High Level Brain Functions and Structure Can Inspire Autonomous Systems with More General Intelligence

Pavel Loskot

ZJU-UIUC Institute, Haining, Zhejiang, China

Abstract: This is a speculative paper discussing high level structure and functions of the human brain. Our brains consist of the evolutionary old limbic system surrounded by the newer cortex and neocortex. The high level brain functions can be viewed as interactions between two complementary sub-systems. Alternatively, the high level brain structure and its functions can be described assuming the left and right hemispheres. The main objective of this paper is to inspire a high level design of intelligent autonomous systems while being aware the brain own limitations. Using Sherlock Holmes's style of inductive reasoning, some constraints and loose bounds on the design of such systems are suggested. This strategy complements other lower level approaches in the literature, for example, studying and mimicking processing flows of our visual perception.

Keywords: Artificial intelligence; brain function; brain hemisphere; brain structure; energy efficiency.

Claims

a. Knowledge of high level brain structure and functions can be used to design intelligent systems as well as to devise systems for the brain control and manipulation.
b. In complex systems, the structure and function are interrelated. This can be exploited by deep learning.
c. The human brain represents a very loose upper-bound on the achievable complexity of any technology.
d. The human brain level of general intelligence is not achievable by any existing or future technology.
e. The energy efficiency of information processing is one of the most fundamental limits in physics of computations.
f. Biological circuits are difficult to control, but they are inevitable in constructing systems with general intelligence due to their energy and information storage efficiency.
g. Building general intelligence systems is constrained by the availability of appropriate mathematical tools.
h. General intelligence is not the same as passing the Turing test.
i. In many scenarios, more general problem solving rather than general intelligence may be sufficient.
j. General intelligence can be decomposed into a finite set of tasks and functions of varying specificity.
k. General intelligence can be approximated by combining many narrow-sense intelligence systems.
l. General intelligence must be implemented as interacting hierarchical heterogeneous circuits.
m. The reality should be projected into multiple views to aid the perception and decision making.

1. Motivation

The human brain offers the most general intelligence we are aware of. The brain is also the most complex structure in the known Universe. For all complex systems, the function and structure are closely related. The coupling between the function and structure appears to get stronger as the system complexity increases in time. Since none of the existing technology can reach the complexity of the human brain, its functionality including general intelligence cannot be reached. It is very likely that accomplishing full general intelligence at the human brain level will mandate the use of biological systems, perhaps artificially grown under a controlled evolution in research laboratories. Ethical issues aside, the technology in Life Sciences may one day progress sufficiently to allow keeping living brains outside the body, transplant the brain parts between individuals and even species, and interconnect multiple brains into a super-intelligent cloud. More realistically, our brain presents a very loose upper-bound on the achievable complexity of any technology. It implies that, with our current technology, we can at best hope for merely implementing some selected functions of general intelligence. However, the number of configurations of such artificial intelligence systems can be extremely large or even infinite. The bottom line is that our current technology already enables to build different artificial intelligence systems having very different features and capabilities depending on the target environment and the desired applications. It should be

