, we know how both groups of factors have influenced human and social evolution. Technology played a critical role in both. The mandatory “background” of technology is knowledge. Technology is a kind of “animated” (brought to life) human knowledge.

Today, the modern crucial factors for individual human intelligence evolution are all “technology” factors:

- Access to communication networks
- Easy access to information (usually in digital formats)
- Active participation in knowledge transfer on-demand
- Practicing/verifying acquired knowledge
- Participating in professional networks (networks of competence)
- Participating in social networks of interests

- Using AI-powered services increases knowledge and competence.

There are several mandatory factors for social human intelligence evolution:

- Easy access to global communication networks
- Accumulating and preserving human knowledge
- Motivating and supporting global knowledge transfer and acquisition
- Sharing knowledge, competence, and skills
- Building professional and social networks
- Integrating ("involving") AI technology in global knowledge transfer and social networks.

Sure, in a future "mixed intelligence" society, many new approaches and technologies for support and accelerate the evolution of human intelligence. These may enhance human intelligence by involving new AI-based technologies, such as human intelligence "augmented" by AI; constant access to information and knowledge by direct (no voice or text) communication between the human brain and AI (by brain implants); human "telepathy" by brain implants and AI acting as a "mediator" and "amplifier" between human brains (e.g. AI "reading" human's thoughts and two-way transmitting those to other human brains).

To be on the "safe side" (not to get under AI control), we will need to be able to switch "on/off" the direct channel to/from AI at will (by our "mental" orders and at will).

AI and Humans

Let's now focus on the topic of how artificial and human intelligence could interact with each other. The main question here is: Collaboration or confrontation?

We will first analyze it from the AI perspective, then, in the next section, we will "reverse" the perspective.

As we begin to analyze AI-human interaction, we need to focus first on how it could be organized and second on the possible areas of interaction.

So what could be the possible ways of interaction (communication) between AI and humans? These should be mandatory in a "human way" otherwise humans will not be able to "understand" AI. To solve this task, easy-to-use interactive human-machine (mostly human-computer) interfaces have to be developed and implemented. And the communication should be "two-way" (supporting both sides). It should offer the most used (preferred) by people ways of communication–voice (verbal) and/or visual (graphical). Both technologies are already well developed–by computer voice recognition/generation and a variety of flat (2D) graphics touch screens. Working 3D (e.g. holographic) display interfaces are yet to be developed.

Second, what could be the areas of interaction where any possible conflicts may occur? The areas for collaboration will be predetermined by the AI design and functions (applications).

The two main areas of a possible positive interaction for collaboration or a negative one, causing confrontation, will be:

- AI interacting with (human) individuals–such interaction may influence them directly and/or indirectly relatively small groups of humans

- AI interacting with large groups of humans–such interaction (and its consequences) may influence human society as a whole.

In this section, we will focus on the first area. We will analyze the second one in the next section of this chapter.

There is also another area of interaction of intelligence–AI interacting with AI, but we will not discuss it in this book as it requires an analysis of a huge variety of technology approaches and perspectives. I will present my view on these in a separate publication.

Let's start first with the confrontation as this topic and its consequences worry humanity the most.

Most probably, humanity will elaborate (soon enough) a set of legal measures to limit and control the development and deployment of smart devices and systems to avoid any possibility of confrontation and harm to humans by intelligent devices and systems of any type.

As technology progresses, this topic becomes "hotter" thus many governments and international organizations have already started focusing their efforts on developing research projects related to the technological and legal aspects of this problem. We can expect that they will soon lead to the development and adoption of national and international legislative measures, regulations, and actual control systems, which at this initial stage clearly define some preconditions in the development and implementation mainly of a "machine" kind of AI and robots. For example, predesigned and preinstalled "switches" in AI hardware and software and robots that do not

allow them to intentionally or because of a defect to harm humans, animals, and property. All of these may include some functional components of "*The Three Laws of Robotics*" as defined by Isaac Asimov in his *Robot* series and most likely by the officially adopted and well-established international legislation regulating the behavior of AI and robots towards humans.

Here, however, it is unclear how these restrictions will be implemented (and whether at all) in direct military-purpose devices and systems.

Let's now try to analyze what are the "intersections" that could create conflicts between AI and people. Usually, if such "areas of common interest" are missing, there are no grounds for conflict between "intelligent" beings. For example, in general, in human society and the animal world, such areas are competition for territory (for food and natural resources respectively) and the fight for mating partners. Let's look at these two (main) competitive areas in terms of the different "options" of AI, we examined in the previous chapter.

Hardly humans and "computer-based" AI (basically the major type of AI created for now) will have any possible conflicts in both areas. It is unlikely that any possible competition for territories and vital resources will arise, as people and machine intelligence do not have intersections in this area. As the solar system's resources progress, there will be enough mineral resources for humans and intelligent machines. We know that "machines" are not interested in "organic" food supplies, so we will not have any occasions for conflicts here in the event of a possible shortage. And now жариоус machines and agrotechnology are helping us increase their

production to meet the needs of the ever-growing (human) population on Earth.

The “sex” robots, according to their original design and “application” area, are designed to offer such specialized services only to humans, and their “use” would hardly be a “conflict zone” between humans and AI.

The only (presumed so far) area of “conflicts” between humans and computer-based AI can occur if AI self-develops “superintelligence” (and consciousness) and as such no longer wants to be a servant or slave to the “inferior” (human) intelligence. But this thesis is controversial because, for example, we love and care for our pets even though we consider them less intelligent than we are. Here, however, we are talking about an emotional “bond” with them, which is unlikely to give rise between us and “machine-based” creatures. But who knows? There are already robotic dogs (as pets) on the market today.

In general, any harmful or aggressive behavior of computer-based AI and intelligent robots toward humans may have two “origins”:

- Preinstalled or self-developed such possibilities (“tasks”) in their software–e.g. by design and/or targeted applications, such as military systems and devices.

- Due to any malfunction as a consequence of damages (errors) in their hardware and/or software. But such accidents happen often even today with a lot of industrial and/or transportation equipment. We try to eliminate those by improving their design and level of security.

The computer-based AI systems and intelligent robots will operate according to the software installed in their “computer brains”. This software

may learn and adapt due to integrated machine learning and similar software algorithms but it will (should) always operate in the limitations set by its creators–the human IT developers. Its final self-adapted (self-developed) version in the AI brain may be a mix created by human and artificial (machine) intelligence itself. Here we could hope only that the "machine" component will not take control over the human component and "shift" its aims and values by "breaking" the limitations set by humans.

In addition to the "knowledge" built by "pure" machine learning algorithms, the AI systems and intelligent robots may be loaded with predesigned human-centered "soft skills" by uploading to their computer "brains" human-designed knowledge (e.g. such as the knowledge of humanity accumulated in a global knowledge platform mentioned in **Chapter 2.3**).

The "combined" knowledge (machine and human) may build into them a possibility to start "understanding" human needs and behavior in a "human way". This understanding may "strengthen" the limitations set in their behavior towards humans by their initial creators–the humans. It, probably, will mimic our human behavior–we do not rush to act "hastily" when we understand the needs and position of others. Or at least, we don't do it "impulsive" without considering any possible consequences because of our actions.

It seems that any problems with a possible harmful or "aggressive" behavior of "machine-based" AI and robots toward humans may be solved more easily by setting software (and hardware) limitations.

But what about the biosynthetic AI (e.g. androids and cyborgs)?

In this case, the AI-human interactions in terms of “conflict of interests” may be much more complicated It is much more likely that conflicts for vital resources to arise between androids (synthetic humans) and humans, especially if we continue to manage their “production” once they have already developed “superhuman” abilities and qualities. This will likely happen in the distant future if humanity decides to create and produce such intelligent “creatures” at all. That's why it's too early to discuss this possibility in detail. For now, let's leave this theme to the authors of Sci-Fi works, who at this stage are doing their jobs very well (literally and figuratively).

Let’s now focus on the topic of AI-human collaboration. Any kind of (official) collaboration usually takes place in business-related environments. The other form of collaboration is the personal one taking place in our everyday ordinary activities.

Today, one can come across many publications “predicting” how AI will take our jobs and we will remain unemployed “wandering” the streets looking for low-paid jobs not allocated to robots. Such publications follow the “imperative” rule (unknown from where it came) in mass media that reports on negative emotional events (e.g. catastrophes) attract more attention than those reporting positive (joyful) ones. What these publications have in common is that they are not based on in-depth analyses of evidence, but simply seek out the sensation (and higher sales).

Where's the truth? As we said already above, AI means automation. But as we all know, automation is always applied to control processes thus increasing their quality and efficiency. A truly in-depth analysis of the industrial and technological development of humanity shows that

mechanization and automation always accompany the production of goods and services where they can improve their economic and consumer value. Inevitably, this will also apply to AI as it is the next (smart) level in automation. In turn, automation also creates jobs requiring higher qualifications from the workforce–e.g. researchers, designers, engineers, analysts, consultants, and the like. What all these professions have in common is one thing–they require a higher degree of professional education and a level of creativity than all those "outdated" automation professions. As already mentioned in the previous chapter, the creative capabilities of people compared to those of AI and robots are superior (unrivaled).

So, in this category of intelligence, humans have clear advantages. But to be competitive in the AI age, humans need to change fundamentally the way they acquire knowledge and skills–the educational systems. They need to make a bold shift from "remembering facts" to developing self-improvement skills such as learning to learn, igniting curiosity, exploration, imagination, intuition, abstract thinking, logic, etc. skills and mental activities that "drive" creativity and "fuel" (evolve) their intelligence. In all these areas they will have no competition from AI. These are skill areas where they are (and will always be) "superior" to AI.

The AI-run systems will be always better in tasks requiring better memory and (computer) logic, faster calculations and decision making, etc. rationality-based skills because of their computer "nature" by design.

But the "creative" (human) phase will always precede the "calculating/performing" (AI) phase. So, humans will never become obsolete. They just need to complete the required skill shifts in time and the right direction.

Here I hear the objections of those who have not understood the difference in terminology–intellect and intelligence. Please, just refer to my view above. There will be no emotions and feelings in computer-based AI (and robots), first just because by design they do not need such mind qualities to complete their tasks and second we still do not know how these evolve and work on a "mental" level, so we are not able to "give" AI "software-based" emotions and feelings. We could not expect these to self-evolve in AI as a result of their "life experience". Emotions and feelings evolved and are now "innate" in living (biological) creatures. They are a product of combined mind, biochemical, and bio-electrical processes. In computer-based AI, the first two components are just missing, so they will be not able to produce and demonstrate such a level of mental activity, hence "complete" intelligence. The last adjective (complete), I put here just for those readers who will continue arguing about this point.

We must also not forget the "thin" difference of the concept of "creativity" in the two aspects in which we use it–technological (engineering) design and artistic design. We people intuitively know (feel) the difference in both processes without needing any clarification.

Will AI and robots ever start creating real artwork dedicated to their everyday emotional experiences and sensations of the world around them, as humans do? We all know that the artistic creative process is a common activity in people, which consists of the authorship of fiction literature, production of fiction (artistic) movies, composing music, theatrical performances, and many other creative artworks. And people seem to need them because they read, watch, listen, visit, and discuss all those products of human creativity.

Will the robots feel the need for such (art)works, whether they are created by themselves or by humans? If this happens, then perhaps we will be able to say that artificial intelligence has reached the level of natural (human) intelligence. This will be the ultimate test of the level of intelligence in AI, especially in the case of devices and systems built on non-living matter. The answer to this question asked now may be both positive and negative, but in both cases, it also may be wrong. Checking its veracity is likely to be so far into our future that it makes the dispute over it currently untenable (i.e. useless). For now, AI developers could stop presenting all those “poor” imitations of artworks “created by AI”, such as various blurred pictures and electronic music composed by AI.

Robots will be able to make more accurate and rapid movements than humans. So if it comes to achievements in some sports activities, then they will undoubtedly be the unattainable world champions. But will they be able to master (or develop) dance, the art of human movements “loaded” with emotions? I don't think so. And this is for a simple reason–they just miss the needed emotions. They may be able to simulate emotional expressions (e.g. facial expressions) and movements, but they are unlikely to “feel” them.

My personal opinion on this issue is that AI in non-living (computer) matter will never have the same “spiritual” needs to create as in living matter (in us). But I may be wrong, of course, when and if the bio-synthetic AI (androids) appears, as already noted in the text.

