ON HUMAN INFORMATION CAPABILITIES

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ABSTRACT

Main aim of this paper is to explore the human information capabilities with link to open problems in computer science. We come with working hypothesis reflecting currently known research experimental evidence of human information capabilities. As every hypothesis, presented hypothesis needs further verification to show confirmation or disconfirmation in result. Nevertheless, this work opens novel topic on scientific research with aim to resolve presented open problems and review of classical paradigm in computer science.

1. OPEN PROBLEMS

Beside the proposed parallel challenge in HW and SW design, even toady we can observe certain limitations we are facing [2].

Physical walls: Computer science has already faced physical walls in implementation of logical gates, in silicon chip (concerning size, overheating, unsustainable power consumption). Therefore researchers are switching to parallelization. But once maximal parallel speedup is reached there is no obvious clue how to continue this settled performance growth.

Theoretical walls: Are open questions closely related to model of Turing machine, TM. Here we can note undecidable problems like Halting Problem; NP-hard and NP-complete problems like SAT Problem. Beside the fact there exist theoretical computational models more powerful than TM, like TM with Oracle, Site machines; due to the infinite descriptive properties of such models it is not possible to implement it efficiently and use in practice. Thus effective computable theoretical model remains bounded by Turing machine.

Human-Computer walls: Beside the physical and theoretical walls computer science is also dealing with many human-computer interaction (HCI) problems. It is simply observable that as greater difference exist at interaction between human and computer as more efforts must be spend to eliminate human-computer gap (gulf of execution, gulf of evaluation). We cannot change the human computable design, but we can decide how “machine” computation is designed.

Discussion: In future research and development of computer science researchers would like to handle physical, theoretical and HCI walls as presented. Therefore these walls represent the main motivation for alternative computation.

2. ALTERNATIVE COMPUTATION

In following we briefly show two main representatives of real world alternative computing (quantum, DNA computation) and discuss its properties. Both, quantum and DNA are not restricted to silicon chip HW platform (reflects physical walls), comes from nature, real world observation, massive parallel (reflects theoretical walls), promising more efficiency.

Quantum computation: It is known that quantum TM is more efficient than TM, but it is still an open question whether all quantum mechanical events are Turing-computable. For example, Shor [9] demonstrated quantum algorithm for integer factorization which is exponentially faster than the best-known classical factoring algorithm. Quantum computing was also successfully used to solve some of artificial intelligence NP-hard problems [7]. Although quantum computing is promising to overcome physical walls of classical silicon chip design and decrees time complexity at case of certain theoretical problems, it cannot be used in practise due to main disadvantages: expensive to fabricate, today quantum 16-qubit chip (D-Wave) is not enough, decoherence (the lost of superposition state).

DNA computation: Operations of molecular genetics can be understood as operations over strings/strands and by proper sequence of such operations we are able to execute required computation. Adleman [1] demonstrated DNA "*algorithm*" for solving of well-known NP-complete problem, the "travelling salesman" in polynomial time. He chose to find the shortest route between 7 cities. In later years DNA computation was generalised to solve other NP-complete problems. Although the DNA computing is also promising to overcome physical walls of classical silicon chip design and solving NP-complete problems efficiently, the reality is different due to main disadvantages: representation of problem leads to non optimal space complexity, execution time (e.g. one step can take one day or more), risk of errors during biological operations (requires repeating until acceptable).

Discussion: Alternative computable approaches like quantum or DNA computation come with "*partial*" solution, novel approach, but still have other "*own*" problems. We may ask, what is the next? Is there any other alternative approach which can contribute to open problems/walls?

3. HUMAN INFORMATION CAPABILITIES

As shown in previous chapter alternative approaches are candidates to overcome walls in computer science, on the other hand still not feasible, applicable. In this paper we consider another alternative approach – human information capabilities, which stand for human computation and communication abilities. As human information capabilities are still undiscovered research area (the power and time complexity of human information processing is still unknown) we focus on this topic to contribute positive on presented walls.

Classical computation (as we know today) provides two main services to satisfying human needs. These closely related services are:

- Processing information, form of information may differ (dealing with computation).
- Sharing information (dealing with communication).

Both of these services can be found on human in natural form. Further, there exist specific tasks "*solvable*" by human computation, which cannot be solved by any classical computer or which is hard to solve (e.g. artificial intelligence NP-hard problems) [7]. Here we can note some specific tasks like pattern recognition, path navigation, and natural language processing or more abstract tasks like creativity, free will and consciousness. Moreover, beyond these well-known tasks there is also experimental evidence on human information capabilities which cannot be classically explained on basis of established physical concepts and statistical theory [5].