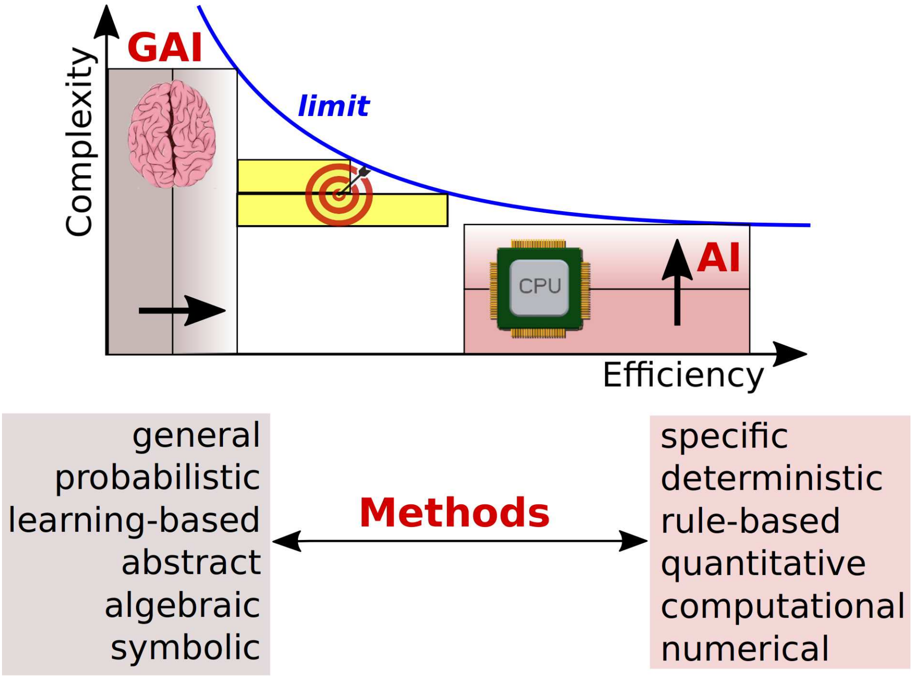

Figure 1. The complexity-efficiency trade-off of problem solving. There is a large gap between the capabilities of our brain and our technology. Different methods are required to solve general and more specific problems.

noted that currently there are no practical and *widely accepted* definitions of general intelligence, even though such attempts were made in the literature. For instance, one can attempt to define the most general intelligence, or the intelligence which can correctly solve most of the problems, or the most difficult problems, or a certain class of problems.

Most of us intuitively feel that our brain has its limitations. In trying to gain an understanding of these limitations, consider Figure 1 showing the complexity-efficiency trade-off which is encountered in all problem-solving tasks. The human brain appears to be designed to excel in solving difficult and complex problems including the tasks pertinent to general intelligence at the cost of algorithmic efficiency of finding the solution. On the other hand, the human developed technology is useful for efficiently solving information processing problems as long as the solution can be well-defined. There seem to be a large gap between the complex-solving capabilities of our brains, and the algorithmic-solving capabilities of our technology. Bridging the gap can be a desirable target for future development of intelligent problem-solving systems. This will likely require combining biological and technological systems. Moreover, as shown in Figure 1, more complex problems require approaches which are general, probabilistic, learning-based, abstract, algebraic and symbolic in their nature. The problem solving efficiency becomes important for less complex problems, and the appropriate methods are specific, deterministic, rule-based, quantitative, computational and numerical.

Considering the evolution of complex engineering systems such as information and communication technologies (ICT), we can identify at least two complementary innovation strategies that occur in parallel. The first approach works with fundamental performance limits which should ultimately be achieved. Knowing the fundamental limits inspires and drives the innovation. The limits can sometime be translated to lower level tasks. For instance, difficult tasks are broken down into simpler problems and the corresponding solutions are then integrated. The second approach aims at iteratively improving the existing solutions until the fundamental limits are reached. In this approach, the problems are resolved as they are identified which, however, drives the complexity of the underlying system. The current AI development seems to follow this latter approach by proposing many heuristic improvements to existing designs of intelligent systems. In this paper, the first approach is advocated by raising awareness of the high level brain structure and its functions.

Furthermore, engineering practice clearly shows that it is extremely useful to separate concepts and ideas from their actual implementation. A given concept or idea can have different implementations with different characteristics and user experiences. In most cases, the main concept or idea is simple, however, the implementation often requires additional complexity to provide a robust solution which is resilient against anticipated as well as unpredictable events. Another widely used strategy for managing complexity in large engineering systems is to separate the problems and concerns and to exploit different levels of hierarchy and abstraction. For instance, modern telecommunication networks have hierarchical topology, and assume multiple abstraction layers to define communication and information processing services.

The current literature indicates that there is an enormous interest to study and understand the human brain. These studies are enabled by modern imaging methods such as functional magnetic resonance and positron emission tomography as they became much more affordable in recent years. As new models of cognitive functions of the human brain are being developed, there are efforts to utilize these models in various machine learning tasks to improve their performance as well as efficiency. Whilst this strategy will eventually bring the desired outcomes, it is still a low level approach which may require lengthy evolution before providing the functionality expected from general intelligence. For instance, most current machine learning methods are mainly concerned with fitting mathematical models to observed data. Since there are limits to what can be learned from the data, the model fitting must be extended with other techniques including causal decision making before having any hope of arriving at more general intelligence.