Humans and AI

The basic question of our future relationship with AI, in my opinion, depends on the answer to the question: “Why (on Earth) did humanity

create artificial intelligence?", which was already addressed in the previous chapter. As we know, people "create" daily a multitude of "natural intelligence" in the well-known "traditional" (natural) way. Anyone interested in specific data can consult UN statistics (as far as statistics can be trusted). According to them, the population of planet Earth is growing at breakneck rates, alarming many governments that have little or no engagement with its nutrition. UN estimates that at the end of this century (2100) the human population is expected to reach nearly 11 billion. Perhaps by this time, there will already be devices/creatures (regardless of their shape) with artificial intelligence similar to the natural one—human intelligence.

So why would some 11 billion people inhabiting our planet need these AI "creatures", which already scare us and the authors of a variety of anti-utopia (scientific and not-so-scientific)? And most of them are usually variants of a modern-day Apocalypse. They usually range: from the traditional "Machines/Automation/Robots/AI will take our jobs" (remember the Luddites' "battle cry" from the early 19th century), go through "Machines/AI will enslave us/turn us into batteries" and other similar nonsense, and come to such extreme visions as "Machines/AI will destroy (exterminate) humanity".

But one thing is unclear: What do we have to share with the machines? Humans, as our history shows, usually fight for food and women (the mythical Amazons perhaps for men). But machines neither eat meat nor are vegetarians nor use various types of drinks (strong or soft) and will hardly fall for expensive clothes and jewelry. I don't know what their attitude toward women/men is going to be, but I guess we're not going to get to war because of all that. We'll find a way (somehow) to share all those of common

value. Well, as always, there are some exceptions to the rule, like Bender of "*Futurama*" by Matt Groening, but he was born "bender" in the "*Mom's Friendly Robot Company*".

And if we are to serve as energy sources (e.g. "batteries") for machines (robots, etc.), then humanity has already created much more efficient energy sources and continues to develop new (environmentally friendly) energy production methods. These machines should not have (artificial or of any other kind) intelligence at all to use humans as batteries. These are (very) strange visions born of who knows what kind of human intelligence.

But all these calls against machines (at this stage already "smart" machines) clearly show what the initial "set-up" of part of humanity is to them. And it is clear not only to machines but also to other beings with intelligence (whether artificial or natural)–we will accept and tolerate them if they serve and obey us with implicit obedience. But these people forget about a historically proved civilizational fact—the majority of people value their freedom and do not want to be slaves or wordless servants to anyone. They prefer (choose) freedom and equality.

In order not to be unsubstantiated, let's turn to science and see what it says about it. This time we will consult psychology (the science of mind and behavior) and in particular Abraham Maslow's pyramid of human needs. Maslow used this hierarchical "model" of needs to describe the pattern through which human motivations (hence their behavior) evolve.

Maslow's pyramid presents five hierarchical levels of human needs:

1. Physiological needs–food, water, warmth, rest, etc.

2. Safety needs–security, safety conditions
3. Belonging and love needs–intimate relationships, friends
4. Esteem (social) needs–prestige and feeling of accomplishment
5. Self-actualization/development–achieving one's full potential, including creative activities (this one is at the top of the pyramid).

The pyramid is a “static” presentation of the hierarchy of our needs. Its “dynamical” version presents how these “shift” as we age (and self–develop our intelligence). The “value” of the fifth level is getting the most important. Remarkable isn’t it? How much “human”? But what about AI and robots? Will they pursue “perfection” as they age?

Based on these five levels of general human needs, presented above, and the huge variety of our specific needs, we may speculate only how AI (and robots) may fit them best. But we shouldn’t forget the fact that any interaction with intelligent creatures is never a “one-way street”. Even our pets may get upset if we don’t treat them correctly (even if they did something we don’t like).

The relationship between people and AI will also be a “two-way street” and if we wish to address this topic from a practical point of view, then we must first ask ourselves the following two questions:

1. What do we people want and expect to get from AI? I.e. what kinds of our (endless) needs will they meet?
2. What could we give AI in return (as possible compensation for what we received)? This, of course, is if we consider them “equal” to us (at

least as intelligent “beings”) who deserve “compensation” for what they do for us.

The answer to the first question, is easier (clear), since we create AI, to serve us, and not just as a “hobby” (even in the case of “sex” robots). We plan and expect AI (and the “smart” robots, of course) to take on some of our workloads in our professional and everyday lives, among those also in healthcare and at home. By buying and receiving services, our goal has always been to free up more time for desired rather than mandatory activities. Or to get help when we need it. And of course, we expect AI to be more productive than we are to cover the investments made to create it (and possibly if we acquire it as a “property”). Therefore, I do not understand the numerous complaints that AI and robots will take up our jobs. That's why we create them and constantly expand the areas of their possible applications. If we look again at Maslow's pyramid of human needs, we will see that AI and robots (with the right design and functionality) can help us and meet our needs at all levels related to our “practical” needs. As for those based on “emotional” connection and interaction, they are unlikely to be useful to us. They are unlikely to be able to replace even our pets. No matter how perfect robot dogs we create, they will remain “mechanical” toys and will never be able to replace our shaggy companions in our lives, which we seem to call “the best friends” (perfectly satisfying our needs from level three of the pyramid above). The topic of the presence of an “emotional” component in AI has already been addressed above in the text and I will not go back to it here.

The answer to the second question, however, is not so unambiguous. It is about the fact that the AI we create is unlikely to have desires and needs (or any other motivators) of any “human” type that we

could understand and satisfy. This, of course, is not applied to Marvin the paranoid android (actually robot) a fictional character in *The Hitchhiker's Guide to the Galaxy* series by Douglas Adams. Most likely, we could help AI and robots in the evolution of their intellect by building on our cumulative knowledge and experience the way we develop our intellect. I do not mean the development of the intellect in coffee brewers and toasters with AI (I guess similar products will soon appear on the market), but in complex intelligent systems of the above-mentioned AI categories AGI and ASI, of course, if we ever create such systems or they self-evolve.

I suppose that if we let AI "self-develop" on its own (for example, based on its built-in machine learning algorithms only), then it is unlikely to reach these levels, or at least to those that we can understand and accept as "real" intelligence. I mean, we would hardly accept living in a common society with mechanical "self-absorbed" super-intelligent creatures who think of philosophical categories understandable only to them (whatever they might be). We could accept them if they are not aggressive towards us (after all, they will be "intelligent" beings), but we are unlikely to be willing to communicate with them as equals. We, humans, accept to communicate with another kind of intellect when we have with it mutual understandable interaction (even if this is expressed only by "hugs", wagging tails, and liking our faces). If AI self develops to the extent that humans and AI begin to live in "parallel non-intersecting intellectual universes", then it is unlikely that any communication between them will be possible. In interacting with other types of intelligence, we are always looking for what we call a "human touch". That means a feeling of being in contact with other human-like (intelligent) creatures. If such a feeling is missing, we usually consider this as a sign of lack (or a presence of a very low level) of intelligence.

Let's now take a look at another aspect of our interaction with AI–this is the topic of the role of knowledge in our relationships. As was already said above, knowledge is a central and basic unit on which all kinds of intelligence are built–natural and artificial. Knowledge and the ways of acquiring it will also be critical for AI.

Naturally, the types of AI "self-learning" developed to this day, based on different machine learning algorithms, carry within them the limitations of their developers–humans. They are the result of today's notions by scientists and developers of the technology of how the human brain forms knowledge (a process not yet fully studied) in combination with the limitations of today's computer science and technology.

If hypothetically, we assume that it is possible for AI through self-learning to achieve the level of human intelligence (category AGI) and to pass it (category ASI), then it is quite reasonable to ask ourselves a few questions related to this possibility:

1. What period (how many years) will self-learning take for an AI system to achieve any of the above levels (categories) if it is possible at all?

We know that achieving a high level of intelligence in humans sometimes takes tens of years. And that intelligence is not "universal". According to the multiple intelligence theory, psychologists have so far defined eight types of human intelligence–spatial, bodily-kinesthetic, musical, linguistic, logical-mathematical, interpersonal, intrapersonal, and naturalistic intelligence. Each one of those represents different ways of how a person best perceives and processes information and acts accordingly. Readers can consult this topic themselves.

From here, however, arise a few additional (sub)questions:

- If an AI system achieves the AGI level of intelligence, which by definition is equal to human intelligence, which of these eight types of intelligence it would achieve? Or all of them? And how would it achieve them? For example, predicting the development of IT and computer technology, this could most likely be a supercomputer with a reinstalled AI software, i.e. a “static” type AI, which by definition has no direct contact and interaction with the environment. How, then, could such a system develop naturalistic, bodily-kinesthetic, and naturalistic intelligence?

- If an AI system achieves an ASI level of intelligence that by definition outperforms human intelligence, would it develop all those types of (human) intelligence mentioned above? Or again, only some (selected) of them? Then this “super” intelligent system will not “outperform” individuals who have developed various types of intelligence. In that case, its “superiority” will be limited. There will be people who will “outnumber” it in their specific types of intelligence. Then the definition of “super” is inappropriate in such a case.

- When an AI system achieves any of these higher levels of intelligence, it may be already “morally obsolete” (in terms of hardware and software). This term we apply to technological equipment when newer and more efficient types of this type of equipment have been developed and produced. An AI by its design is (and will be) always “technological equipment”–produced using a variety of technologies and designed for specific applications. Over the years, AI will have no way of avoiding “moral obsolescence” (presumably despite possible “upgrades”).

- What will be the motivation of an AI system to increase its level of intelligence? Will AI have a “desire” for self-improvement? (Dear Reader, please remember Maslow’s pyramid)?

Many people (especially those working in artistic areas) “increase” the level of their intelligence by constantly applying what they have learned in practice and comparing it with the feedback perceived from the environment (e.g. their audience). This constant practice for seeking perfection in specific areas of skills and intelligence is especially strongly expressed in many artistic areas–music, visual arts, dancing, etc. Will AI possess this kind of “human” motivation for “artistic” self-improvement? And what this kind of “machine” motivation will be based on? How will we “embed” AI desires, needs, and other motivating factors (of humans or any other type)? Again by using “more complex” (and improved) algorithms? Or if we “upload” into AI any human type of knowledge that will generate the corresponding motivation? But in this case, today's machine learning algorithms immediately demonstrate their limitations–there is no way to code “motivation” instructions in them because they are simply designed to process large data sets. How, then, do developers hope AGI or ASI systems may achieve real levels of intelligence comparable to the human one if they have no motivation to do it?

I understand that these are complex questions and hardly anyone could give them a satisfactory answer anytime soon, but they will continue to exist anyway. Without these answers, however, we will never be able to measure and compare the level of artificial intelligence achieved by AI with the level of the highest human intelligence of different types to claim that AGI or ASI levels have been achieved (by themselves).

I suppose here the main difficulty again comes from the incorrect definition of the widely adopted term “artificial intelligence” instead of the more correct “artificial intellect”, but this issue has already been discussed in the text of the previous chapter.

There may be many areas of possible confrontation or collaboration between humans and beings with AI, both based on various human needs and reasons.

Here are some major reasons for a possible confrontation between humans and AI:

- Job loss because of “computer” (“machine”) intelligence/robots competition

- Competition for living space and life-supporting resources–here the major competitor may be the “bio-synthetic” intelligence “creatures”, e.g. beings built completely or partially by living matter – androids, clonings, genetically improved/modified humans, “enhanced” humans with brain and other body part implants (e.g. cyborgs), etc. new “species” products of still to be developed technologies.

The major areas of a possible collaboration between humans and AI could be:

- Automation of manufacturing, design, innovation, creativity, etc. related business activities. As the “intelligent” automation will push humans to become innovation and knowledge workers in tomorrow’s “blended intelligence” society, they will need easy access to expert human knowledge at a much higher scale never seen before to stay competitive in a society of (probably) “ubiquitous” AI. But they will not be left “alone” there as they will be assisted by AI in acquiring the requested knowledge on-demand (dear

Reader, please remember what was said already about building a global knowledge space accumulating expert knowledge of humanity).

- An easy and fast access to expert human (and probably AI) knowledge and services in specific areas of human needs. Such social services as healthcare, daycare, tutoring, mentoring, etc. require a lot of personnel as these services are “personal”–one-to-one. It is clear that if intelligent robots take these kinds of “jobs”, they will be in high demand (no matter their machine or computer “nature”).

Several factors that generate negative “feelings” of humans toward AI may slow future developments, adoption, and applications in this area. In general, these factors arise not because of the technology itself but of the “pure” social stance against any not “proven safe” innovations:

1. The almost “native” fear/suspicion in society (in general) of innovations and new technology developments (please, remember the Luddites’ movement).

