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The Design of Human Inspired Information Model (HIM): Information Processing as Content/Form Computing

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***Abstract*—This paper presents cross-disciplinary research between medical/psychological evidence on human abilities and informatics needs to update current models in computer science to support alternative methods for computation and communication. In [10] we have already proposed hypothesis introducing concept of human information model (HIM) as cooperative system. Here we continue on HIM design in detail. In our design we introduce Content/Form computing architecture initially. Then we apply this architecture on HIM model as basic information processing paradigm. Main inspiration of our natural/human design comes from well known concept of artificial neural networks, medical/psychological evidence and Sheldrake theory of "*Nature as Alive*" [22].**

***Index Terms*—informatics walls, human information model (HIM), neural networks, morphic fields, morphic computing, content/form computing**

I. Introduction

Computing industry has passed parallel hardware revolution and beside proposed parallel challenge in hardware and software design, even toady we can observe certain limitations, walls we are facing [1]. These walls are mostly consequences of physical limitations of silicon chip design (concerning size, overheating, unsustainable power consumption), theoretical limitations (non-algorithmable tasks, NP-hard or NP-complete problems) restricted by model of Turing machine [14] and open human-computer interaction (HCI) issues that implicate from differences, gulfs between classical computer design and human cognition ability [13].These limitations are also main motivation for alternative approaches, efforts (compute and communicate) in computer/information science. Well known representatives of alternative approaches are quantum and DNA computation but due to its "*own*" restrictions it cannot be widely used in practise [18].

In compare to present alternative approaches adopted from nature/human to computer science (e.g. iterative evolutionary approach, artificial neural networks, fuzzy logic), these approaches are commonly studied separately or oversimplified (e.g. artificial neural networks) in contrast to real world evidence. Some of these models are old-fashioned today and do not reflect latest observations from physics, medical science and psychology. Thus we are losing some possibilities that nature/human can operate with. By looking at present scientific medical/psychological publications we can observe new knowledge which is worth to include to current informatics models. For example, in case of artificial neural networks it is unsustainable to consider each neuron as just simple switch. In spite of present progress in artificial neural networks, there exist many properties of biological neural systems that are largely ignored in classical models and as Miller [12] noted these properties can be essential, significant (missing link) for power and efficiency issues (walls) that computer science is trying to deal with.

In our research we also consider human information potential as another alternative approach how to make computation and communication. In previous work [10] we have already proposed information hypothesis that assumes information processing (computation and communication) human inspired model (HIM) based on neural networks concept as cooperative system, research synthesis rather than stand alone approach (to be closer to real human) consisting of multi-levels. Thus we have forwarded a research question: *How we can benefit from these human abilities in computer/information science*? In other paper [11] we have designed several experiments to investigate the possibility of classically unexplainable human information capabilities and its possible impact for information science. Implementation, testing and evaluation of these experiments can be useful for proposed model (HIM) correction as feedback but due its long term estimation is left as a future work.

Considering first HIM concept in [10], it was introduced as sketch (simple mock-up), therefore here we continue on HIM design in more detail and therefore we also propose new type of computation - *content/form computation* which is essential in HIM information processing.

In following chapter we introduce main inspiration by medical/psychological evidence on human abilities and its possible theoretical explanations which stand for theoretical background, foundation in our design. Consequently chapter three describes proper HIM design, content/form computation, by describing the architecture of content and form. Finally, chapter four discusses future and on-going

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work.

II. Related Work and Critical Review

In introduction chapter we have briefly described motivation for alternative approaches in information science and noted our research interest in alternative approach inspired by human information abilities (for purpose of informatics information model design).

A. Natural/Human Motivation

In effort to show relevant scientific contributions and publications (describing nature/human possible theoretical potential), we can highlight Lucas and Penrose contributions, for example. Lucas, in his paper "*Minds, machines and Gödel*" [6], is arguing that the human mathematician cannot be represented by any machines and Penrose [15] has suggested that the human mind might be the consequence of quantum-mechanically enhanced, "*non-algorithmic*" computation. Penrose uses variation of the "*halting problem*" to show that mind cannot be an algorithmic process [14]. Rosen has proposed that computation is an inaccurate representation of natural causes that are in place in nature [20]. Moreover Kampis [7] assumes that information content of an algorithmic process is fixed and no "*new*" information is brought forward. These contributions stand for inspiration and further motivation when re-thinking about nature/human concepts as inspirations for informatics problems.