Another strategy for engineering the systems with more general intelligence is to design brain-computer interfaces. Provided that such interfaces are implemented non-invasively, there are limits on accurately reconstructing the inner state of the brain from external measurements. However, it may be sufficient to accurately and reliably detect a small number of intentions in the mind, so a full reconstruction of the internal brain state is not necessary in most practical applications.

In this paper, the main idea is to explore high level structure and functions of the human brain in order to inspire high level design of systems with more general intelligence. Some of the ideas may also be useful to guide the implementation strategies. The rest of this paper contains the following sections. Section 2 presents a high level structure of the brain whereas Section 3 outlines high level functions of the brain. Conclusions including a brief discussion is given in Section 4.

2. High Level Brain Structure

A high level organization of the human brain is surprisingly straightforward and simple. It is when we move deeper into the structure at lower levels when the brain complexity progressively and rapidly increases. It is estimated that there are 100 billion neurons with 100 trillion synaptic connections in the brain. One neuron processes signals from about 3,000 other neurons. Interestingly, the signal-to-noise ratio for signal transmission between the neurons is very close to its theoretical minimum (known as the Shannon limit in telecommunication engineering). The total throughput of neocortex is estimated to be 1 Terabyte per second while its memory is estimated at 2.5 petabytes of information.

The neuronal and other interactions in the brain are occurring in multiple domains including chemical, mechanical, electrical, magnetic and quantum interactions. The brain is known to have an extreme plasticity, and it is in the permanent state of creating, rewiring, and pruning neuronal connections in response to external and internal stimuli. During the adolescence, targeted pruning specializes the brain structure to improve its efficiency, i.e., the long-term unused connections are removed. The brain has a remarkable ability to carry out self-repair, and to transfer some of its functions between different areas.

The perception of neurons to be hardware and synaptic signals to be software is rather misleading. More accurate vision of the brain assumes that its hardware and software is the same thing, and they cannot be separated. In total, there are over 1 trillion parts in the brain. Each brain cell is a supercomputer on its own providing very advanced features such as self-repair. It is provably impossible to exactly reproduce the brain on any human-made computer. The brain is processing over 20 types of sensory signals from the internal and external environment including visual, aural, chemical, gravitational, acceleration signals and other.

The brain functions are dependent on constant support from other biological systems in the body. This creates many opportunities for indirectly controlling the brain. Despite common believes, the brain is very energy inefficient. It is by far the least energy efficient organ in our body. It consumes between 9% to 20%

of the overall energy in the form of water, oxygen, electrolytes, proteins, carbohydrates and fats. The energy consumption varies substantially between the minimum and the maximum levels during the day when we are awake. Even during the sleep, the brain consumes at least 9% of the overall energy, and it typically consumes 30% of oxygen at rest. The blood capillaries can be found every 100 micrometers throughout the brain. Such high levels of metabolism occurring in the brain produce the corresponding amounts of metabolic waste which must be constantly removed to avoid toxicity. In order to improve its energy efficiency, the brain adopted different strategies and mechanisms to reduce its energy consumption to a minimum as much as possible. It uses hormonal and metabolic control to avoid high energy rational thinking, and also rewards it (e.g. by releasing feel-good hormones such as dopamine). These energy control mechanisms have many social and psychological consequences. For instance, it is the reason why "thinking feels painful", why it is so challenging for students to maintain their study habits, and why ready-made solutions and answers to problems are proffered. Surprisingly many people may prefer hard physical chores to intellectually demanding work in order to maintain the low level of energy consumption in their brain. Without realizing it, we let our brains to act emotionally and be at the animal-level brain functioning most of the time. The higher level social and cognitive reasoning processes in the brain are turned on only occasionally. Since without energy the brain cannot function, the evolution suggested that we should store energy (i.e., eat food) as much as and whenever possible. Hence, the humans are fully governed by biological laws, and are part of the Nature more than they realize.

The key question is why the Nature allowed evolution of such hugely energy inefficient brain structure. One can hypothesize that there is a fundamental physical law that the energy demand for information processing grows quickly with the complexity of such processing. Interestingly, the immune system of our body considers the brain to be a foreign object which must be destroyed. Therefore, the brain must be kept isolated from the cells of our immune system, otherwise it can lead to a death in less than half an hour.