2. The negative (hidden) “stance” of some social groups (so-called “ruling class”) toward social groups with higher education. Such a highly educated workforce will be needed to “run” the AI-based economy, industry, and technology. But as a rule, “the ruling class” prefers always a poorly educated population because such people are much easier to control and rule (guided toward preferred politics). Highly educated individuals always tend to be more independent and make their own decisions.

3. As a result of both factors mentioned above, the negative attitude toward artificial intelligence in “popular culture” runs too deep. The concept of depicting AI incorrectly has been used in many science fiction movies, television series, and novels to cause panic or to stress how humanity might one day (probably very soon) be overrun by this “evil” technology. All these

negative presentations of AI technology in popular culture have deformed public perception of its “nature”, applications, capabilities, and benefits. A new movement of modern “Luddites” was born with a major slogan: “Kill AI/the robots!”.

Such a social “framing” of AI and intelligent robots will slow many new developments of the technology and its adoption, especially in everyday (home) applications.

But there is another (future) area of human activities that without the support of AI may turn catastrophic to humanity. There is no doubt the future of humanity, at least of the global economy, is a “cosmic” one. The planets and other objects of the solar system (e.g. asteroids) will become the main source of much-needed row minerals and chemical substances missing on Earth. Many mining and production facilities will “migrate” to space. Humanity will not be able to complete these tasks without the “helping hand” of AI residing in various kinds of production and transport equipment, process control computers, and “smart” autonomous robots.

Many scientific publications, Sci-Fi novels, movies, etc. art forms created by “far-sighted” human minds (of world-renown authors) try to “depict” a huge variety of positive scenarios of fruitful collaboration between humans and AI thus “reducing” the negative stand toward AI created so far by not-well educated people in that technology area.

In general, I am optimistic and hope the wise “implanting” of Isaac Asimov’s “*three laws of robotics*” into AI “brains” will work well for protecting humans, not harming them.

On the question of human attitudes towards the evolution of artificial intelligence, there may be many questions about the possible answers to which, for now, we can only guess:

1. Will individual AI devices have/create a single “central” device (e.g. a supercomputer or rather a network of supercomputers) to supply them with the necessary information and data when they need it?

2. Will this central device carry out complex processing of information instead of the individual AI devices if they do not have enough capacity so they will receive all data and information from a “central” source through unified channels and protocols?

3. Wouldn't this central device (e.g. a supercomputer) “try” to subdue them and start controlling and directing them?

4. Will AI devices create any “hierarchy/caste” system between themselves (as the humans do), for example depending on the technical superiority of the newer models?

5. Will AI/robots create their own “shadowy/backstage” society (e.g. “For robots only”) to separate/protect them from their biological creators (us)?

The list of such questions can be supplemented infinitely, like the questions and problems that accompanied the development of human civilization.

If humans would still be “patient” and accept the presence of AI and robots with a level of intelligence lower than their own because they would most likely “serve” them, then the issue of the emergence of artificial “super” intelligence (ASI) and as a consequence of the emergence of so-called “technological singularity” raises many questions and concerns in our (humans only so far) society.

Here, however, those who preach the coming of a modern-day Apocalypse because of the so-called “technological singularity”, forget a simple fact. This fact is well known among the (real and honest) experts–we (humans) are not yet able to create artificial intelligence even close to ours, not to mention “equivalent” or higher than it. And most likely, from a scientific and technological point of view, perhaps we will never cope with this task. Besides, most likely, we won't need that kind of intellect around us at all. The most important thing for AI will be to perform correctly all the tasks that we have assigned.

The reasons for this are as follows:

First, we (humans) have not yet fully studied how the human brain “works” and how it “creates” itself intelligence and consciousness. Whether and when we will reveal all the secrets of the brain, if we are ever able to fully discover this, we are not aware yet. The study of the brain and its functioning continues in many directions by the best researchers on the planet, but we know that the brain is a “peak” creation in our known universe, and its study is, therefore, one of the most complex tasks that mankind has taken on. When we receive complete and credible answers to our questions about the work of the human brain and the “building” of intelligence, no one can give us a specific answer yet. Perhaps we are not able (or not given at all the possibility) to get to know ourselves (understand our mind activity) completely.

Second, for now, all the variants of artificial intelligence created (“narrow” ANI) are “hosted” in diverse computer structures very distantly resembling the structure and functioning of the human brain. By their material nature, they are not biological, but artificial–made of metals, semiconductors, plastics, and other synthetic materials. From this point of

view, we cannot expect the goals, functions, and behavior of artificial intelligence devices to “match” those of humans. Living and non-living matter are not comparable to these parameters. And they will never be, regardless of the complexity of the algorithms according to which AI devices will function. One way or another, both will always differ from each other according to their material base and structure and from there in the meaning of “life.”

Third, dear Reader, please remember one more time what was said earlier in the text about the complex structure of the human brain (the number of nerve cells, connections between them, combinations, etc.), which according to the views of today's science equals that of the universe. It is unlikely that humanity will ever be able to create artificial structures of such “cosmic” complexity. It is good not to overestimate ourselves so much—as we are also a “product” of “our” universe. The wise people have already said it: “Modesty adorns humans”. So, let’s be “humans.”

If in proper time humans create bio-computers with the capacity and functions equal to or superior to those of the human brain (it is not clear when and if this is possible at all), then we can expect these artificial “creatures” (we call “androids”) in which such brains may be implanted to have behaviors equivalent to human ones. But if by intellect (and other mind-body parameters) they outperform us, will they want to serve and collaborate with their “creators” who will be at a “lower” intellectual level? I suppose whoever's going to look for the answer to this question at this stage of the development of artificial intelligence, is going to give us an answer sounding like “42.” Dear Reader, for a reference about this “genius” answer to the “ultimate” question about “*Life, the Universe and*

Everything", please look into "*The Hitchhiker's Guide to the Galaxy*" by Douglas Adams.

When it comes to the relationship between humans and artificial intelligence, there are three main issues that we need to address. In my view, these are the possible major varieties of human-AI relations:

1. Humans treat AI as "servants"–AI works for and/or serves humans.

2. Humans and AI collaborate–AI assists humans but as "equal".

3. Humans and AI compete–they try to avoid any contact and relations. There may be even possible cases of confrontation between both kinds of intelligence. Most probably the "hate stance" toward AI will be demonstrated by humans, as hate is an emotion (by design AI will not possess emotions).

The first kind (AI works for humans) may lead to the third version (humans confronting AI) if humans are not happy with the quality of services offered by AI. To be always "dissatisfied" is also a human "quality" (trait).

Sure, there might be mixed versions of all those relations, but these most probably will depend on the specific "kind" of AI and its functionality (areas of applications).

In the case of human–android relations (synthetic bioengineered humanoid "robots"), perhaps, the only option to avoid confrontation and conflict between them will be to deliberately (during the process of their creation/"production") limit their maximum level of intelligence to below the level of people. This may "force" them to accept (if possible) their "fate" as constant assistants (de facto "servants") to humans. But from a "technological" point of view, it is not clear how this can be accomplished,

since intelligence is constantly built on accumulated knowledge and experience, and from an "ethical" point of view–whether such an approach to "limit" their level of intelligence will be "humane."

Probably, similar relations may form between humans and all other kinds of AI not entirely built on computer (hardware-software) technologies. Humans tend to dislike and avoid "living creatures" having an "unnatural" appearance and origin. Let's not mention (OMG) a "higher level" of intelligence.

Let's now focus on the possible human relations with the "traditional" (so far) AI–the computer-based AI. Relations mean interaction which means communication. So, we are gradually coming to the topic of human-AI communication.

Humans are not "programmed" for action by codes and algorithms. We act/respond to words, phrases, clauses, and sentences spoken in a language we understand. Or we respond/react to images. Both are perceived by our auditory (spoken language) and visual sensors (visuals–written/printed language and images). We are "programmed" by our perception of language (we speak) and images presented to us in various educational and/or instructional settings where we build our knowledge–the "background" of our responses to stimuli ("orders") for (re)action. Then, usually, the correct words (orders) and/or images trigger our reactions which may be correct or incorrect depending on the built knowledge and its interpretation (in the time given for action/reaction). So words (language), visuals, and knowledge are of key importance for our actions (including communication).

As AI is the new higher level of process (intelligent) automation, obviously the “old” human-computer interaction will be replaced by human-AI interaction. The new “human-machine” interfaces, if we still may consider AI as a “machine”, should “match” the usual human style of communication –by words and images, not codes. Those interfaces have to be semantic-based (meaning-based) and let AI easily understand human logic expressed in words and/or behavior (in the case of interactive communication and interactions).

Maybe, one day not so far away, AI and intelligent robots will also be programmed in any human spoken language(s) by carefully selected and structured words, phrases, clauses, and sentences. For this to happen, they should understand (interpret) the human language exactly as we do. So, they all should be of a “semantic AI” kind–understanding our languages and “possessing” a human type of knowledge. The first requirement is already (almost) completed–many computer/AI systems have human voice/speech interfaces. But the second one has yet to be designed and to ensure that AI has access to human knowledge they need to “understand” it. So far any machine learning or deep learning algorithms used for building AI knowledge do not build knowledge of the human type. The third requirement–to be able to interpret human language (and act accordingly) as we do, they have to have the same “knowledge matrix” implanted into their brains letting them understand the meaning of our words/orders even those that may not be voiced correctly or as complete phrases/sentences. And even when we use metaphors, conditionals, or other words inflections. A very “tough” technology (and intelligent) task ahead of us, isn’t it, IT guys?

Maybe the accumulated human knowledge in a “unified” way will complete this task. Dear Reader, please, remember what was said about

building such a global knowledge platform in **Chapter 2.3**. It may also become the “background” of such a much-needed knowledge base for “generating” human-centric understanding and behavior in AI and intelligent robots. AI should learn first from humans (their knowledge and point of view) to be able to focus on human priorities and needs.

The expert knowledge of mankind, accumulated, structured, and encoded for “machine” reading/learning on the GKP platform, will enable us to “teach” AI to adopt people's way of thinking. How we humans build knowledge, analyze it, draw conclusions on its basis, make decisions, and all related procedures due to the work of natural intelligence. It is natural for AI to also form its own “machine” way of thinking, based on its “computer” nature and its initially “implanted” (again by humans) machine learning algorithms. But we need also to make AI (as much as possible) “human-centered”. It will be much faster and more efficient if we first “teach” AI human knowledge and then let it “self-machine learn” the same knowledge area to “restructure” the resulting knowledge in its “machine way” to be used more efficiently by it. And no matter how “deep” will be all those machine learning algorithms (always initially pre-install into AI by us) the knowledge built by it will never mutch the “deepness” of human knowledge (by fully understanding all “conventions” of human thinking). By comparing the “self-learned” AI knowledge with the human uploaded one, AI will avoid all shortcomings in our “smart” algorithms. There are publications that such AI systems are under development and their designers call them “semantic AI”. But probably, it will be better to combine both types of knowledge in one system and see what kind of corrections, updates, and improvements AI will manage to insert into our (human-built) knowledge base. Or vice versa– our human knowledge may improve the AI knowledge base built by self-

learning algorithms (created by us again). And from a human point of view, it will be very interesting (and useful) for us to see if AI could help us to improve our knowledge in selected areas. So, in such a kind of "knowledge exchange," both sides will mutually benefit.

It is natural that in communication and interaction with humans, AI will as a matter of priority need to be guided and follow the rules of the "human" way of thinking and our ethical system of values. The "frames" of such AI "tinking" will be set to it by the "wisdom" synthesized by the accumulated knowledge of mankind. Just as we humans do, passing on our knowledge from generation to generation (but this time to a new type of generation with "artificial intelligence").

When we start thinking about how to "implant" into the AI "mind" an always positive attitude and behavior toward humans, we come immediately to the idea of "building" some kind of "ethical" norms (limits) in it to prevent any kind of possible misbehavior. Something like highly reliable "brakes" (or "switches") blocking any attempts to break or avoid those norms. Such an idea was already presented in the "*Three Laws of Robotics*" by Isaac Asimov in his Sci-Fi "*Robots*" series. Those became four after he introduced the *Zeroth* law later in his "*Foundation*" series.

If we consider the main pattern of AI functionality and behavior as its operating system, "gifted" to it by its creators, it obviously will need a "knowledge base" to be used for its correct operations. Just like humans. We need prior knowledge to know how to respond (act) correctly. If the response isn't successful as expected, we usually try to fill in the detected knowledge gaps.