B. Biological Aspect of Neural Networks

Generally, in informatics there exist many models, systems inspired by nature/human (neural networks, fuzzy systems, evolutionary design, genetic programming). But these approaches are commonly studied separately in contrast to real world evidence and some of these models are old-fashioned today and do not reflect observations from physics, medical science, psychology. By looking at present scientific medical/psychology publications we can observe knowledge which is worth to include to current informatics models. Some researchers are aware of this situation, for example Penrose and Hameroff [3] had introduced neural model extension with quantum properties – Orch-OR model and assume its behaviour essential for ability of being consciousness. Further Miller extends informatics model of neural networks by developmental (evolutionary) model with "*seven programs*" reflecting liveness neural properties. To describe huge gap between medical/biological knowledge and classical informatics assumption let us cite from recent Miller's paper [12]:

"*In spite of the success of Artificial Neural Networks (ANNs), there are many aspects of biological neural systems that have been largely ignored. Marcus argues convincingly about the importance of development in the understanding of the brain; mechanisms that build brains are just extensions of those that build the body. Despite this, there are virtually no evolved artificial developmental neural approaches in the research literature. There is now abundant evidence that sub-processes of neurons are highly time-dependent so that many structures are in a constant state of being re-built and changed. In addition, memory is not a static process and the location and mechanisms responsible for remembered information is in constant (though, largely gradual) change."*

As we can see, there is still enough motivation and inspiration for extending classical models of neural networks. In case of detail Miller's model [12] (*Developmental Model of Neural Computation*), neural network is consisted of 2D grid of neurons, each neuron has its genotype representing the genetic code of the neurons. Further each genotype includes seven chromosomes representing small procedure/program. Thus chromosomes are directly linked to the functionality of neuronal parts. By using specific evolutionary strategy (e.g. mutation) genetic code is changed and such the *living properties* handled by chromosome programs are changed too, in this way some biological aspects of real/live neurons are reflected. In compare to other neural network models Miller has observed that different Wumpus (game) worlds preserved properties network like sustainability and prevention of pits. It was not possible (at that time) to compare its effectiveness with any other artificial neural networks.

Although noted model is contributive and highlights hidden potential of biological neural networks, this model assumes that main changes in neural networks (structure, weights, health) are handled by evolution through genetic code changes. In real biological neural networks there are many changes but only a few are caused by change in genetic code (long time estimation) and real changes in biological neural structure, metabolic brain activity are much faster (short time estimation) than changes in DNA. Moreover in this model, natural laws (procedure/programs) are assumed as static (classical assumption) which is also in contrast with our HIM neural network design, see chapter 3 below.

However the evolutionary gene extension, biological growth and die aspects in neurons seem to be essential for natural ability approximation, modeling, there are still many hidden aspects. For example there is a huge evidence of human abilities which cannot be explained on basis of established physical concepts and statistical theory. It is assumed that such activity is executed beyond any physical part of human body (brain) [23, 21, 8]. Although the explanation of such scientific evidence [21], near death experiences [5] is still matter of discussion and open questions, we should at least consider such evidence as part of human information capabilities.

C. Evidence on Unexplainable Human Abilities and Theoretical Explanation

From point of psychology C. G. Jung was one of the first who was scientifically interested in human unexplainable phenomena. To describe some interesting observables he defined term *synchronicities as events that can be non-causally correlated if they belong together in the sense of expressing a common underlying archetype* [9]. Later with increased theoretical background of quantum mechanics he was positively surprised how his intuitive macroscopic

definition of synchronicity is analogous to microscopic definition of *quantum entanglement*.

Scientific focus on medical and psychological evidence supporting unexplainable phenomena had arisen mostly at the end of 70s. Biologist Sheldrake was one of the first initiators who proposed *hypothesis of formative causation and theory morphic fields/resonance* that led to re-thinking of Darwinian theory of evolution, morphogenesis and further to explanation of classically unexplainable phenomena in nature. This also led to increasing demands of psychological experimental testing. For example, in recent biological studies, Sheldrake [24] has conducted experiments with animals and human subjects and has found statistically significant results that support *unexplainable* human abilities (e.g. telepathy). In consequence also psychological experiments were conducted to investigate such phenomena and some of them were replicated several times [4]. Moreover recent medical studies based on near-death experiences (NDE) [5] pointed out the critical review of classical medical paradigm: observing metabolic brain activity in response to specific thinking process does not necessarily implies the role of brain neurons as origin of thinking process and can be consequence (mediator) of unexplainable non-neuronal activity. Described studies have evoked broad discussions in biological, medical and psychological publications [7] and turned research focus more into inner human scope.