The brain evolution was unstable and chaotic, but also extremely fast, mainly due to artificial selection. It took only 4.5 million years to evolve the human brain from a 300 grams monkey brain. In comparison, this is 20 times faster than the evolution of birds to be able to fly (a lot simpler task to achieve). The main structure and organization of the brain comes form Paleolithic age about 2.5 millions years go. There are several theories why the brain evolution occurred. The key drivers behind the brain evolution are solving reoccurring tasks which were (and still are) important for the survival such as getting food, reproducing and maintaining safety. The key role was played by the emergence of social interactions including language development (the theory of social brain), navigating in complex 3D environments, using tools, and adjusting from night to day living. Within social interactions, the key tasks were cooperation, cheating, and decoding feelings of others. Interestingly, mutual cooperation activates the brain areas which overlap with the centers for reward. This suggests that cooperative behavior was crucial in our evolution. In addition, physiological and psychological pains originate in the same area of the brain, so they cannot be easily distinguished.

Artificial selection means making conscious decisions about choosing mating partners to maximize the evolutionary fitness over broader and more carefully selected features. It enables to rapidly adjust the selection in response to changes in the environment and in the society. In given state of economical and cultural development, the society prefers certain skills and capabilities. For instance, the widespread industrialization in the 19th and the 20th century prompted establishment of many technical universities. It provided the intellectually capable individuals with an upward social mobility which made them more visible to evolution.

More importantly, artificial selection caused decoupling between the evolution of the brain and of the body. Consequently, the phenotype and somatic functions are shared by all human beings on the Earth. However, the brain structure, and thus, also its functionality can show striking differences even among close relatives. These differences cannot be overcome by any education or upbringing. Some parts of the brain may appear only in some individuals while the size of some parts can differ as much as 40 times in different individuals. Such huge variations in our brain structure are larger than e.g. the differences between the brains of fox and wolf. The brain variations are reflected in cognitive capabilities. It explains why some people have very unique talents, and why they are very rare geniuses. For instance, the Intelligent Quotient (IQ) is one dimension for assessing the brain capabilities. The IQ number should reflect the thinking efficiency of an individual, i.e., the ability to think fast and to remember more. These skills, however, can be improved to some extent by an appropriate training.

Interestingly, emotions can drop the IQ by 30 or more points. At the IQ level of about 160 (often regarded as a geniality threshold), the notion of IQ breaks down as more complex thinking patterns start to emerge. Albert Einstein is assumed to have the IQ score just above the 160 threshold. Einstein himself attributed his groundbreaking scientific discoveries to his imagination rather than to intellect.

The overall average brain mass peaked at about 1650 grams 150,000 years ago. The brain mass has been slowly but continuously declining ever since. This decline became faster after the beginning of the industrial revolution about 200 years ago. The current average brain mass is about 1350 grams. The loss of 300 grams of the brain mass over the past 150,000 years is significant. The aging causes the brain mass loss of about 30 grams every decade. The decline of brain mass is also interesting from the perspective of complex systems. In general, as systems grow in time, their complexity increases, since the problems are becoming more complex and require more complex solutions. However, the complexity increases are not occurring uniformly, but as sudden and abrupt leaps over time. Moreover, the scientists claim that all major human inventions, especially those related to information processing and recording such as writing, book printing and ICT can be clearly detected in structural changes of our brain.

One must wonder why larger brains were not develop also in other animals, especially primates, since they had to process the same environmental information as humans. Moreover, it is apparent that larger brain (i.e., intelligence) does not guarantee survival. For instance, large animals may become extinct whereas insects are more likely to survive even drastic environmental changes.

The basic high level brain structure is depicted in Figure 2. The limbic system represents the evolutionary oldest part of the brain, although it only forms 10% of the overall brain. It is always on, but it has very little energy demands, so its functions are relatively easy to maintain. It is mostly hormonally and metabolically controlled (in general, bigger areas in the brain dominate and control smaller areas). The limbic system provides basic emotional responses, and drives our instinctive behaviors and desires without conscious motivation such as anger, reproduction, eating and dominance. It is the main source of living will, so it affects everything else.

