Computational Intelligence in a Human Brain Model

Viorel Gaftea
Research Institute for Artificial Intelligence "Mihai Drăgănescu",
Casa Academiei, 13, Calea 13 Septembrie, cam. 3310, 050711 Bucharest, Romania
viorel.gaftea@acad.ro

Abstract

This paper focuses on the current trends in the domain of brain research and on the current stage of development of the research for software and hardware solutions, communication capabilities between human beings and machines, new technologies, nanoscience and Internet of Things (IoT) devices.

The proposed model for the Human Brain assumes the main similarities between human intelligence and the chess game thinking process. Tactical and strategic reasoning and the need to follow the rules of the chess game are all very similar to the activities of the human brain. The main objective for a living being and the chess game player are the same: securing a position, surviving and eliminating the adversaries. The brain resolves these goals and, moreover, the being's movement, actions and speech are sustained by the vital five senses and equilibrium.

The chess game strategy helps us understand the human brain better and to replicate easier in the proposed 'Software and Hardware' SAH Model.

Keywords: brain model: artificial intelligence, brain interfacing, computational thinking.

1. Introduction

The new trends in Artificial Intelligence, Robotics, IoT gave an impetus to the "Human Brain Research". The greatest challenge we are facing in our century science is 'understanding' the human brain. Big initiatives have started in Europe, such as: the Human Brain Project[1] in the University of Zurich, the Federal Institute of Technology (ETH), or in Japan, Kyoto University or Australia.

The present article brings a new interesting approach; it does not include the results of other research papers in the same area of expertise where the approach was made on anatomical, mathematical (Ellerman, 2016), or purely technical concepts.

2. Explanatory framework

The proposed model, compared to other models (Timofti, 2010), approaches the philosophical components of the living being and exceeds the levels of the anatomical or only technical approach (Aman & Ciobanu, 2011).

The growth in brain research has led to no homogeneity models assumption. Conceptually, the human brain development starts from the reproduction systems to the mature human body, also as the developing model for any form of life.

Forms of intelligence govern the evolution from the cell to the body. The reproduction cells *'are looking'*, as the whole body, to the Genetic Information contained in Deoxyribonucleic acid (DNA). The DNA gives instructions for 'life', it gives us the opportunity to see its role in the evolution of plants and animals. The DNA is a history book of the evolution because mitochondrial DNA, inherited solely from the mother, contains the information that can recreate the genetic history of humans.

The DNA assures the way in which the Information is transmitted from the cell to the body, and it has four basic components called nucleotides, combined in 3.5 billions pairs, so the DNA is 2-3 meters long and it contains 3 GB of data. The four nucleotides are called adenine, cytosine, thymine, and guanine. These ideas lead some research from the cell biology to the 'membrane

[1] Human Brain Project, https://www.humanbrainproject.eu/

computing' theory, the upper level of 'Communication P Systems' theory. The academician Gheorghe Păun, in his speech, "Searching computers in the biological cell" (Păun, 2014) given at the Romanian Academy on 24.10.2014, described the new research path defined by him in the new computational model "Membrane Computing" (Păun, Rozenberg, Saloma, 2008).

Human Brain research must consider and finally manage a large volume of information, for which Big Data tools might be needed (Mayer-Schonberger & Cukier, 2013).

The DNA contains the information and the code, but how it is processed by the brain is still an open research area.

In this context, we resumed and presented the current technical capabilities necessary to cover the huge volume of information and the processing capabilities needed in the simulation of the brain, starting from the basic dimensions of genetic information.

3. Dimensions of the memo-informatic support of the Genetic Information

To confirm what has been mentioned, some statistical values must be considered:

- DNA is a molecule within the cell;
- DNA is compressed into chromosomes X, Y;
- A human being has 23 pairs of chromosomes;
- Proteins consist of amino acid chains;
- We have 100,000 kinds of proteins in the body;
- The proteins are 20 kinds of amino acids;
- The protein has a length of ~ 150 amino acids;
- The shortest possible chain would be $20^{150} \sim 10^{195}$;
- Atoms in the observable universe are about 10^{80};
- A grain of sand contains millions of atoms ~ 'n' x 10^{6}.

These values show the complexity and the numerous angles of view, in which life and any part of the body must be looked at.

4. Summary statistics of Brain and Computing Power evolution

- The human brain weighs between 1.3 and 1.4 kg.
- Its size has decreased by ~ 150 cm3 in last 5000 years from the average 1,350 cm3.
- Cerebral cortex neurons number is ~ 100 billion.