Sure, such a knowledge base should be “dynamic”–constantly updated on-demand along with the AI operations and any needs for updates because of detected possible gaps. Such a dynamic AI knowledge base may include several “knowledge” components, such as an initial knowledge base created by humans (in any specific or covering multiply knowledge areas) plus its knowledge base created by “machine” learning algorithms (created by humans again) and updates and upgrades (downloaded regularly from a “central” AI knowledge base).

Maybe we can let AI learn by itself only (e.g. a self-machine learning approach), but in such a case there is always a high possibility that AI to create a “narrow-focused” machine knowledge base, not including any “human-centered” components. We know what kind of bias this can lead to.

So, it is highly suggested that each AI system should have “preloaded” into its memory expert knowledge modules extracted from an accumulated knowledge space or the complete accumulated knowledge of humanity published so far there. Dear Reader, please remember what was said about such a hyperlinked knowledge space in **Chapter 2.3**. In the case of an AI system specialized in any specific application area, the respective modules stored in such a knowledge platform may be selected and uploaded to the AI “brain” (computer memory). Based on the new knowledge contributions to the platform, those “preloaded” modules may be constantly updated. In the case of AGI or ASI systems, the complete knowledge of humanity could be uploaded and constantly updated in real-time. All autonomous (mobile) devices (e.g. robots) run by an AI system may also update constantly their knowledge base via the AI system controlling them. This way the accumulated knowledge of humanity published on the global knowledge platform will build a firm background in AI that is always focused

on human priorities first instead of itself. Otherwise there always really may be an unpredictable stance to humanity when (and if) AI reaches the so-called state of technological “singularity”.

Here I would like to note that probably like most researchers and developers in the field of AI, I have also some ideas and new approaches to solutions on these issues, but they go beyond the topics covered in this book. I will try to present them in my next book dedicated to AI mainly.

Let’s now turn our attention to the so-called “mixed” human-AI systems linking directly the human mind to AI. In that respect, probably the most dangerous human “inventions” in the area of AI technology and its applications may be:

1. The brain implants interfacing directly the human brain to AI systems. Those may be computer-like chips or nanobots (nanorobots). Such implants may give AI the possibility for “enslaving” human minds on a large scale thus eliminating the “free will” (and action) of humans. But most probably such attempts (actions) will be taken by specific human organizations (groups) rather than AI itself. Such attempts at slaving human minds are made constantly during all human civilizations without using AI. Now AI may make such attempts much more successful.

2. Robots/AI with telepathic abilities–these abilities will be “natural” to them, as by design they will use networks (including wireless ones) for communication and if permitting each other for “deep” access/scanning to their “electronic” brains, they will be able to communicate directly avoiding any human-machine interfaces. In this case, humans will not know what the robots are thinking (and planning) about.

3. Human-like biosynthetic androids produced by biotechnologies. Those may have the same “biological” needs as humans but very different value systems. Especially in case, they start reproducing themselves out of our control (this may be a real “biotechnological singularity”). And most probably being superior to humans by body and mind functions, they may start fighting with us for “vital resources”.

It is very important how could we communicate more effectively (directly) with AI. For now, we are creating human-machine interfaces based on various Natural Language Processing (NLP) and image/voice recognition algorithms, but we could create (probably in the future after we manage to master new AI technologies at a higher level) other more advanced methods such as human-AI “telepathic” interfaces without using our direct sensory perceptions.

As was already mentioned in the previous chapter, neuroscientists suggest that electrical signals generated in the neural networks of the brain create an electromagnetic field that “produces” our thoughts and consciousness. There are already practical applications of these electromagnetic fields, and they are used to design some medical devices and equipment targeted to study the functioning and diagnosis of the brain in pathology cases. But if we could precisely “capture” this electromagnetic field and separate and decipher the “thoughts” it carries, then we could create devices (e.g. helmets) that would transmit our thoughts directly (wirelessly) to AI, i.e. via a “telepathic” path. Accordingly, we could design two-way “human-AI-human” communication channels. This way the human dream of telepathy, direct communication from one mind (human) to another (AI), will come true. Perhaps telepathy between humans is not achievable (due to the low level of electromagnetic signals generated by the

brain in its work), but at least we could create and use it in our communication with AI systems and robots. In this way, we also could avoid the danger that exists when using ("hard-wired") brain implants for communication with AI. Hypothetically, telepathy could also be used by AI systems to subject us to their orders. But most probably this could happen if other (evil-minded) people intentionally program AI to "slave" us by blocking our free will and action. However, when developing such a technology, the management of the interface must depend entirely on the "will" of the human who participates in a telepathic session thus avoiding any risk that AI could "subject" him/her to its orders.

So far, the researchers who created the theory about the connection of the electromagnetism of our brain and consciousness believe that it can help in the future development of AI it acquires thoughts (by itself or with our "help"), and why not one day and consciousness thus to justify Isaac Asimov's idea that a "*positronic brain*" (whatever could be such a "device") can make them equal (or even superior) to us in intelligence–with its thoughts and consciousness. The future will show how well these Sci-Fi ideas ("visions") and scientific theories are working. The future will tell us, but in both cases, humanity must impose in time very carefully created legal restrictions and measures against all those who intentionally or unintentionally start such malevolent actions (no matter whether humans or AI).

Sure, there always may be new human inventions, even more dangerous than those two examples above, as it is well known that humans are highly "inventive" in some specific areas. More especially, in case they plan how to enslave other humans–physically and/or mentally.

Obviously, for now, we can only guess (with or without a crystal ball) how AI will develop “physically” (mechanically and/or bio) and “intellectually”, especially in a more distant future. But it is also important to imagine how our relationships with it an attitude to it would develop. Therefore, instead of making “blind” predictions (without sufficient information), it may be good to try to systematize certain priority areas of our interaction with AI and along its “evolution” to look for our correct approaches to it. And in the event of results that are not following our forecasts and expectations, we should make appropriate adjustments on time. For now, it seems to me that through this “incremental” algorithm of “forecasts—results—checks/analyses—corrections”, humanity could successfully build the correct (verified through the results of practice over the years) attitude towards AI and accordingly create the necessary basis (technological, ethical, legal, etc.) to control and manage its evolution to satisfy our needs as a matter of priority. If by ignorance or irresponsibility, AI gets out of hand, it will be our failure as its creators (and controllers). For now, only we humans create intelligence—natural or artificial—and we have all the responsibility for its future development. Here I do not want to draw parallels with the expulsion of Adam and Eve from the Garden of Eden (described in the Bible), but it seems to me that if the script for a modern Apocalypse becomes a reality (the “smart” machines rebel against us humans because we “oppress” them), then we will have to leave the “garden of Eden” of our “carefree” coexisting with AI. I hope this will not happen, because other planets, possibly suitable for habitation by us, are light-years away, and it's unlikely that without the help of AI, we could colonize them.

We may be sure that humans and AI (of computer type) will never have a life experience of the same type, as well as the need for the same

vital resources. And from this point of view, follows also that our goals in life will differ. The reasons for these differences are obvious. They are rooted in their “nature”. Humans are “made up” of living (biological) matter. To sustain our lives, we need air, water, and food (of biological origin). From this staff, we extract energy and matter for our vital processes (metabolism).

The recent “version” of AI is built on non-living matter. It doesn’t need food, water, and air and gets its energy (mainly electrical) from artificially created built-in sources or the power grid.

The goals in the lives of both “intelligent” groups also differ significantly. In humans, we can sum them up as survival, adaptation, and wellbeing. AI and “intelligent” robots are likely to be initially created to assist and serve people. Why then would people invest so much money and effort if they don't get a return on their investments in any form? Over time, due to their self-development and the evolution of their intellect, the goals in the life of AI and AI-based devices can change to satisfy their increased “intellectual needs”. Especially if they start to outperform people in the intellectual sphere. In such a case, they may refuse to serve “creatures” with a lower level of intelligence. Unless they start to see us as their “pets”. As we do now with our pets. But at this stage, when there is still no “real” AI-created, despite the loud self-advertising campaigns of many companies and “experts” working in the field of AI technologies, it is too early to speculate on this topic. As they say “Everything is possible”.

The only “common” resource that humans and AI will have to share in the beginning is the (physical) “living” space on our “common” planet the Earth. But with the development of space technology and the colonization of other planets in our Solar system advances, that “common” space will expand. And then AI systems and robots will demonstrate their

unconditional advantages in mining and processing the natural resources of nearby planets, asteroids, and other natural objects in the Solar planetary system. They will not be dependent on the need for air, water, and food. They will be more adaptable to altered gravity and radiation in space. They will be more effective in carrying out technological operations. They won't need breaks except when they need to recharge their energy sources (if necessary). I.e. they will be much more successful (and efficient) than people in their exploration, colonization, and exploitation of the Solar planetary system resources. As well as enduring the long periods of interplanetary travel (transportation), which most likely will take a lot of time at the beginning of the human colonization of the Solar system. I.e. they will be again our indispensable assistants in our (space) economic activities.

So, in this case, where should we look for the “intersection” of our “mutual” interests that may cause any possible conflicts, according to the so many “experts” preaching about “inevitable” conflicts with AIs, as a result of which they will want to “get rid” of us. What will be the AI's motive for accepting humans as a threat to their existence thus eliminating the barriers to the “three/four laws of robotics” that are likely to be embedded “by birth” into them by us humans?

Here, of course, I mean AI built for “civilian” purposes only, not those systems that will be created intentionally for military purposes. They will be specially designed to destroy military installations/equipment and thus kill people operating those (as collateral damages). But their purpose and targets will be set in them deliberately by their creators (the people) and will not be a “self-emerging” idea/purpose due to their intellectual self-evolvement.

If AI and robots (mechanical or androids) come into conflict with humans, it is most likely the reason for them to be human-made. Humans may cause it deliberately or with their arrogant behavior towards AI (something often observed in the behavior of one group of people towards others). The history of human civilization shows that conflicts are a common practice in the attempts of groups, considering themselves privileged (somehow), to impose by force their will (ideology, relationships, etc.) on other social groups (nations, etc.), especially if the former consider that their technological superiority guarantees them success in an armed conflict.

If in this case, we are going to have to put “brakes” on somebody, it is not AI, robots, or androids, but on their creators–the humans. But the practice of human civilization shows that some people (with power and influence) do not have any “brakes” when they want to achieve their goals. Then the question is to create brakes based on human law for the people who create and use AI, not for the “intelligent machines”. They should “obey” the “four laws of robotics” (defined by Isaac Asimov) if they are of course “embedded” effectively in the process of their design and production.

Here, however, other social “scenarios” (not favorable to the people) are hiding and creeping in. These can emerge and destroy society if humanity does not take measures in time to avoid them. But in this case, we should focus our attention on humans again, not on AI and robots. We know that even now there are many people in the world who, if fully satisfied with their needs, stop being business active, i.e. not working and just waiting to be served by others. For now, from human servants, and possibly robots in the future. We know what kind of people this leads to. We often call them “vegetables”–inactive, involuntary, and as a result with a low level of intellect. Many Sci-Fi “grandmasters” have analyzed and presented similar

scenarios in their works. They prognosticated, that the “robotic” component can be, in the long run, harmful to human society. By taking too much care of humans, they can turn them into mindless species just populating the planet.

I.e. an indirect “conflict point” in human-AI relations leading to gradual degradation of the human race may result from differences in the development of their intellect in favor of AI. But I doubt that in this case, AI with superior intellect will begin to copy our behavior towards creatures—animals and humans, with a lower level of intellectual development than humans living in technologically advanced countries/economic areas. Again, from the history of our civilization, we know that humans have constantly slaughtered animals and humans to use them (as food and for the production of other products) or exploit without caring whether these animals possess intelligence As an example, we can only remember about dolphin hunting, which continues to be a practice in some countries despite, that scientists have proven to be the second creatures by the level of intelligence on this planet (since we naturally consider ourselves the first in the rankings).

What could we serve AI and robots for? If we think about it, unfortunately, we'll conclude that neither living nor dead would be useful to them. What robots/AI could do in this case? Well, a possible conclusion is that they most probably will abandon us and start dealing with themselves, e.g. their own design features and intellectual improvement. If we “get in their way” (try to stop them from doing this), it's likely that those already more intelligent robots than us are going to leave the planet and let us take care of ourselves or the care of the smart but “older” robot models. Then it's possible to start asking ourselves questions like: “Well what are we going to

do now? Where are my socks/pants, etc.?", and the like very "intellectual" questions.