As far as we know, Sheldrake *morphic fields/resonance* explanation is applicable to the most cases of classically unexplainable phenomena (including human abilities, near death experiences) and moreover it is scientifically testable too. This theory has large impact for psychological findings, evolution of nature forms/ morphogenesis. It rebuilds classical paradigm of science and think of all Nature as being alive with inherent memory. Although the hypothesis of a memory inherent in Nature is very radical, controversial, and unconventional some recent finding (experimental verification) conducted independently by Sheldrake [23, 24] and others [17, 21] led to statistical significant results supporting this theoretical assumption.

In more detail Sheldrake theory [22] assumes that nature is capable to operate with inherent memory, and what science classically thinks about the laws of nature, Sheldrake suggests habits instead. Base of memory processing is morphic resonance that is influenced across space or time. Memory is described by existence of morphogenetic fields. Members of a species are united by the ability to access and transmit information to and from these fields right through morphic resonance. Morphic fields are organized and inherited in hierarchy according to similarity between members of species. Organisms then evolve by inheriting the habits of previous members of their species through this process. Main implication is that behaviour/reactions depends not only on the chemical genes coded in DNA but are also influenced by morphic resonance from past members of the species. In this way not only the form is evolved but also the laws of nature (not static) and are changed dynamically depending on past members. In case of individual memory application, it is mostly depended on self-resonance morphic field, not directly stored in the brain and on the existence of a collective memory (field of memories), to which we all contribute. Sheldrake proposes that brain it is more like a tuning system, like a radio receiver, to pick up memory inherent in the morphic fields. Basically morphic fields are described similarly as the gravitational or electro-magnetic fields (field is expanded beyond the form of its source). Meanwhile these two kinds of fields are material fields, although they are not material themselves, but are created by and maintained by physical mass, Sheldrake morphic fields are assumed as immaterial fields, because are not restricted only to sources of material forms (e.g. single word, symbol or piece of SW can has its own morphic field too).

From point of related theories, it is interesting, that Sheldrake theory converges and follows C.G. Jung findings on *collective unconsciousness*. There is also correlation with interpretation of quantum mechanics - Sheldrake theory was merged with quantum physician Bohm holonomic interpretation of quantum physics [2], in later years Bohm suggested that Sheldrake's hypothesis is in keeping with his own ideas on what he terms "*implicate*" and "*explicate*" order [22, 2]. Furthermore there is direct relation to K.H. Pribram holomic brain model, which assumes memory spread over physical brain instead of specific location at certain part [16].

D. Morphic Computation

In recent years (2008), Resconi [19] has introduced general concept of morphic computation which is inspired by Sheldrake hypothesis of morphic fields. His computation is expressed through changes in morphic field which is mathematically substituted by deformation in space whose geometry in general is non-Euclidean. Further Resconi claimed [19] that Morphic Computing is a natural extension of Holographic Computation, Quantum Computation, Soft Computing, and DNA Computing and all natural computations bonded by the Turing Machine can be formalized and extended by his new type of computation model – *Morphic Computing*. These findings have fundamental implication for computer science and represent its theoretical background as well.

III. DESIGN OF HIM – CONTENT/FORM COMPUTATION

As we can see above, in nature/human design there are still many hidden aspects which are worth to include to current informatics models. Although we do not know the diversity, power and complexity of human information capabilities and moreover we do not know its all causers and principles, at least we can operate with information which is already known, classical scientific concepts (e.g. neural networks), theoretical explanations and results of experimental evidence.

This chapter subsequently describes whole design of HIM as computing model. First in 3.1, we briefly recall abbreviation

of our information hypothesis and multi-level reference model as proposed [10].

A. Multi-layered view on HIM

In classical computer science there exist many human/natural based approaches (e.g. iterative evolutionary approach). These approaches are commonly studied separately in contrast to real world evidence. We have already presented information hypothesis which assumes *human inspired information model* (HIM) as cooperative system operating on multiple levels including non-physical level (see figure 3.1). The proposed information hypothesis (see $\boldsymbol{H_1}$ 3.1) and related reference model were introduced just as theoretical sketch.