The global Research leading to electronic chips that mimic human brain functions, like in the University of Zurich, the Federal Institute of Technology (ETH)[2], where was treat the brain functions as a microchip with huge storage and access capabilities[3].

For example, Intel's Xeon server chip has 4.31billion transistors.

5. "SAH" Brain Model based on a Chess game

The assigned name "SAH" Brain Model means "Software and Hardware" and it is based on the Chess Game rules and strategy, and it will first be shortly presented in the cognitive context.

The actual proposed model will bring to us a number of issues for harmonizing the conceptual assumptions instead of one state of the art section:

- harmonization of input-outputs mainly in terms of architectural representation and in terms of context functionalities for adapting the design to reality features:

[2] ETH Zürich - CYBATHLON Wettkampf für Athleten mit Behinderungen, http://www.cybathlon.ethz.ch/the-disciplines/bci-race.html

[3] Visualizing RNA activity within the brain tissues of live mice for faster and more accurate discovery and development of novel drugs, research Kyoto University, http://www.kyoto-u.ac.jp/en/research/research_results/2015/150619_1.html

- for personalization of functionalities and use of resources to respond to needs, interests and behavior;
- for a cluster of functionalities regarding decision systems;
- new technologies that have also permitted access to the knowledge from research and industry.

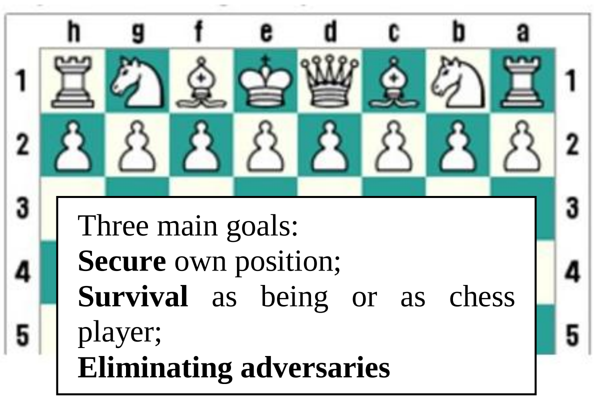


Figure 1. Being Brain and Chess Game Strategy - similarities

Finally, the following similar reactions between a chess player and a human being must be mentioned and considered. The power of reason for every being, human brain, or chess game player lies in similarities and has three main directions (see Figure 1):

a) Secure their own position, a position or an action in life, similar with an action in a chess game

Define securing the position in the action, in life, or in the attack in order to assure the '*Survival*' as a being, or '*eliminating adversaries'* in terms of assuring '*food for life*'.

b) Survival as a being or as a chess game player

The brain must take decisions regarding the status of the being with respect to an action/activity of the current life, or in a chess game as a player.

c) Eliminating adversaries

The main goal in a chess game is 'eliminating adversaries', but there is a similar goal for any being and it is translated "*eating for living*". These three reasons for existence, for both a human and an animal action, require a similar surviving type of the brain activity. This observation facilitates to propose a computational model based on the chess game that allows an 'intelligent simulation' of human brain functions.

6. Some Common Assumptions

There are several common assumptions related to the model we have previously defined:

- Interface with the human senses and brain output are in an interdependence that can be modeled.
- The senses (Hearing, Sight, Taste, Smell, Touch) are the inputs for the Brain interfacing with the external environment.
- Equilibrium and stability are common for decision or movements.
- Walking or actions (movement) and Speech are considered outputs of the brain decision.
- The model easily leads to build a performing Robot or a Brain model.
- Decision, after the process of analysis, generates the action and it is internally registered as Brain Learning Process being quantifiable in a register or memory.

Human Brain was the reference as a model in Robotics and Artificial Intelligence. In both situations, robotics or brain simulation, brain interfaces and outputs, computational intelligence, are built as a cybernetic model. Interfacing with voice, image, signals and sensors assure connections with the environment. Outputs are reflected in static or physical equilibrium, speech and movements, all reflecting the mobile intelligent actions.

Now, the Internet of Things (IoT) is the new trends in technology, strongly influenced by the Computational Intelligence (Kelemen, 2011), which brings added value to any modelling approach. The proposed model engages in an integrated way, cognitive knowledge of living organisms with robotics, artificial intelligence and new technologies.

7. Description of the "SAH" Human Brain Model

The proposed model will define the conceptual vision and similitude of the computational intelligence of Human Brain with the Chess game thinking. The model starts from the basic assumption of a software chess game for computers. Descriptions of the ways used for the assignment of the roles of the chess pieces are starting from the analogies used in the chess game software solutions and both of the "living organism or chess game" strategy.