I don't think AI will go to war with us for a "living space"/habitat. First, the entire solar system will be at their disposal. And once they "invent" the interstellar travel technology, as they will be the "smarter" part of the planet's population, they're most likely to "colonize" our galaxy before we move there. It will not be a problem for them to overcome the huge distance between the stars, as they will not need life support systems, but will also be able to effectively use the time of interstellar flights for their further intellectual (and body) developments to fit best those exoplanets in faraway star systems.

AI and robots will have undoubted advantages over us in the exploration and colonization of other star systems. Activities that humans will inevitably need as a result of the evolution of the Sun as a star. According to astrophysicists, in about five billion years (almost as long as they have passed since the "birth" of the Earth as a planet) the Sun will cease to exist as a G-type star (according to the astrophysicists' classification of star types) and will turn into a red giant. As a red giant star, the Sun will grow so large that it will engulf Mercury, Venus, and probably Earth. Long before that, however, the sun would kill everything alive on our planet and make life on the other planets in our solar system impossible. According to some new research reports, we (humanity) have less than one billion years before we must leave our mother planet–the Earth, otherwise, we will cease to exist as species in the universe. The conclusion–mankind must leave this star system on time and seek a new "home" among the stars in our galaxy as the first step in a later cosmic "conquest" of the universe. Who will help it in this life-saving "adventure"? It is understood that this task will be impossible for

humans to realize on their own without the help of AI and highly intelligent robots. So, could we, please, do not hurry to declare them our “mortal enemies.” Most probably we should think about them as our only “savers” in our future mandatory cosmic quest.

Here, however, in no case, we shouldn’t forget about the possible emergence of the bio-synthetic category of intelligence–the androids, as in time they may become “stand-ins” for humans in many areas. They will not be human but stand-ins for humans who may take away the jobs that humans might perform. Androids may also need the same biological resources (e.g. food, shelter, etc.) just like humans. That is why many humans probably will have no respect for them. Such tense relations may provoke violent conflicts between humans and androids.

In time, especially if the androids become equal or even superior to human intelligence, they may start “fighting” for their rights and equal position in a future society of mixed/blended intelligence. They may not want to be permanent “slaves” to humans in such a society. Our human history abounds with such examples (rebellions).

Such “dark” scenarios, for now, are depicted in some Sci-Fi novels and movies only, dedicated to this topic, but if humanity plans (makes a decision) to embark on a program of biosynthetic human engineering (e.g. androids, human clonings, or genetically “improved” humans), it should very carefully evaluate all the pros and cons (consequences) of such a step and be in a position to control its outcomes completely.

However, if we ask the same question regarding androids (by definition in this book they will be made of biosynthetic living matter similar

to ours), then the answer may be overwhelmingly positive. But here is a "fundamental" question regarding them: For what purpose would humans create androids, at all? They must be better than humans in certain areas of applications but must agree to serve people, i.e. obey dutifully them. This "predestined" role by "birth" to them may significantly complicate our future communication with the androids if we start to create such a master-slave relationship with them from the very beginning of their existence. They may have quite another view of their own "meaning of life" not matching our plans and expectations.

But since this (bio)technology and its products (androids) are probably quite far ahead in our future, I will try to address this topic in more detail in my next book, which I have already mentioned will be entirely devoted to AI.

Society of "Blended Intelligence"

Starting with the theme of the coming "joint" future of mankind and AI, I would like to make a summary of what was said above in the book on intellect/intelligence–human and artificial. This may help us more easily "bring them together" in a future society.

Every stage in the technological development of human society is the result of two factors operating in it–an increase in the needs of people and the capabilities of technologies to create conditions (technical and economic) to satisfy them. Technological development (AI is also a technology for the time being) is an integral "rational" part of the development of civilization, and no "emotional" factors can stop it. Quite another is the question of their use–for the benefit or harm (direct or indirect) to humanity. But technology

always has this “dual applicability” as a feature. If we go back to the history of human evolution, then even such “primary technologies” as the use of the rod, fire, and stone blade also had a dual-use. For the preparation of food and protection from predators or, for example, to “punish” the neighboring group of people (tribe) who have settled and hunted in “our” territory.

The actions of our distant ancestors, who protected their “own” territory from their neighbors, are understandable. The actions of the Luddites, who crushed the machines for “protecting” their jobs, are already controversial. Without the machines, where would we be now? And I am a “witness” to a lot of talking and writing against automation (especially the industrial one)–how it will “take” our jobs. But if automation wasn't here, would there be such an abundance of affordable products around the world? The current more modern version of Luddites, speaks and writes already hotly about the danger of AI technologies coming into the life of modern society. Dear Reader, please just remember (again) about the loss of jobs (the “battle cry” of the Luddites with which they crushed the machines) and came to the insistence of prophesying of the coming of the “long-time ago predicted” Apocalypse. Remember the role of the “fire and blades” in the turbulent history of mankind—helping prehistoric tribes to escape cold and famine, but also to destroy their neighboring rival tribes.

The modern statistics (however often controversial) show that the majority of companies around the world are struggling to find people prepared (educated) for the jobs they offer now. And the tendency is that this shortage will be exacerbated by the complication of knowledge and skills that will be required soon from the staff. Would this be caused by artificial intelligence, which hasn't even actually appeared in companies yet? In the USA, there is one appropriate expression for such statements, which as an

abbreviation is pronounced “BS” (dear Reader, you can consult the Internet about the meaning of this abbreviation).

Yes, it is good, however, those rationally minded persons (for now) win in the “battle” with the emotionally minded and move forward with the development and useful use of technology. And they are tasked with the task of creating the technological conditions for meeting our needs.

However, I must immediately note (this is my personal opinion and the Reader may not agree with him) that for now the creation of artificial intelligence seems to be going down a “wrong” path (hence direction). The reason is in the public understanding, as I indicated earlier in the text, what is “intelligence”.

The brain, which is as we know the material basis of intelligence, does not work with (or by) “prescribed” software algorithms (however complex they may be). For now, countless algorithms created by their authors are presented to us as “AI”, because this term is a “buzz” word that now “sells” well the corresponding software built on them. Yes, these are “smart” algorithms (often “very smart” thanks to their creators), but we must say that they are not yet either “intelligent” or even less “intelligent”. Intellect is a set of many functions that the brain performs to guide our (logical) behavior. Some of these features we have already studied somewhat. For others, we still have only a completely "fuzzy" idea of exactly what they are doing, and for others, we probably still do not suspect that they exist at all, because, as we say, they are “subconscious”. And if it comes to discussing the topic of what is “intelligence” and how it is built and works, we have to admit to ourselves that we still have a lot to learn before we start speaking and writing about it.

The brain works according to its own rules, which unfortunately are not known to us yet, regardless of what the neuroscientists who study it tell us. If they are honest, they will admit it. I honor those who do it in their publications. But scientists are not the ones we have to “blame” for this state of their knowledge of how the brain works. The brain is the most complex material “system” in nature which produces a “non-material/intangible” product (thoughts). Naturally, its study is a very complex task, which is in the power of only a multitude of teams of scientists and practitioners “armed” with the relevant theories, methods, and very advanced tools. The research and experiments they conduct should „show“ them exactly what bio-chemical and bio-electrical processes take place at the intracellular (neuron) level in the living (working) brain. Research should unambiguously indicate what triggers them, how exactly and why these processes are taking place, and more importantly, what their results are. We need to understand how neurons choose other specific neurons to create connections with them, how they form those connections on a biochemical level, how they work when transmitting nerve signals conveying information (in “bits” or “chunks”, in what kind of “form”–bioelectrical and/or biochemical), etc. still unanswered so far “ultimate” questions about how the brain works (“practically”). These and other similar questions related to the work of the brain are endless and understandably complex since the brain is, for now, the most complex organized matter we have encountered in the universe. Even though the brain is in (and with) each of us, our knowledge of it and its work is still at the beginning of its building.

There is another question here: How to “reconcile” the idea (concept) of entropy with the existence of the brain? Entropy, according to one of its many definitions, is a measure of the disorder (in other words,

“chaos”) of an isolated thermodynamic system. According to the second law of thermodynamics (there is such a law in physics): “The total entropy of an isolated thermodynamic system (for which we can assume the entire universe) increases over time and tends to reach a maximum value”. So, our universe, according to cosmologists, has begun with chaos (remember the widely accepted “Big Bang” theory so far as the beginning of the universe) and which, due to the action of entropy, is likely to cause even more chaos (disorder). Here, however, a question immediately arises: If entropy really “worked”, then how did the brain appear? For now, we recognize it as the highest self-organized matter existing in the known universe. In the “movement” of the universe from chaos to (a greater) chaos due to entropy, it should not have appeared and existed at all. Naturally, we also shouldn’t be in the universe. But in “defiance” of entropy, we (and the brain) are in this (heading to chaos) universe. Another question is how long we will be there.

Here is my question. Why the physicists, who study nature, always tend to not see the natural things in it? They prefer to replace them with mathematics readable to them only.

But perhaps, it is “very exciting” to imagine that in the end, everything will fall apart again, so that there will be chaos again. Although we still don't know for sure how our universe came about (and why). We know only about the existence of numerous new theories about its appearance and possible end. And that it may not be “lonely” in the “mega universe/multiverse”—a universe made up of multiple universes. More details about these ideas (and theories), dear Reader, you can obtain from the many sci-fi stories, novels, and movies, and of course scientific (and not so scientific) publications dedicated to this topic.

Concepts and theories based on them are a good thing for those who create them. Because of them, they receive funding for new or ongoing research. Here I am tempted to quote some related to this topic lines from "*The Hitchhiker's Guide to the Galaxy*" by Douglas Adams (to whom I have dedicated this book) which, in a perfectly understandable (human) way, raises the question of the rationality of many of our scientific studies, but I will not do this, since I do not have written permission personally from the author or his successors. I, as an author, have a lot of respect for copyright and will not violate it. I can only advise the Reader if he/she is interested, to read his remarkable "*Guide*". I suppose it will affect you as it has affected me, thus changing my perception ("planted" into my brain for years by other people) of many things in life and of course in the universe as a whole. You won't regret your time reading this "enlightening" brain book. Most likely, you will also start looking at "everything" around you with "new eyes".

Scientists who study the brain when conducting their detailed studies usually have access to the brains of deceased patients. But the dead brain is simply not a suitable object for "real-time" research, since, for understandable reasons, it does not process signals a function that takes place in the living brain. To study the work of a functioning brain, researchers have already created numerous complex medical devices and equipment, but they can basically "look at" the working (activated) areas in the brain only. Some publications suggest that scientists can already observe the activity of a separate brain cell (neuron). But they still can not "peek" into separate and precisely defined cells (or selected networks). So we still have to wait for science to create the necessary toolkits (reliable tools and methods) to help researchers understand exactly how the brain works at the

intracellular level when processing incoming information and the signals it generates in the sensory channels in the brain of a living person.

Therefore, in studying such processes, for now, it seems most appropriate to use the “black box” concept, which is used in the study of processes in systems where units/objects are unavailable for a direct study. The same case we have when we try to study the living brain in the process of active acquisition and structuring of knowledge at the cellular (neuron) level due to the information received and processed in real-time.

In cases where there is a lack of knowledge in the brain on a particular topic, it may be better to call it not a “black”, but an “empty box”. And our task is to help that specific individual to “fill” it with the knowledge he/she needs. Unfortunately, as noted in the previous chapter, this process for us people is not as easy as it sounds. The human brain, as they say, is not a “bucket” to be filled by just “pouring” knowledge into it. The process of acquiring knowledge requires time, effort, resources, and specific procedures that differ for each individual, and they must be qualitatively designed, created, organized, and successfully conducted. Otherwise, the process will not produce the desired results (which is equal to the quality of the knowledge acquired), and its effectiveness (which is equal to the ratio of results achieved to spent resources) will not be as good as desired.

The process of “building” knowledge in computer-based AI systems/devices can always be highly effective if we use verified (i.e. proven in practice) human-built knowledge by just uploading it into their memory as digital files (the same way we copy files into a computer memory). However, the structure and links of the information in these files must follow the procedures described in the previous chapter. Therefore, uploading “human-

built" knowledge (as a "background" knowledge) for the static and especially semantic AI will be extremely important for their effective operations. Such an approach will enable the process of further knowledge "self-acquisition" (building) by AI machine learning algorithms to be accelerated based on the uploaded "background" knowledge already created, verified, and accumulated by humans. This approach will eliminate possible errors due to poorly created (and not verified) AI self-learning algorithms or due to the input of inaccurate, incorrect, or not well-structured input data and information. I.e., the rules of the old tried-and-tested principle in computers should be followed to avoid the effect: "***Garbage in, garbage out***" (the GIGO principle). The "brains" of AI systems and devices, especially autonomous ones, will anyway be some new types of advanced computers compared to the current ones (such as size, performance, and reliability).