***H_1* 3.1**: *Rather than describing human information capability like independent neural network, iterative evolutionary computation or fuzzy system, etc, we are assuming the synthesis of these approaches as cooperative information (computing and communicating) system based on neural networks, molecular neurobiology, evolutionary approach and phenomena related to quantum mechanics at least (as proposed on reference information human model, see figure 3.1).*

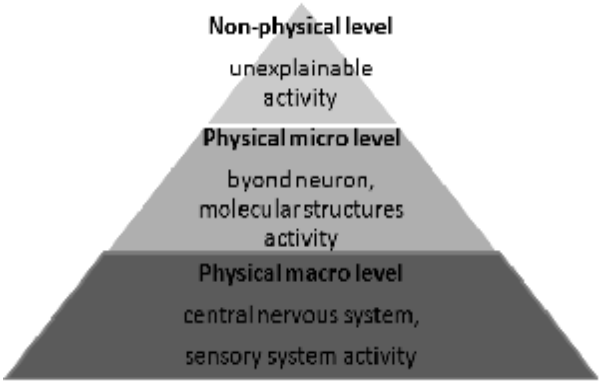

Fig. 3.1: general multi-level model of human information capabilities, each level is linked with others as cooperative system. This is a reference model.

In consequence to [10], here we continue on HIM model formal description in more detail and consequently we also introduce new type of information processing called *content/form* computation as main computation principle on HIM. Here main motivation comes from current medical, psychological evidence on human abilities [24, 5] and its theoretical explanation especially by theory of *morphic fields*, *morphic resonance* proposed by Sheldrake [22]. Furthermore we are also inspired by informatics model of neural networks especially by related work of Miller [12] who extended classical concepts of neural networks by seven programs reflecting living properties (see chapter introduction and critical review above for detail).

In following sub-chapters we consequently introduce main computing principle applied in HIM and whole HIM detail structure as neural network conception.

B. Content and Form Architecture

Before introducing new type of computation – *content/form* computation on HIM model, let us first define basic terms of *Content* and *Form*. As we can see below these terms are simple abstractions analogous to Sheldrake's theory of Morphic Fields/Resonance (defined for purposes of informatics).

Def. 3.1.: By *Content* we denote non-physical, abstract "*empty term*" that exists without boundary on *Form*. If there is a *Form* then it is filled (spread over) by *Content* depending on type of the *Form*. Thus without any *Forms* empty *Content* still persists. *Form* can be represented by any physical mass or by non-physical abstract terms too (except for *empty term - Content*). *Form* itself cannot exist without boundary to the *Content*. There is a hierarchy of *Contents* according to its type of similarity (reflecting the hierarchy of *Forms* too). Thus higher *Contents* encapsulate inherited *Contents*. The top most *Content* is denoted as the *Root*. *Form* behaviour (methods) is driven directly by its *Content* which encapsulates past states (*memory*) of the *Form*.

Example 3.1: It is generally known that inheritance properties in nature like growth depends on *Form* of DNA, thus we could be thinking that DNA drives the behavior of growth itself. But by reflecting Sheldrake theory and considering the definition 3.1, since DNA is also a *Form* it is subject to DNA *Content*, which drives growth indirectly through DNA *Form* (see figure 3.2 for *Form* dynamics illustration). Furthermore DNA *Content* is encapsulated according to hierarchy in *Root* which propagates its goals to lower, inherited *Contents*. Since all types of *Contents* are encapsulated in *Root*, its separation is only illustrative/virtual and is closer to holomic interpretation.

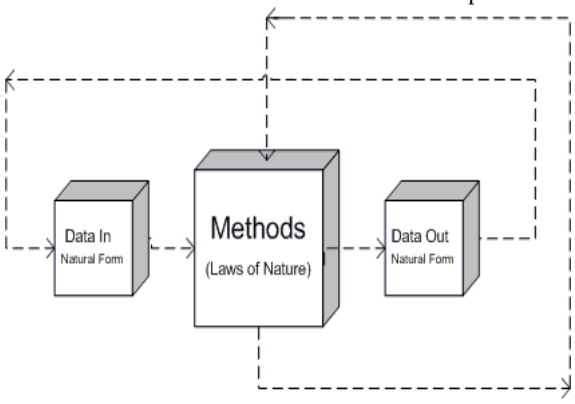

Fig. 3.2: Form dynamics (without Content interaction), data and methods are both type of Form, thus each of them is dynamic. Input is driven by methods and output; meanwhile methods are driven by past applications on input.