The cortex and neocortex represent 80% of the brain mass. They are evolutionary newer parts, and they are used for reasoning, and to perform many other complex tasks. They developed from the centers for sexual behavior which is strongly affecting all our choices and decisions up to these days. The neocortex control is more complicated, but it is the key for influencing and controlling the behavior of people in modern societies. These parts of our brain have high energy demands. There is constant negotiation between the old and the new brain and between the instinctive and socially acceptable behaviors which is known as the duality of consciousness. There is clear clinical evidence that different parts of the brain are used differently by males and females. For example, the frontal cortex evolved to specialize in caring for children by females, and to share resources beyond the closest relatives which does not exist in other mammals. This part of the brain was subsequently adopted by males as the center for innovation and creativity. Moreover, the frontal lobes appear only in humans. They provide human capabilities such as strategic thinking, planning, social interactions, and understanding other people feelings and also abstract concepts including humor, irony and poetry. We can say that frontal lobes act as a specialized computer inside the brain.

A fundamental question is why the evolution designed the brain divided into two asymmetrical hemispheres (not only in humans, but in many other species too). This asymmetry is in contrast to other symmetrical paired organs in the human body. The brain hemispheres are interconnected by mere 2% of all the neurons. The main purpose of these neurons is inhibition (25% of all the neurons in the brain have inhibitory function) of one of the hemispheres as a result of constant negotiations between the left and right hemispheres. The inter-hemisphere communication varies in time. This plays a significant role in dividing the attention between the hemispheres ion constructing appropriate representations of reality. The attention is, in general, much more than just a cognitive function. Tuning the attention can change how the reality is perceived.

3. High Level Brain Function

The 99% of processes in the brain occur in the unconscious mind. The processes in the unconscious mind can be thought of as being automated. The automation is crucial for skillfully and effortlessly performing many tasks in our everyday lives. They were developed as a result of evolutionary adaptation to the environment. A

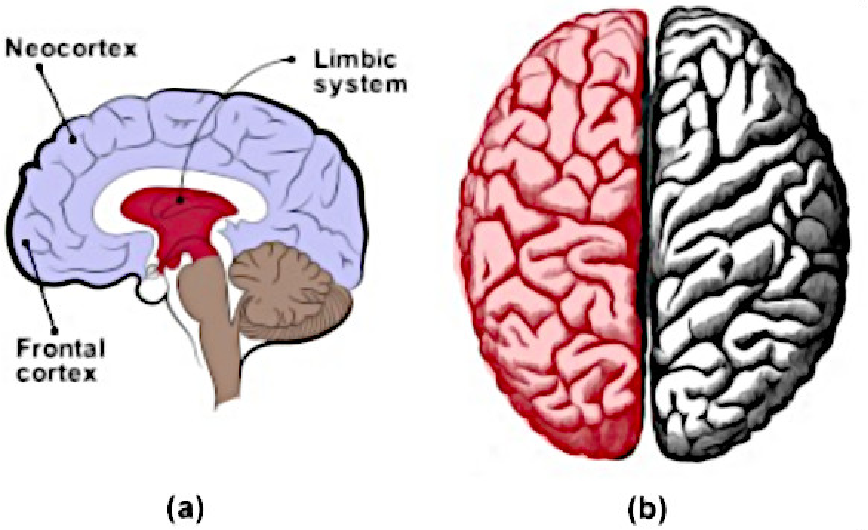

Figure 2. **(a)** The limbic system (old brain) and the cortex (new brain). **(b)** The brain is divided into the left and right hemispheres which have asymmetrical structures.

revealing high level abstraction of the human brain functions assumes two cooperating (sub-) systems. This functional description of the brain is oblivious of the actual implementation of these functions in the brain structure. In particular, our mind can be seen as consisting of two cooperating systems. Both systems are necessary for our existence and the long-term survival and evolution in the environment. The always-on System 1 performs many simple autonomous tasks in the unconscious mind. System 2 is activated occasionally in order to solve more complex problems using the conscious mind with focused efforts.

3.1. System 1 and System 2

The first functional system, System 1, allows to generate impressions, intentions and feelings. This system employs parallel integration and processing of incoming information from the environment. It enables fast and decisive reactions to changes in the environment. It performs mostly accurate short term predictions of changes in the environment, but the learned routine decisions may occasionally lead to mistakes. In general, our brains appear to be much better in predicting than reacting to situations in the environment. System 1 prefers familiar situations where predictions are easier, and the decision mistakes are rare. Conflicting information is not tolerated, and must be immediately resolved. System 1 is automated and always on, so it is designed to have low energy consumption. The automation is achieved by learning and defining schemas as memorized procedures for solving various problems.