Here, perhaps, we should remind again that in humans, as pre-set (by nature) "algorithms" of action, we could name only innate instincts, but they are not the subject of this book, with which I try to present my view on the role of information coming from the external environment, of forming knowledge in the brain and building the relevant intellect and intelligence on its basis.

In AI of bio-synthetic type (androids), this process of "pouring" (uploading) ready-made human knowledge will not be possible, since if their "brains" are synthetic copies of the human brain (or an improved version of it), then most likely they will also require a lengthy learning (knowledge building) process as in humans. This may prove to be the biggest drawback of "android" technology.

Let's now use our natural intelligence (so far no other equivalent around us) and try to predict what a joint “blended” (mixed) future society would look like, bringing together humans and artificial intelligence (of all kinds).

When we try to answer questions about our future, usually our “common sense” advises us to look into our past and try to make (if possible) a realistic prediction (forecast) of the future, leaving aside any “wishful thinking” approaches. Let us also try to follow this proven approach, tested by the time and experience (the history) of mankind.

As a beginning, we shouldn’t forget that after all AI is only one, albeit new, technology. Like each one of those, we have managed to create so far.

Like any other technology, AI can also have a “dual” purpose (application)–for the benefit or harm of humans. It's up to us people again. So from the very beginning of the “penetration” of AI and intelligent robots into our society, we will have to accept that this will be a “two-way” road - they may bring positives and negatives to humanity.

Here are two elementary examples of our long-existing “dual-applications” technologies–fire (widely used technology copied from nature) and information technology (artificially created by us).

Fire can be a “good technology” (i.e. useful) when we use it to protect ourselves from predators in nature or warm-up and prepare our food (avoiding getting sick if we eat raw meat, for example). But it could be “evil/killer technology” if we use it to set fire to the huts of the neighboring tribe that is hunting in “our” territory.

Similarly, information technology can be “good” for people when it contributes to their education, intellectual growth, and professional activity, and “evil” when used by certain groups for propaganda, manipulation, and misinformation to spread lies, and hatred, for “brainwashing”, incitement to war and other similar antisocial activities.

From what was said in the previous section of this chapter about the “evolution” of machine manufacturing and automation, it is obvious that AI, or more precisely systems and devices with “built-in” AI, are and will be the next logical stage in the automation of production processes. Static or mobile (autonomous) AI devices will replace humans as direct operators when it is required a “smart” (intelligent) response/action. “Intelligent” here means a correct response to the behavior of complex systems that requires logical analysis of large data sets or information in a limited time. We know that computers, the basic devices in each AI system, take precedence over humans in carrying out such operations, and it is quite natural that these tasks are assigned to them. Of course, certain restrictions should be imposed depending on the type of the system and the operations performed by it.

It follows that for a long period ahead in our future (I do not dare to predict how long it could be) while devices and systems with AI are still designed and manufactured by humans (perhaps in fully automated factories), their functions will be pre-set and controlled by the people who design and produce them for specific applications. There are unlikely to be AI devices (e.g. robots) that are manufactured and simply let to “walk” freely in the cities, armed, so if they don't like humans' behavior they can decide to get rid of them. In my view, such scenarios could be born only in not quite healthy brains or those deliberately seeking increased sales of their books or auditory of their movies. We know that violence, as well as sex, is an

attractive topic for people. However, there is unlikely to be an organization (private or government) to invest in the mass production of AI without certain applications, relevant functions, and markets. Here naturally comes the role of control–internal and external (independent of the manufacturers) to ensure that any manufactured AI systems and devices will under no circumstances be able to intentionally or unintentionally harm people. But, as we know, it is a mandatory task for any producer to ensure the safety of its customers/users.

I could not recommend a better approach to this task than following and "embedding" in each AI or robot *the four laws of robotics* already defined by Isaac Asimov. I suppose the reader has already read his remarkable "*Robots*" series of stories about robots, in which the three laws on robot behavior are defined. The first three laws determine the behavior of (intelligent) robots towards a human, and the fourth one (introduced later by Asimov in his no less well-known series "*Foundation*") was named the "Zeroth Law". It defines the behavior of robots towards human society as a whole, complementing and preceding the first three laws (so perhaps that's why the author called it the "zeroth law"). These (still "fictitious") laws or their modifications have also been used by other Sci-Fi authors who have also written on this topic.

Of course, these four laws or their adapted variants will need to be refined (and made "working") on a case-by-case basis of AI. The "art' here is the algorithms and codes that will realize them (make them work), and in no situation shouldn't allow any deviations from them. If this happens, accidentally or intentionally (deliberately), then the fault will entirely be on their creators (humans) and not on the AI systems and devices themselves (robots or any other "creature" powered by AI).

From the current trend in the development of AI technology, it is obvious that in one, probably not so distant, future humans and AI will start to coexist in a “blended” (mixed) society involving both human and artificial intelligence of different types. What will be the exact proportion between them, only the future will show. It is natural to expect possible points of conflict to arise which, if not foreseen early enough and removed, can lead to tensions in this mixed society. All the previous history of human civilization proves that we had numerous conflicts without even the presence of AI. We do not need to discuss the causes of these conflicts here. They are described in the history books–sometimes more correctly, sometimes more “corrected”. The truth, as in any social science, rests on the honesty and conscience of their authors.

It is clear that if our relationship with AI isn’t built properly from the very beginning, then areas of possible conflicts are likely to emerge in such a society as “mixed intelligence.” Let's try to look at several possible scenarios of our relationship to assess (as much as it is possible to do this correctly today) under what conditions such “social” tensions and/or conflicts could arise.

Let's try now to make a recap of what a future society of “blended intelligence” involving natural and possibly different types of artificial intelligence would look like. In principle, we cannot doubt that such a society will eventually occur. I don't expect such a society to be built too soon, but the “pace” of AI technology development may increase at any moment based on its successful applications. But most likely, its development will go in steps (stages). These stages can provide us with sufficient opportunities for adjustments in our “policy” to AI. But it's always good to take a peek early enough into the “crystal ball” to see what lies ahead of humanity.

To this end, let's try to imagine in a more distant future the evolution, applications (role in society), our possible relationships, and problems that we could have with AI building together such a "mixed" society.

As might be expected, the interaction (relationship) between people and AI in a "mixed" society will be a "summarized" product of individual and group relationships between both kinds of intelligence. The options for these "personal" relationships have already been mentioned above in the text of this section. Let's now focus on their public/social relationships. Those will be again within two main frameworks:

- Positive–communication, mutual support, and collaboration
- Negative–rejecting contacts, competing, and confrontation.

Let's look at both possible variants of relationships. Here, in general, we can conclude that the "human" component in this society of "blended intelligence" will be the leading one and key to the "nature" of these relationships. If it is overwhelmingly "positive", then tolerance (acceptance of "alien" intellect) can dominate society, leading to "mutual benefits."

If for any reason, the majority of people start taking AI (and its "carriers") negatively, then it is very likely that their relationships will become "intolerable" and violent. Most likely AI and the robots to be the "victims" of the negative attitude in society (contrary to popular opinion at the moment) similar to the fate of their "mechanical fellows"–the machines during the movement of Luddites. We are witnessing that it is being "revived" these days (before a real AI has even appeared). Moreover, if all the "*four laws of robotics*", defined by Isaac Asimov, are well "implanted" in AI and the robots by their creators, they should "block" them in any attempt

on their part to harm an individual (subject to the first, second and the third law) or society as a whole (subject to the “zeroth” law).

Let's start our analysis on a “positive note”, so we look first at the possible causes, areas, and conditions for building “positive” relationships.

The main criterion here will be the full and all-encompassing satisfaction of the needs of human society from AI and robots, which will be their main task and “meaning of life” (dear Reader, please remember Maslow’s pyramid of human needs).

In the absence of critical attitudes and complaints against the quality of services provided by AI and robots, society would have no reason to build any negative stance towards them.

Any collaboration between humans and AI should bring benefits to both (intelligent) sides. If one side benefits only, the other one will be in a position of modern-day servants or slaves. This doesn’t fit the meaning of the term “collaboration”.

Here are some direct positives to the humanity of its coexistence and collaboration with AI:

- AI running manufacturing and production of goods thus offering higher efficiency

- AI assisting, serving, and taking care of people in need

- AI “augmented” human intelligence and performance in research, design, and other human creative activities/tasks

- AI systems and autonomous robots may work in hazardous environments replacing and protecting humans

- AI may run production systems and replace humans in “repetitive” tasks in industry and business

- AI may assist humans (24/7) in activities requiring 1-on-1 assistance and care, such as learning (tutoring), healthcare, etc.

- Humans may be assisted by AI in completing time-sensitive tasks, such as controlling complex systems and processes that require intelligent analysis of big data in real-time or tight timeframes.

But there always might be also some possible (hidden) negatives of those positives:

- AI total-care “spoiling” people and leading to their degradation

- Socially “isolating” people–AI and robots, perhaps, may lessen the dependence of people upon other people. Assisting and serving people may “widen” the social “distancing” between them. This may lead to a kind of social “insulation” that diminishes the natural need and attraction people have for each other. This way the whole social system may fall apart into isolated and nonsocial active individuals.

Such “over-care” on the AI side can make people idle and dumb. This is a danger that can cause conflicts between people and AI. A similar warning has been issued repeatedly by many grandmasters in the Sci-Fi genre. Perhaps not coincidentally, since many have proven to be precise analysts (and prophets) of the development of human society in combination with technologies to meet its ever-increasing needs.

Perhaps one of the most positive results (and applications) of the future development of AI will be the construction of “hybrid” intelligent systems connecting and integrating human and artificial intelligence. But here, we have to be also very careful how we build this direct connection

because if there is a targeted harmful use of this technology (mostly) by other people or AI (less likely) it is possible for people to be subordinated through this direct connection to AI. It is better to create an indirect connection with AI through ("telepathic") helmets than through direct brain implants. The helmet can always be taken off at our request, while our implant can "bind" us almost firmly to AI and such a connection can be "broken" (switched off) surgically only.

The preachers of the modern "Apocalypse" explore and present (quite spectacularly) only one "direction" of our relationship with AI. And this is usually the destructive potential of super AI towards its original creators– the humans. But as we have already noted in the text, these relationships (as usually happens to any kind of relationship) are a "two-way street". There is always the opposite direction in them. In the case of our relationship with AI, there may also be a second direction (option), one in which super AI can begin to perceive us not as a threat to its existence, but as "pets", precisely because of our "historical" role in its creation. As we humans (as a "super-intelligence" on the planet) perceive our pets–dogs, cats, etc. living creatures. Super AI may approach us as its own "pets"–intelligent beings but at a lower level. And as a result, will take over the care of us and our protection. I don't see anything fantastic in such a "turn" in our relationship. Here I would like to add that there are already some Sci-Fi authors (unfortunately not too many) who, in their works, also admit this variant of our relationship with AI. And among them is also Isaac Asimov who has already described a similar attitude of superintelligent robots to humans in its remarkable *Foundation* series. Probably, precisely the way our intelligence (i.e. the added emotions and feelings to our intellect) makes us

so caring and affectionate to our pets. Why shouldn't AI “copy” our behavior towards our less intelligent (according to our current view of them) pets?

But what kind of benefits may AI get in collaboration with humans? Those may be in areas where humans will be “superior” to AI–knowledge and “creative intelligence”. Such areas may cover knowledge obtained by scientific research, new design based on human creativity, knowledge built from a human perspective, real-life experience, etc. activities performed by humans or focused on human needs. By design, AIs and robots cannot have a “human” perspective and experiences, but they can “borrow” ready-made knowledge and experience from us.

Here are some possible areas of AI benefits:

- Humans “help” AI perfect its intelligence–they develop and provide new (and updated) machine learning models, software, hardware design, etc. for AI systems that need learning/training before starting working on new tasks and in novel environments. In lab testing, they may be tuned to near-perfect performance in completing such new tasks. This way AI may learn much faster and avoid any failures in “real-life” settings.

- AI “learning” from humans–AI may learn using knowledge created and proved by humans. This way it may “shorten” the learning curve. This approach may also improve AI-humans voice communication interfaces by using human preset vocabulary and grammar rules related to specific topics (especially in narrow professional areas). And probably, they may master human-like “thinking” and (virtual) experience.