C. Content and Form Computation

Here we highlight impact of Content/Form architecture on computation. As described in introduction and related work chapters, the classical scientific paradigm assumes that natural forms are driven by laws of nature (morphogenesis), see chapter *Comparison of Related Forms* in [16] for detail. Meanwhile the forms are not static, laws are assumed as static and not changing [22]. In computer science, computation also generally assume that data (forms) as not static meanwhile methods/functions (laws) mostly expected as static (except for a few programming languages like Python or C#). Even in extended Miller's model of neural network [12], livness functions as methods are assumed as

static. Now let us consider the application of definition 3.1 according to Sheldrake theory. From this perspective there is no longer separation between operations with Data and Methods, since both Data and Methods become Form, thus Data and Methods are *treaded* (operated) in similar way. In other words we can say that Methods are assumed as Data too and operated by Content based on its goals and past states of its Form. Now we apply this general principle of *Content/Form* computation on HIM concept.

Note: Here, meaning clearly from point of information science/informatics it is not strictly important whether the biological/psychological theoretical explanation on human abilities (we are taking inspiration from) is necessarily the most accurate one or whether there is already enough evidence to support it in present. If there is significant effect for solving problems in informatics then the theory is welcome to be adopted as well.

D. Form of HIM

According to proposed reference model (see figure 3.1), HIM model is based on concept of artificial neural networks. Hence here *Form* is consisted from neural structure (set of interconnected neurons), set of default methods (stands for natural laws) and input data.

Neurons and Data

The key element of neural artificial paradigm is neuron itself. Here the form of neuron is represented by classical model of artificial neuron (including inputs, weights, threshold, transfer function and output). At each step of computation each neuron has its state that indicates its current configuration. Input data indicates proper inputs for neuronal propagation and goals (instructions) for Content (see below).

Neuronal Structure

Although the structure of neural network influences its efficiency and complexity, in case of HIM model, the default interconnection, number of hidden layers, proper structure representation and type of propagation is not the key factor here. Thus for instance we can assume Hopfield recurrent network structure as its Form.

Methods – Laws of Nature

Similarly to Miller's abstraction [12] of biological – natural laws in real neuron, here we also assume several basic methods reflecting livness properties of neurons. Biological neurons have number of input dendrites and a single axon as output. Each dendrite can split in branches like tree-growth and axons can too. According to standard neuron livness behavior we assume following default methods:

- Branch-Growth: creation, destruction, growth of new branches on dendrites and axons.
- Axon-Reconnection: axon can reconnect to another dendrite of neighbor neurons.
- Signal-Process: process input signals in neuron's body – soma.
- Neuron-Growth: creation, destruction of neurons.
- From Axon to Dendrite Propagation: pass output of potential through axon to the dendrite branches.
- Weight-Update: update neuron's weights.

Since methods are Form it can be locally changed, removed or new methods can be added. Methods are updated locally for each neuron processing according to current neuron's *Content* and its present state. Since methods are Form that can be changed in runtime, it is also necessary to distinguish methods configurations (states).

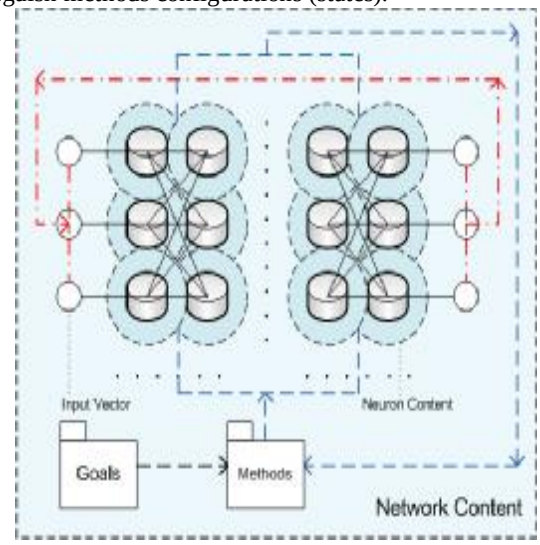

Fig. 3.3: Schematic diagram of HIM computing model with Content/Form architecture. All Neuron-Contents are part of Network-Content, thus neurons can indirectly interact through its Contents too. Network Content objectives (goals) are represented as fuzzy logic statements which are satisfied by *Form* transformations (computation in network).