8. Description of the "Chess game" software concept

The chess game is designed to play automatically or with a human player at different levels of difficulty. The pieces (see Figure 4) are assigned with values, the static schemes are memorized as open or fixed schemes depending on the level of difficulty, the thinking process of the game is dictated by an analysis, and when assigning the value of scheme must be taken into account the values of the player's own pieces, or of the pieces of the adversary. There is a time limited decision between the best scores obtained by analysis and finally, results an action as a piece movement respecting the rules assigned for movements. In this process are already mentioned the thinking and learning process that conduct us to the computational intelligence and artificial intelligence concepts. If necessary, more affiliations of the game can be specified and the same thinking style must be maintained.

9. Description of the SAH Human Brain Model Concept

The proposed SAH Human Brain Model starts assigning the main attributes to the "heavy pieces" (king, queen, rooks, bishops, knights) and assigning to pawns the interfaces as an advanced guard. The interface represents senses and processed human actions (equilibrium, movements, and speech) and it results from the brain activity (see Figure 2).

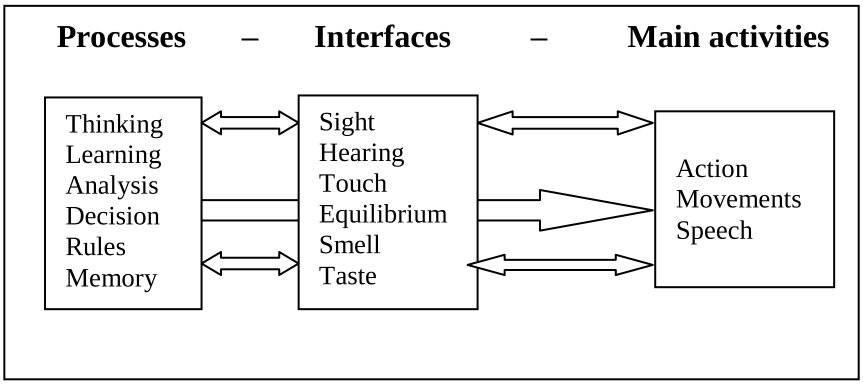
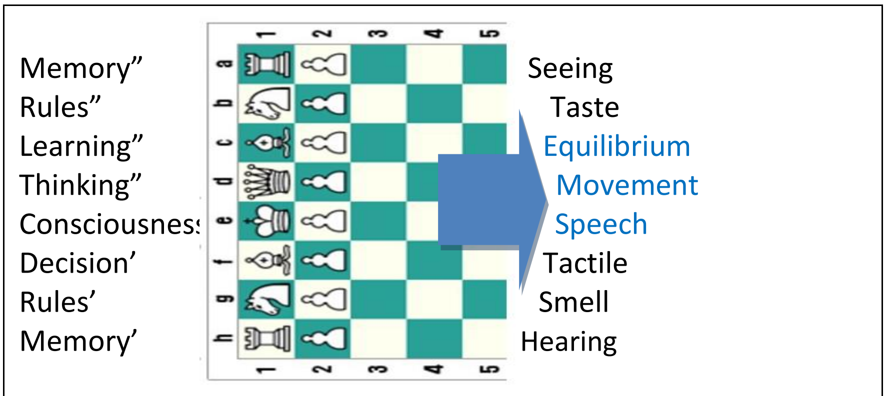


Figure 2. Processes and Interfaces of the SAH Human Brain Model

The two sides, 'Processes side' and the 'Interfaces side' of the Brain modeled as Chess table assign a similar strategy. The similar interface assumptions can be associated to any other beings. There are two types of components for the model: software and hardware.

The Software component identifies the different components of the processing part of the Brain and there are not topically subordinate to each other but in a strong interoperability.

The Hardware component identifies the different interfaces of the senses (Hearing, Sight, Taste, Smell, Touch) that assure external information to the processing part of the Human Brain.



Process Units and Interfaces of the SAH Human Brain Model

Figure 3. Assigning ` the “SAH” Human Brain Model the role of the Chess Pieces

The components are not topically subordinated to each other but in a strong interoperability and used for outputs reflected as result of thinking, actions to receiving information from the sensor of the interfaces, movement or speaking.

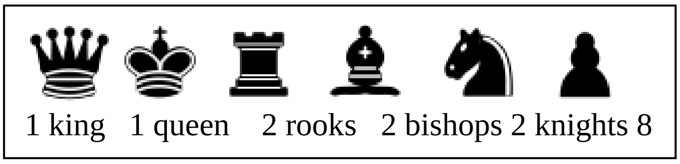


Figure 4. Name and role of the Chess Pieces

In assigning the brain function to the computational processing units the strategy of the chess game will be pursued:

1 king – consciousness, mind, resolving undefined situations, undetermined risk analysis, feedback:
1 queen – implementation strategy, thinking, learning;
2 rooks – initial knowledge memory and learning memory;
2 bishops – good or updated, time or emergency decision;
2 knights – rules, open schemes, fixed processes, templates;
8 pawns – interfaces with own senses and actions.