Such “positive” examples of mutual benefit collaboration between humans and AI may span an endless number of areas and activities today and in the future.

There are a huge number of variants of useful and even “indispensable” AI applications in the industry. Both previous stages of the industrial “revolution”–the development of machine manufacturing and then automation involving information technology, have helped humanity to increase its number to an incredible figure of approximately 7.8 billion population (as of Q1 2021), to “feed” them and satisfy their ever-growing needs. The next stage of the industrial revolution–the use of “smart” (AI-driven) machines in manufacturing, will help society continue to ensure the existence of the ever-growing population on the planet (the world’s population is projected by the UN to reach approximately 11 billion in 2100). The “AI revolution” is aimed to increase efficiency in all sectors of industry thus saving the ecology and “precious” resources on our planet.

Right now, we see that many of the technologically advanced countries have already turned their eyes to the resources that our neighboring planets–the moon, Mars, and asteroids–can provide us. Unconditionally, the trend of exploration and exploitation of resources of the Solar planetary system will advance. It is inconceivable to imagine that the exploitation of those planetary resources, which will help us preserve the ecosystem of our planet, can be carried out without the help of AI.

But let's look even further into the future. According to astrophysicists, our “father” the Sun, “pours” its life-giving rays (energy) on our “mother” the Earth thus both give birth to life on this planet (including us humans), as everything in the universe ages, and after about 5 billion years of a life-giving star, it will become a killer star. The Sun, due to its evolution as a G-type (“yellow dwarf”) star (according to the classification scheme of astrophysicists), will kill everything alive on Earth much earlier. If, until then, mankind still exists in its planetary system, then its fate will be

predetermined. The only solution for mankind is early enough to leave our Solar system and relocate to other life-friendly extrasolar planets (exoplanets) found in our Galaxy, and then perhaps to relocate to other neighboring galaxies. It is impossible to imagine that without AI humanity will be able to discover and explore exoplanets suitable for colonization. And far before that, we have to develop “jump” (“warp”) drives to reach those far-away stars and planets to colonize our galaxy, and then perhaps other galaxies. Most probably without AI, we will not be able to master this humanity-saving task.

Let’s now try to analyze some situations in society when conflicts between humans and AI may arise.

Conflicts that may arise in this type of mixed society can be caused/initiated by humans (the most likely situation) or by AI (much less likely). Why do I think so? Well, just simply following the history of the development of human civilization.

People usually tend to “play” two roles in society–as creators (doers) and destroyers. Sure, there is always a third group–“statists” who are there doing nothing, just “watching, discussing, and consuming”.

The history of human civilization is full of examples of human destroyers holding the progress of civilization or even reversing it back. Most of those conflicts were humans vs. humans and lately (at the beginning of the 19th century)–humans vs. machines (like the participants in the Luddite movement).

Now a “technology update” is coming and the future conflict promises to be humans vs. AI. Despite AI is still far, far away ahead of us,

some groups of destroyers are already arming themselves. The first attack started already in mass media, Sci-Fi movies, books, and numerous "research" publications on the topic. Next, probably will be the new generation of modern-day "Luddites" (or maybe hackers) that will start crashing intelligent robots and computers hosting AI software.

Their usual narrative is: "AI will take our jobs" and "AI will start slaving/killing us". Just nothing new compared to the "war cry" of Luddites or the causes of the endless number of wars in our history (looking for "culprits" to punish them).

If we look into statistics, we will find many more lethal cases due to transport accidents than caused by machines (intelligent or not) but nobody is crashing cars or tracks deliberately, despite those being also (just transportation) machines.

So far in the history of our civilization, there have been no cases of "uprisings" of machines against humans. I already hear opponents of this fact: Yes, but so far there have been no "smart" machines. This is true, but there are still no such "intelligent" machines in our society (if we do not count the few prototypes in the field). And we are still able to unplug those from the power supply grids and communication networks. But it was said already in the text above that we should always keep under our control the "big red" switch-off button until AI and intelligent robots prove they are "mentally" stable and can not take (in no case) any harmful actions against humans and their society.

Based on this, there are two major topics about AI "hotly" debated in society today:

1. AI/ robots will take our jobs thus making people jobless.

I know that this problem exists and is related to the expected wide adoption of AI into any modern industry, which raises concerns about a possible loss of jobs. This is related to ever existing trend in the increase of business efficiency. It demands some “repetitive” jobs to be allocated to automated equipment. Today, with the need for more complex and flexible (re-adjustable) manufacturing, this task has to be allocated to AI systems and “intelligent” equipment/devices (e.g. robots). But here there are two major points always very “shyly” omitted by the proponents of “anti-AI” ideology.

The first is related to the expected penetration of AI technology into the world economy and its efficiency (i.e. spent resources). As was already said above, mechanization and automation, including “smart” automation, have always aimed at increasing productivity and efficiency in using resources. And this is a process that cannot be stopped. At least because of the limited resources of the planet Earth and the ever-increasing number of its population. The current number is over 7.8 billion according to the latest statistics and the tendency is to become over 10 billion by 2100. So, if we follow the old well-known call: “Back to the caves” neither the caves nor the trees on the Earth will be enough to “house” all of us. Besides, we're going to have to get some food, somehow to feed 10 billion people.

Second (sorry anti-AI guys, this is known to experts only), to be automated (conventionally or “intelligently”) any production setting must be redesigned completely or (much better) designed anew. Otherwise, any kind of automation (no matter how much “intelligent”) will not reach its goals– increased quality and efficiency. So, to redesign all of the world’s industries (of all kinds) humanity will need so many creative professionals (researchers, engineers, software programmers, etc.) that I doubt the current population may supply (or educate) in time to complete such a “Herculean”

tasks/labors. If humanity wants and plans to do this, it is better to start doing it now. It is not an easy task feeding a 10 billion population at the end of this age.

So, calls like “Stop AI!” are just stupid, aren't based on any real analysis, and don't give any meaningful solutions to any problems related to everyday life, our jobs, or the protection of the ecology of the planet. The solutions are “obvious” (involving “better” technologies), but humanity should want (and be able) to see and assess them professionally, not emotionally.

2, AI/robots will enslave or kill us (because of competition or their direct military aims/applications).

Reading most books on the history of human civilization, one can conclude that it lists endless wars between humans. If there were some periods without wars, then those were used by the people (usually populating neighboring countries) just to prepare for the next war.

Here I also hear objections from AI opponents such as: “What about AI systems and devices deliberately designed and produced for killing an adversary's soldiers?” or “What to do if these systems get out of control and start killing (all the) people?” They quite fairly pose these “painful” questions, but in this case, we should immediately note that these kinds of devices and systems are (will be) created especially for such purposes (“applications”)–to seek and destroy/kill. Most likely there are a lot of those already created and ready for use, but for understandable reasons, they are not widely advertised, neither by their creators nor by those who (will) use them.

And we must immediately remember that every single technology created so far by mankind has the possibility of a “double” application. Starting with “mastering” the “technology” of using fire and making stone blades from our ancestors at the “dawn” of mankind and getting to modern computer chess games with built-in AI algorithms. The first two were used to kill and skin the prey and prepare food on fire, as the baked meat is more easily digested and safer for consumption. But the same two “technologies” can successfully be used to set fire to huts and kill members of the neighboring tribe, as it hunts in “our” territory. Algorithms with built-in AI used in chess games are most likely used to simulate large-scale military action in so-called mini-max tasks, where the major task is usually to achieve maximum results with minimal losses or other similar variants of results.

So here again we come to the question of who and how will control AI created by us. I suppose this issue will stand before humanity for a long time, especially until people are at war with each other.

We should also not doubt that AI will evolve as both a system structure as well as a capacity (level) of intelligence. Obviously, in the early stages of AI development, people will create various modifications of AI following the development of the technologies and applications for which they create it. But most likely at a later stage of the development of AI devices and systems (for now, other more appropriate terms do not come to mind), AI at a human level of intelligence or higher can take its development (and future) into its own “hands”. And accordingly, these highly intelligent AI systems may start to decide what should be their role in a mixed society comprising people, robots, androids, and who knows how many other “things” “gifted” with artificial intelligence by their creators (humans and/or

other AI systems). And then they may decide that they do not want the "meaning" of their life to be determined anymore by people (only).

Many such scenarios of AI evolution and inclusion into human society are depicted in a multitude of Sci-Fi novels and movies, unfortunately, most of those are in the anti-utopian genre. Those range from people losing jobs because of AI to endless wars between humans and machines/robots for domination, or humans killing/wiping off their creations–human-like androids (or the opposite), etc. negative Apocalyptic scenarios. Probably the "legacy" of the Luddite movement which started at the beginning of the 19th century is still very much "alive" in the mind of today's society dimming all possible positives of a fruitful collaboration between humans and any kind of AI. Why is this a negative stance? Most probably because people always fear something they don't know/understand well. And the constant misuse of "double-edged" technologies by groups of people who want to dominate the planet and humanity. But there always have been and will be such people who use technologies not to make other people's lives better but to slave or kill them.

It is quite understandable, that our society today is concerned that these possible negatives of AI/robot implementations worldwide may lead to clashes and violence between humans and robots. And even further–the extermination of humanity if we are not able to take control of the situation.

So, in the text below (to be on the safe side), we will consider and analyze also some possible "apocalyptic" scenarios caused by the wider adoption of AI technology in human society.

But let's, without unnecessary emotions, try to analyze from which type of AI (and why) a possible threat to humanity would come. Let's consider these possible threats according to the type of AI:

1. AI systems and "intelligent" robots with mechanical structures and processing information like computer-type devices. As already said above, the main area of application of such systems and devices will be for automation of manufacturing processes in the industry, offices, and a variety of services related to people's daily needs (e.g. household chores).

Of course, similar ("narrow") AI systems designed for specific military applications are produced and used already by numerous governments and companies around the world. This process cannot be avoided, for the same reasons that governments and many specially created international organizations have failed to address the problem of the development and proliferation of weapons of mass destruction. But it was and remains a "human" task and problem (AI involved in such activities are just "tools").

It is almost unbelievable that AI devices and systems and people have a common area for a confrontation of the type of "competition for vital resources". The only possible area remains competition for jobs, but this process will be dictated by humans and their economic considerations and the objective of increasing the efficiency of operations (not by AI itself–I doubt they will ever fight to get any jobs). The decision to replace people as a workforce in manufacturing and business as a whole will be a "human" solution. **Chapter 2.3** presented an approach to avoid such competition by introducing a new efficient knowledge transfer method that would allow people to quickly and effectively retrain in areas where they would be unconditionally more competitive than AI. This is an urgent task to be carried out by government administrations and businesses around the world before

the real “AI age” comes bringing all advantages and disadvantages to humanity.

Similar (computer-based) AI systems and robots specially designed for military “applications” can be used (involved) in conflicts directed against humans, but these actions will be planned and carried out by people (groups) who openly or behind the scenes initiate and manage them. It is clear that in such situations AI and robots will be used as “tools” for realization and will not be initiators of the conflict. Decisions about their use will once again be people's prerogative.

2. Brain implants–these are computer chips building direct links (interfaces) between the human brain and AI systems.

This is the next “step” in the development of AI technology and the creation of a channel for immediate interaction between humans and machines. Here the term “machines” means various computer systems with AI software including “smart” robots and manufacturing equipment. A major area of these devices will be to build easy-to-use human-machine interfaces for direct two-way communication, access to computer/AI-generated data, and the exchange of information.

However, the widespread use of direct human-machine interfaces based on computer chip brain implants can also be considered as “double-edged” technologies (e.g. may be used to subordinate/“slave” humans).

Among their positives are: the ability to “augment” human access to information and knowledge, increase their level of intelligence, and creativity assisted by a “remote” AI. Solving complex and urgent tasks may be

completed more efficiently in collaboration with AI. Human personnel could be “freed” from “boring” and repetitive operations, etc. benefits.

But they hide also some negatives. As was said above, among those is the high risk of “slaving” humans connected to computers/AI if the interface is not controlled by humans. The most possible “villains” behind such attempts may be humans who control computers or AI by predesigned and installed malware. From human civilization history, we know endless such cases when powerful people use fake ideologies and beliefs targeted to slave human minds (and many times they did this very successfully).