System 2 is focusing on conscious reasoning, and it functionally complements System 1. System 2 allows to choose what we do and what we think. It has much more narrow focus than System 1. It appears to function step-by-step sequentially. Thus, System 2 is slow compared to System 1 and demands our effortful attention, but it enables to correct the reasoning and perception mistakes made by the first system. However, System 2 is significantly more energy hungry than System 1, so it is activated only when required, e.g. when the decision mistakes made by System 1 become costly. The analytic processing in System 2 considers evidence and question assumptions suggested by Systems 1. It is also comfortable with the presence of conflicting ideas. System 2 starts emerging from 3 years of age in normal child development, and it does not exist in other primates.

3.2. Divided Brain

An alternative description of the human mind assumes the left and the right brain hemispheres and their functionality. The popular view is that the right hemisphere is responsible for feelings, imagination, creativity, fantasy, art, and creating holistic views of reality whereas the left hemisphere is practical, math and details oriented, works with facts, and performs logical reasoning. In more serious scientific studies, this popular view has been recently found to be rather inaccurate. The fact is that both hemispheres cooperate to synthesize models of reality. Both hemispheres are involved in reasoning, creating emotions and speech processing and many other tasks, although from different perspective and with different attitudes.

More specifically, the left hemisphere somewhat resembles System 1 described above. The left hemisphere strongly relies on our long-term memory and the previous experiences. It enables to make fast decisions, but its jumping to conclusions is error prone. It breaks down the reality into fragments which are narrowed down to certainties. The fragments can be then related to the things we already know and understand. The left hemisphere does not know what it does not know. The fragments are not judged or otherwise evaluated. The left hemisphere attention is attracted to non-living objects. The reality is narrowly perceived as a fixed snapshot. It enforces explicit abstractions, and generalizing the reality into a relatively small number of categories and representative tokens. This leads to loss of uniqueness, and atomization and anonimization of reality, since such representation is easier to process, organize and predict. It subsequently leads to often unwarranted optimistic perceptions of reality where the difficulties are denied and problems are ignored. The left hemisphere demands the reality views to be explicit and clear; the implicit, hidden meanings and contexts are not understood. For instance, the language as the most explicit form of communication is largely processed in the left hemisphere.

The functionality provided by the left hemisphere is more prone to be seen as a computer algorithm, since the outputs can be clearly related to the inputs. It is easier to explain and understand how the left hemisphere works. The left hemisphere believes that more data can provide better perception of reality (as in machine learning, this could be true to some extent). More importantly, the left hemisphere generates reality perceptions which are then used as prior information in the right hemisphere.

The right hemisphere is concerned with broad, holistic views of the world. It is superior to the left hemisphere in both visual and non-visual perceptions. The reality is seen as a flow of interdependent moving or animated parts in a 3D space-time continuum. The depth and strengths of perceptions and of emotions are considered. The objects are not categorized into small number of categories as in the left hemisphere, but their uniqueness is preserved. The implicit or hidden meanings are decoded, and the context can be extracted. This makes the reality representations in the right hemisphere to be quite accurate, as these representations are synthesized using sensory inputs and less from information stored in the memory. Interestingly, the right hemisphere is also responsible for the perception of music as well as playing musical instruments. The right hemisphere is vigilant, and always open to options and new opportunities. However, it is also much more careful about reaching conclusions, and it questions the decisions made by the left hemisphere.

The right hemisphere controls and utilizes the left hemisphere. Both hemispheres are necessary to jointly create a perception of reality. It is a semi-automated process which can be summarized as follows. The snapshot of reality is first broken down into well-defined fixed pieces by the left hemisphere. It consults the prior experiences and representations in the memory. The pieces are passed onto the right hemisphere as prior information. The right hemisphere reconstructs the overall picture, places it into a proper context, and it may identify new objects. The extracted information is then passed back to the left hemisphere where it can be stored in memory as abstraction or a representation of reality. It can be retrieved from the memory later even when the recognized objects are no longer present in reality.