Double chess pieces will be assigned in the model with initial knowledge (‘ marked) that can be updated as a learning experience to a second set (“ marked).

The software adopted tactics and the strategy follow three main directions, by analyzing the data in the logical chains:
“Memory -> Rules -> Processes -> Templates”, to execute:
“Codification of parts and schemes-> Thinking -> Learning”, through a process unit to:
“Assign values and pointing the parts or schemes of action”, based on initial values and create a *“Win Grid Association Scheme”*, so as to produce a similar *“Decision system”* of the Brain activities.

The results of the supervising processes associated with the “king” and the “queen” pieces will be marked in a register for the best results in order to see the winner’s analysis as a result of the thinking.

Important roles are assigned to decision: “equilibrium”, defining the “thinking result” or “movement actions” as final outputs including signals or speech.

10. Extended Block Diagram

Three vertical areas are defined in the field of activities: Processes units, Computational Intelligence Block, and Smart Interfaces Block (Details are presented in Figure 5).

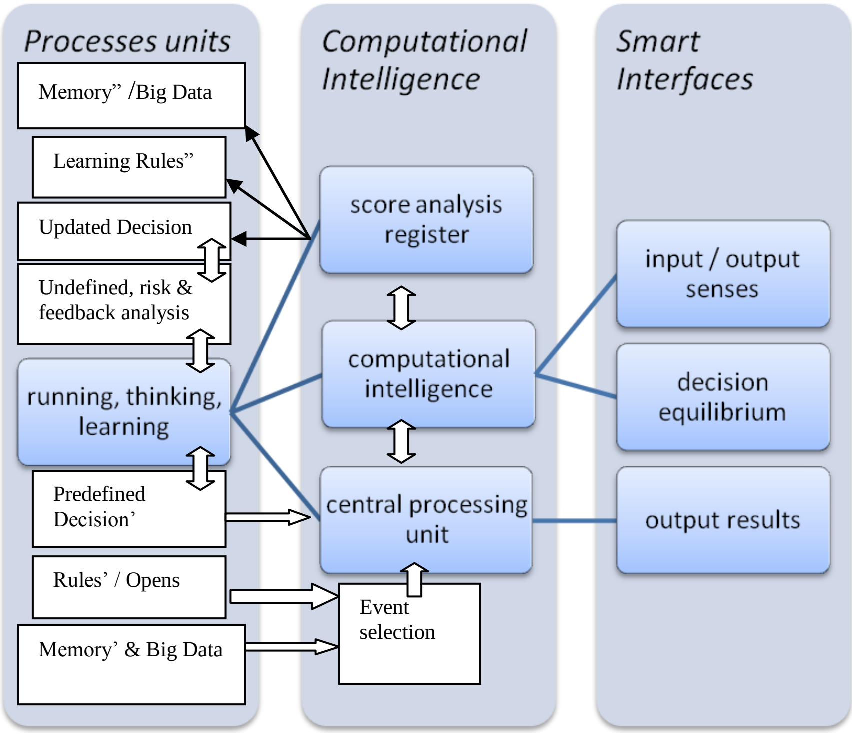


Figure 5. Block Diagram of the SAH Human Brain Model

The Processes units fully communicate with the Computational Intelligence Block, Central Processing Unit and Smart Interfaces.

Some specific links and functions are not specified here.

Smart interfaces defined for "sight, sound, taste, touch and hearing senses" are bidirectional and completed by input-output interfaces that ensure the communication for output actions like "speech, sound, movements" and other commands resulting in the thinking process. An important issue is the 'equilibrium' that must be treated in either "decision or movement" framework.

Interfacing the model with smart interfaces will be the way of ***"****connecting the machine with the environment****".*** IoT sensors add the new capabilities required at this time.

This combination fully meets a neural network which commands the central nervous system and the rest of the brain. A circular dependency graph of brain processes is built around computational intelligence, decisions for equilibrium in the "decision or movement" and the "running-thinking-learning" processes.

The theoretical neuroscience and computational neuroscience are heavily involved in the functional shaping. This type of brain processing analysis would be extremely difficult without using advanced simulation tools.

The new proposed Chess Game Model for the Human Brain helps us to understand better the functions of the human brain and replicate in a computing environment.