E. Content of HIM

In proper design reflecting the definition 3.1 we should define each *Content* for each type of *Form* (or group of related/similar *Forms*), thus we should distinguish *Neural-Structure-Content*, *Neurons-Content* and *Methods-Content* plus *Root-Content*. But in case of our design we make simplification and distinguish only *Network-Content* as *Root* and *Neuron-Content* as encapsulated lower, inherited *Content*.

Neuron Content

In our simplification *Neuron-Content* is memory of past states of each neuron *Form*. It is updated after each neuron input processing. It also encapsulates states of all methods applied at each neuron input processing. Before each neuron processing, current neuron state (configuration) is compared with its all past states (as evolution review) and objectives in *Network-Content* to decide how methods should be applied and modified.

Network Content

Network-Content drives the processing in whole network through its goals (passed through inputs) and memory - past

states of *Neuron-Content*. Thus it encapsulates all previous states of each neuron including methods locally applied (see *Neuron-Content* below). Goals are represented by set of objectives that *Content* is going to achieve via *Form* transformation. As all *Neuron-Contents* are part of *Network-Content*, neurons can indirectly interact through its *Contents* too (beside main interactions through interconnections in network *Form*). For detail description of *Network-Content* processing see figure 3.3 and section 3.6.

F. Information Processing in the Network

At the beginning of computation, network contains default grid size – amount of interconnected neurons (set to initial states), default set of methods (see above) and input (including proper input data and Content objectives). In first preparation step, objectives from input are passed to *Network-Content*. In network information processing we distinguish two types of computational steps: *neuron step* (processing of information by neuron) and *network step* (processing of information by all neurons in network).

At first *network step*, input is processed through first neurons in input layer that propagates it to other neurons until all *neuron steps* are completed. Here, type of propagation depends on neuronal structure assumption (e.g. Hopfield recurrent network), as noted above. Before each *neuron step* its state is compared with its *Neuron-Content* (memory – including all states of neuron and states of methods that were previously, locally applied on this neuron) and with objectives in *Network-Content*. According to this comparison methods are locally (meaning in range of specific neuron) corrected and then applied. For illustrative description of *Network* processing see figure 3.3.

Until the objectives in Content are satisfied (fitness factor reached) network steps are repeated. Proper *Content* objectives are not defined as precise logical formulas but as fuzzy logic statements.

G. Implementation

We have proposed model of computation (HIM), using introduced Content/Form architecture. Model is based on well known concept of artificial neural networks and mostly inspired by Sheldrake theory of "*Nature as Alive*" [22]. Although this theory is very radical, it has deep impact to classical scientific paradigm and although it operates with non-physical terms like morphic fields/resonance (that is hard to represent by existing technology), our simplified Content/Form abstractions applied in HIM model can be easily SW implemented, simulated on existing generic HW or HW simulated using specific HW with dozens of small computational units as neurons with direct access to shared memory as *Content* (e.g. using inexpensive graphic processing units as accelerators). Regarding SW resources, since existing object oriented programming (OOP) languages operate with terms like hierarchy, inheritance or encapsulation Content/Form architecture including dependency hierarchy can be lightly represented.

IV. Conclusion and On-Going Work

In this contribution we have presented cross-disciplinary research between psychological evidence on human abilities and informatics demands to update current models in computer science. Main aim was to reassume information hypothesis, reference HIM model sketch (proposed in [6]) by detail design of HIM as computational model. This aim was presented via introduced Content/Form computing architecture and its application on HIM concept.

Natural/human inspiration on HIM concept was reflected by understanding HIM as cooperative system instead of stand-alone approach. This inspiration mostly comprises evolutionary theory, neural networks concept, neuron's biological-living aspects, fuzzy logic and Sheldrake theory of "*Nature as Alive*".

In future work we are going to focus on implementation and on investigation of designed HIM model properties on different tasks (e.g. game solving) on various HW configurations. In conclusion of this research we would like to observe results to be able to compare/highlight advantages/disadvantages of designed model with other existing models of artificial neural networks.

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