As mentioned above, the complex task solving is carried out in frontal lobes of both hemispheres. Both hemispheres are involved in creativity and both are important for scoring well in the IQ test. However, to achieve an “aha-moment” or a genuinely original creativity, the right hemisphere is clearly superior to the left hemisphere. The autistic spectrum disorders are known to affect more the functioning of the right hemisphere.

It has been noticed that the balance between using the right and the left hemispheres differs in different cultures. It is likely that the left hemisphere periodically dominated our thinking and decision making in some historical epochs. The 21st century appears to be dominated by the left hemisphere again. This tends to create a mechanistic world where everything must be controlled, measured, analyzed, and quantitatively evaluated. Only exactly defined options are accepted. Everything is governed by a large number of small rules creating a complex web of management. The reality becomes a flow of well-defined pieces, and artworks and music are simplified to shallow patterns and rhythms. The trust, humanity and social cohesion are lost while aggression and unwarranted optimistic attitudes rise and problems are ignored in the society. This creates a perfect environment for the sociopaths to rise in such societies.

The right hemisphere is more functionally universal than the left hemisphere, so it can take on some of the functions from the left hemisphere in case of injury. The other way of moving functions from the right hemisphere to the left hemisphere is much more difficult. Consequently, the stroke in the right hemisphere has more severe consequences. Neural networks in the left hemisphere appears to be more locally and more tightly coupled whereas neural connections in the right hemisphere are more global. There is a common misconception that at birth, the brain is a dense unstructured mash of neurons, and the whole brain network structure is created by learning during the child development. In reality, the brain at birth already consists of many existing modules which just need to be specialized and finalized in the learning process. For instance, the language module is ready to imprint any language as a mother tongue, but this module is not created from scratch. Moreover, the brain achieves an enormous level of implementation efficiency by allowing overlaps among different modules, so some modules and tasks are shared. On the other hand, the seemingly same tasks can be carried out in different parts of the brain. In large scale intelligent systems, it may be too challenging to design such circuit overlaps, and probably much easier to avoid any overlaps at all.

4. Conclusions

Learning how the brain works, how it evolved, and about its structure and functions is not only interesting. It enables to understand how people perceive reality and make decisions. It can also provide general design guidelines for building intelligent systems. Understanding the brain structure and functions provides many opportunities how to approach this latter problem. In this paper, our strategy was to focus on high level description of the brain, and to use inductive reasoning to obtain some engineering insights into how the systems with general intelligence could be designed. It is likely that this approach can yield different upper-bounds constraining the design of such systems. The human brain is currently the only known instance of general intelligence, but it still cannot solve any kind of problem, or its solutions may be inefficient. However, it is necessary to assume more specific definitions of intelligence in order to narrow down the design process.

A system with general intelligence should be first specified by a complete set of tasks. The tasks may be constrained by the environment and may determine the minimum required sensory inputs. The functions performing these tasks must be then deduced. The implementation can be achieved by assuming a tightly coupled hierarchical modular architecture where specialized modules solve different problems and tasks. The modules may be designed and implemented differently, for example, they can perform cognitive reasoning using machine learning, or use rule-based logical reasoning. The energy consumption is likely to be one of the critical implementation constraints.

5. Bibliography

The majority of facts presented in this paper were collected from the works of these researchers:

1. Daniel Kahneman Israel in his book "*Thinking Fast and Slow*" described high level functionality of the human brain as interaction and cooperation between two systems. Both systems have different characteristics, process different information, and lead to different outcomes and decisions.
2. Ian Mcgilchrist wrote a book "*The Master and His Emissary*" where he discusses differences between the left and the right brain hemispheres. He clarified many popular myths about functions in both hemispheres, and explained how the hemispheres interact in making decisions and creating the perceptions of reality.
3. Frantisek Koukolik is a Czech scientist in neuropathology. He wrote a number of books summarizing the scientific findings from foreign literature about the brain evolution, evolutionary psychology, and brain physiology. His books are full of interesting information, but unfortunately, they are only available in the Czech language.
4. A few years back, I came across a Youtube presentation by the Russian biologist Sergej Saveljev from a research institute in Russia. In his talk, he explains the most fundamental principles of the human brain including its evolution, functionality and physiology. The talk is in Russian language.