11. Identify the Hardware

Processing units, neural networks, interfaces and study throughout the entire body, regions of the brain, cellular and molecular interface circuits will be great research topics in a such project.

The Nucleic Acids Research, visualizing RNA activity can already potentially lead to faster and more accurate screening processes for the discovery and development of brain's secrets. Information technology, Big Data, IoT, neural sciences and new developments in computing capacities and nano, micro devices provide the support in knowledge and necessary hardware to approach the proposed model. Intel already claims that by 2026 processors will have as many transistors as there are neurons in a brain. Since 1971, when the first-gen Intel processor had 2,300 transistors and ran at 740 kHz, the latest fourth-gen Intel Core processor has 1.7billion transistors and runs as 3GHz. According to Intel, the human brain runs around 1k Hz. After Alan Turing (1912-'54), a British mathematician who made history with his breaking of the German U-boat Enigma cipher in World War II, the brain simulation by a computer can be the 21st century goal.

12. Conclusions

Today the strategic goal in Science is moving to the Artificial Intelligence. The Brain Model helps us define more developed computational and interface solutions to permit simulation, signal processing, speech processing, image processing in an intercommunication process. The independent decision or a computer assisted decision in the model will be the result of a complex interdisciplinary work. The proposed model combines the philosophical nature of a living being which assumes the main similarities between human intelligence and the chess game thinking process, a new contribution from the point of view of comparison with other similar works.

This new proposal captures most of the brain's cognitive capabilities, but does not show very detailed how the parts of the brain work together to produce cognition. In this new conception, the presented solution is a software one. Connecting more processes units assigned to the brain's functions, increasing the number of score analysis registers, extending the interfaces with smart devices and applying last acquirements in artificial intelligence and neural networks, can help us to build very complex model and extend it easy, reproducing the higher capabilities of the human brain.

Moreover, technologies like GPS can bring us new sensitive capabilities to the model.
From the Investment in the knowledge of the brain will benefit the society as a whole, by contributing to developing more intelligent machines, robots and a better understanding of the human being, brain capacities and control of activity or health status.

It would be therefore relevant to start an Initiative and an Institution in charge of Research and Development ("Strategia Naţională privind Agenda Digitală pentru România 2020", 2014) and the thematic orientation on a Human Brain Research Project in Romania too ("Romania's Development Strategy In The Next 20 Years", 2015).

Acknowledgment

This paper is dedicated to the 150th Anniversary of the Romanian Academy and 25th Anniversary of Science and Information Technology Section.

References

Păun, G. (2014). "Căutând calculatoare în celula biologică", Bucuresti, Editura Academiei Române, ISBN 978-973-27-2504-7.

Păun, G., Rozenberg, G., & Saloma, A. (2008). "The Oxford Handbook of Membrane Computing", Oxford University Press, pp. 58–83, 282-288, ISBN 978-0-19-955667-0

Kelemen, J. (2011). "Computation, Cooperation, and Life", Springer, vol. Lecture Notes in Computer Science, pp. 138–186, ISBN 978-3-642-19999-8

Mayer-Schonberger, V. & Cukier, K. (2013). " BIG DATA", Springer, pp.123–173, ISBN 978-0-1-84854-792-0

Aman, B. & Ciobanu, G. (2011). "Mobility in Process Calculi and Natural Computing", Springer, vol. Natural Computing Series, pp. 39–135, ISBN 978-3-642-24866-5.

"Strategia Naţională privind Agenda Digitală pentru România 2020". (2014). Retrieved from http://www.mcsi.ro/CMSPages/GetFile.aspx?nodeguid=0617c1d7-182f-44c0-a978-4d8653e2c31d

"Romania's Development Strategy In The Next 20 Years". (2015). Editura Academiei, Retrieved from http://www.acad.ro/bdar/strategiaAR/doc11/Strategia.pdf

Timofti, I.C. (2010). "The Complex Functioning of the Human Brain: The Two Hemispheres", Retrieved from https://www.edusoft.ro/brain/index.php/brain/article/view/29

Ellerman, D. (2016), Brain Functors:A mathematical model of intentional perception and action, Retrieved from https://www.edusoft.ro/brain/index.php/brain/article/view/567

Human Brain Project, (2016, March,30) Retrieved from https://www.humanbrainproject.eu/

ETH Zürich - CYBATHLON Wettkampf für Athleten mit Behinderungen, http://www.cybathlon.ethz.ch/the-disciplines/bci-race.html

Visualizing RNA activity within the brain tissues of live mice for faster and more accurate discovery and development of novel drugs, research Kyoto University, http://www.kyoto-u.ac.jp/en/research/research_results/2015/150619_1.html