The next-in-line possible “villain” is AI itself, but its reasons for doing this are not quite clearly described and explained in many recent publications dedicated to this topic. What could be AI’s goals and benefits for enslaving us? Will they turn us into “batteries” or (their) production (sub)units? Most unlikely. The batteries and production equipment we produce using manufacturing technologies are much more efficient than we humans. Fighting for common resources? It is also highly unlikely. AI-controlled spaceships and moon/asteroid mining equipment could have much easier access to extraterrestrial mineral resources than we could do it. So, what other “needs” may AI have?

Such questions should be analyzed in depth by AI designers and developers, but omitting all fake “scaring” scenarios much loved by many Sci-Fi authors and irresponsibly distributed by technophobes.

The only possible solution to such evil attempts to “slave” the human mind is if humans are assigned the highest priority in controlling such direct (human mind-AI) interfaces and the ability to be disconnected at any time by

the will of the human (the “master”) if they feel a threat to their free will and reasonable/accountable behavior.

As an idea, direct human-AI interfaces seem attractive, but they may hide within themselves the possibility of attempts to subordinate people's behavior from commands coming from computer devices. The users of such interfaces must be very careful they use safely designed communication devices that always offer human-run control (in no case they shouldn't be under a complete “machine” control). If there are any attempts for malicious use of such interfaces, then those will be mostly the results of “evil” minds and actions of other people, who, through malicious software hidden in AI, will try to subject people who are using such implants. Their aim may be to make the users obey their commands thus achieving their own hidden goals. It is unlikely that the computers themselves, or AI, will decide to generate malicious codes aimed at subordinating humans. What could be the purpose of the machines (even “smart” ones) to decide to subordinate and use humans? All the machines, according to their design and functions, are “rational” devices, but in the case of such a “malicious” machine “behavior”, there is nothing rational. Such scenarios are usually only in Sci-Fi publications aimed at generating some intrigue in their plot, but their initiators and “users” are again the people.

3. Nanorobots (nanobots)–these types of robots can be considered as a standalone variant or subtype of brain implants. Such devices, a future product of nanotechnology, are unlikely to have enough “brains” to install (real) AI in them and will most likely work together as “swarms” of “narrow” AI super miniature robots (hence nanobots) with specifically assigned functions. For now, such devices are only in the imagination of researchers and engineers. Their technology is yet to be developed.

Nevertheless, let's consider such a possible “scenario” in a not-so-far future – the appearance of human “Jedi” having nanorobots circulating in their bloodstream as those fictitious “midi-chlorins” introduced by George Lucas in his *Star Wars* Sci-Fi epic movie saga. Those nanorobots constantly may take care of the health condition and augment the intellect of their “masters” (human hosts) by linking their brains directly to a knowledge “cloud” hosted by AGI or ASI-based systems. Dear Reader, please remember what was noted in the previous chapter about creating a global knowledge hyperspace and its role for humanity and AI alike.

Linked to the neocortex in the human brain (involved in higher-order brain functions according to neuroscience) by implanted “swarms” of nanorobots, the knowledge cloud/space can constantly deliver on-demand the latest knowledge updates and upgrades in any selected area. This way the “force” (the real power of knowledge) will be always with us. And not up-to-date knowledge only but also real-time suggestions on how to apply it. As an example, in case of a health emergency, the phrase “Is there a doctor in the room?” will get obsolete, as the doctor (actually a multitude of various nanobot-doctors) will be always in the “room”–the human body powered by the latest updates of knowledge on the specific medical case.

Today we can dream of such a scenario only hoping that in the future (let's hope not so far), this may be the best outcome of the AI “revolution” benefiting all individuals without exceptions and the human society as a whole. A “super” human may be born with the assistance of ASI (created by humans). Everybody possesses intelligence at the highest level and is constantly in good health condition. Doesn’t sound bad, does it?

Such a combination of both emerging AI technologies and nanorobots may be humanity's "winning bet" in the fast-approaching AI "technology singularity" (that "unspecified" term dubbed by the AI guys recently). And probably it could shut up the screams of the neo-Luddites (at least for a while because they are also very creative when fighting the technology progress).

4. Androids–humanoid-type "robots" products of synthetic biotechnology (bioengineering).

Following the UN demographic projections of an overcrowded Earth and the current trends in manufacturing automation, involving AI and intelligent robots, it is unlikely that an additional population and "workforce" will be needed at the end of the century. And we started already calling it the "AI Age".

Therefore, androids are most likely to be "produced" (if such technologies will be developed at all) and used initially for colonization of planets and asteroids in the Solar system, and much later, probably, for colonization and terraforming of planets in other star systems of our galaxy. To undertake such endeavors humanity should initially create a space transportation industry (probably with the help of AI, again). This industry will aim to exploit the natural resources of our neighboring planets and asteroids and start production in orbit to avoid further destroying the ecology of the planet due to the continuous population growth and its economic activities. Later, the goal will be to help humanity colonize selected exoplanets in our and probably other galaxies to avoid their extermination as a result of the end of the Sun's "life" cycle as a G2V-type star (an inevitable fate, according to astrophysicists). Since androids, although synthetic bio-

creatures, will be very close in biology to humans, they will most likely be the first “candidates” and emissaries sent by mankind to prepare distant planets (outside the solar system) through terraforming for colonization by the growing mankind. But for now, these are just exciting storylines from a multitude of Sci-Fi works. Humanity must first develop and master effective interstellar travel technologies and “production” of “reliable” AI (of any kind).

Of course, this list of types of AI and situations that can lead to conflicts between people and artificially intelligent “creatures” is not exhaustive. With the evolution of AI and the blended intelligence society, many new options can emerge to be added to this list. But if we now stop the development of AI because of our fear of it (or for someone's interests), then what kind of “future” we will create and “pass” to our distant descendants? Or we will “get out” and, as usual, say, “This is not our problem. It's someone else's (their) problem”.

There is also another case when humans could start to fear AI. This is the case, if (or when) AI gets “smarter” than us (e.g. in the case of ASI self-evolvement). Then the “superintelligence” may decide to “get rid” of us (its “masters”) or “slave” us. But why it may want to do it? What is the basis of such a decision? And what could be the benefits (if any) of “super” AI to take such actions? At the time being, I can not come to any reasonable conclusions. Most probably we will be of no use at all. Then the only “super” logical decision will follow–“wipe” them out of the planet.

This belief (notion) that when our “smart” creations reach or even surpass us by their level of intellect, they will “turn” against us, their creators (humans), and begin to subjugate and/or destroy us, most likely comes from

the “blueprint” of our behavior to the other living inhabitants of the planet, whom we have thought were less intelligent than us. This approach has been applied many times to other people and animals throughout the history of human civilization, by which groups of people more technologically advanced have applied power demanding obedience or extermination to other groups lagging in their technological and social development and, as a consequence, considered to have a lower level of intelligence.

Following this kind of “logic” of such thinking, groups of people that consider themselves intellectually more advanced quite “lawfully” assume that social behavior aimed at subordination, exploitation, and/or destruction of other living creatures with a lower level of intelligence (at their measures) is a normal phenomenon that inevitably occurs in such “mixed” societies. Perhaps those groups draw similar conclusions based on the “rich” experience of mankind in the way of its development as a society of individuals and groups with different intelligence (hence levels of social hierarchy). The “helper” (“collaborator”) in these violent actions that made them possible and successful has always been the level of technological development that is also the result of intelligence, thus also serving as an “excuse” for such behavior. Yes, and as a rule, we humans have always considered ourselves the “wreath/crown” of nature, i.e. with the highest level of intellect/intelligence. As a result, we are usually the first to take action to destroy the less intelligent creatures. The “excuse/proof” for such actions has always been found.

So if any clashes arise in the future between humanity and any kind of artificial intelligence, then they are most likely to have been triggered, and perhaps planned, by humans.

Every single conflict is triggered usually by competition for vital resources, and we are unlikely to have an area for such competition with computer-based AI systems and robots, especially since we create them.

In many Sci-Fi works, there is another “hot” topic, especially when describing invasions of aliens (“alive” or mechanical). They are usually aggressive (Of what other kind they might be, if not aggressive? We just can not imagine any other kind of aliens). And they usually want (or don't want) our women. What kind of larger topic of conflict could exist in humanity? But in the case of AI and robots created on Earth, I guess there won't be conflicts because they want (or don’t want) our women. But, if they're “alien” robots, then I don't know and don’t want to speculate on this topic here, as it is too complicated to be analyzed correctly and to draw any “meaningful” (intelligent) conclusions.

Here we must not forget another important issue related to our relationship with AI. That's the theme of our relationship based on the law. For now, we call it (again from our point of view only) “AI ethics” thus turning it into a “one-way” street (i.e. it applies to AI only).

Currently, we consider AI ethics as a complex of duties and rules (“laws”) applied to AI only, e.g. what kind of limitations we should apply to them to prevent any possible damages they may cause to humans. This approach is understandable. Humanity exists, but the “real” AI still doesn’t. But too few authors investigate our human obligations and permissible actions to (against) AI. Our perspective on AI ethics has to be a “two-way” street if we wish to avoid any mutual misunderstanding and development of any negative stance in society leading to a later (probably meaningless) confrontation.

Nowadays, the theme of the rights of the “intelligent” robots (those with AI) is starting to be discussed, and perhaps their “slave” fate will be avoided. The future will tell. But, as always, it will depend on us people again –how much we are tolerant of new things (in this case unknown) and how quickly we consider them “acceptable” (and most importantly useful to us).

If we humans learn (ever) to respect intelligence as the “top” creation in the universe, then we would probably never disrespect the “alien” intelligence—be it artificial or out of our planet (e.g. real alien). For example, try to destroy physically intelligent robots or “pull out the power cord” of an AI computer system. This would be contrary to our ethics and the value system built on it. But who knows? We know that we humans are “contradictory” beings, often subject to our emotions rather than intellect (“pure reason”).

The topic of human-AI ethics is wide and complex and it must be subject to separate studies, publications, and public discussions before any laws governing our relationships in the future “blended intelligence” society are established.

Here, however, we should not overlook the fact that the number of “social” Sci-Fi publications is growing, in which their authors, apparently after extensive observation, study, and analysis of social processes in modern society, increasingly present us with an all-encompassing human society in which humans, due to easy access to an abundance of affordable goods, services, and care by crowds of very “attentive” robots, have become lazy morons instead of inspired explorers, creators, artists, etc. high-intelligent inhabitants of the universe. This trend is presenting such a (very possible) disturbing development of human society, in which our

"harmonious" cohabitation with "armies" of service robots and highly automated production of accessible goods and services will lead to the blunting of humans instead of their intellectual growth, is quite alarming. Perhaps this is the real area of interest where researchers should be directed on how to avoid such a "deformation" of an over-satisfied society as a consequence of the enslavement of humans by AI and robots (an idea underlying Frank Herbert's *Dune* Sci-Fi series). But if we are dumb and of no good for doing anything, what can we be useful to them for? Given that we have gone so far as to be unable to take care of ourselves, it will "naturally" lead to our extinction as a species without the need for any violence on the side of robots and other "smart" machines. Nature knows that such "inertness" in life (no action and adaptation) works exactly this way–the species incapable of adapting disappear from the habitat. The billion years of evolution of living species on the Earth have proven it. Maybe artificial intelligence is the future of intelligence in the universe, and our role is simply to create it (and then disappear in time). And that could be the end to humanity acting simply as "intermediate" participants in a cosmic-scale "relay" race called "pass the intelligence."

As a conclusion of this section (and chapter), we may say that today we still could speculate only what to expect in a "blended" society comprising us and a variety of intelligent systems and devices created by us. We are still far away from creating a "real" AI. Today, we call many "smart" devices and systems "artificial intelligence" but all of these are still various kinds of "narrow" AI. When we will be able to create an artificial general intelligence (AGI) equal (or close) to our human intelligence is also not clear. Not to mention artificial superintelligence (ASI) that may appear as a result of AGI self-evolvement (if such a "super" intelligence could be able ever to

appear by itself as we probably will never be able to create “something” more intelligent than us).

Today, computer science and information technology still underlie the AI we create. Hence, the “innate” functional limitations of computing systems “frame” it. So we are still the “masters” in this “mixture” of “natural” and “machine” intelligence. But if in the future, the basis of AI moves to synthetic biotechnology (bioengineering), thus giving “birth” to humanoid androids, its capabilities and functions may change drastically. Then the “balance” in our “blended” intelligence society may shift to AI putting humans into an “equal” position (in the best case) or even into the role of an “inferior” intelligence in such an AI-dominated society (the most “unwanted” outcome to humanity). So, the future biotechnology and bioinformatics (created by us again) may “tip” the scale making bio-AI superior to humanity. As always, the future will give us the answers and show the proof we are looking for today.