In summary, we do not know the diversity, power and complexity of human information capabilities and moreover we do not know its all causers and principles [4]. For instance, there is experimental evidence which link mind process with holonomic quantum interpretation [11], but quantum interpretation is still subject of open question. It is not possible to answer such open questions in this paper; hence here we operate with information which is known, classical scientific concepts (e.g. neural networks) and results of experimental evidence (e.g. unexplainable human phenomena) to propose research synthesis – working hypothesis with aim to contribute on walls in computer science.

4. WORKING HYPOTHESIS

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. Here we assume these approaches as cooperative system, research synthesis rather than stand alone approach (to be more close to real human). This also reflects real evidence of human scientific results (psychology, neurobiology, and quantum mechanics) [3, 4]. Whole hypothesis is divided into three parts and linked together. Now, we postulate hypothesis statements consequently.

$\boldsymbol{H_1}$: *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 computable system based on neural networks, molecular neurology, evolutionary approach and phenomena related to quantum mechanics at least.*

In real world human mind, thinking is physically related to brain functions, where brain include biological neural network (refer to neural network computation) which describes a population of interconnected neurons or a group of disparate neurons whose inputs or signaling targets define a recognizable circuit. This circuit is evolvable and reconfigurable (refer to iterative evolvable approach). The field of molecular neurobiology overlaps with other areas of biology and chemistry, particularly genetics and biochemistry and study behaviors on molecular level, behind neuron size. Study of nervous behavior on such level brings us to microscopic world where quantum phenomena are examined. Further the evidence of non-local physical, chemical and biological effects supports quantum brain theory [4]. These theories where proposed by various researchers [3, 10, 11] (refer to quantum phenomena). With respect to $\boldsymbol{H}_1$ and following $\boldsymbol{H}_2$ statement, recently in computer science it was proved that assuming "*ingredients*" of real modern computing like non-uniformity of programs, interaction of machines and infinity operations in cooperative model, simultaneously; leads to model beyond Turing machine, see also chapter 1.

$\boldsymbol{H}_2$: *By considering and supporting all phenomena in cooperative computable system as stated in (H_1) computability of human computable model is increased in terms of complexity/efficiency, in contrast with considering each phenomenon as independent model, stand alone computable approach.*

With respect to $\boldsymbol{H}_1$ and $\boldsymbol{H}_2$ statement; further research in following third statement can also bring us explanation why human is able to solve NP-hard problems similarly as quantum computation; meanwhile these problems are not efficiently solvable by classical computation today [7].

H$_3$: *Based on (*H_1*) and (*H_2*) computation and communication patterns can be designed to overcome some of relevant physical and theoretical walls in computer science.*

4.1. Towards Human Information Model

Meanwhile human science is referring to psychology (natural SW), biology, medicine (natural HW); the technical science is referring to classical computer science and physics. Here we have to meet both research attitudes to fulfil common goal. To verify the presented hypothesis statements $\boldsymbol{H}_1$, $\boldsymbol{H}_2$ and $\boldsymbol{H}_3$ we deal with human information model. In general, we may try to describe the best model for human information capabilities, but the best model will always remain human himself. Moreover it is not currently feasible to answer all human-information open questions in one model. Therefore presented model stands for links of "*what we know*" separately to observe "*what we need to overcome*". At this phase, we do not need to answer all questions to be able to use what we have, we are. Figure 4.1 shows general multi-level model of human information capabilities. The existence of each level was confirmed by experimental evidence as described above and is examined further.

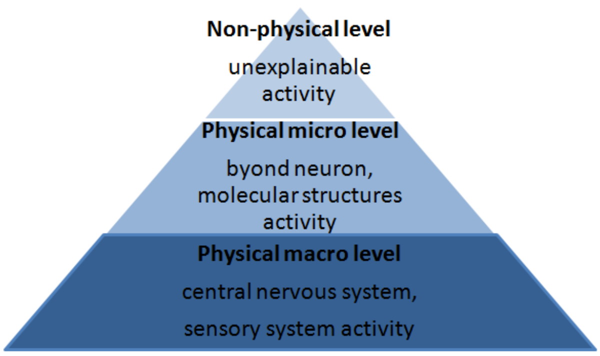

Figure 4.1: Multi-level model of human information capabilities, all levels are cooperative.

Physical macro level refers to nervous system linked with sensory preceptors which can be described as neural network connected to external devices. It is still an open question what variant of neural network is the best approximation for human-natural network. Currently the model of Analogue Recurrent Neural Networks (ARNN) is examined as human neural network candidate. If ARNN operates with real numbers then computable power is equal to Turing machine with oracle [13].

Physical micro level refers to evidence of computation beyond the neuron level. Molecular neurobiology has discovered that biochemical transactions play an important role in neuronal computations; on level where toady quantum mechanics is the most accurate description. For instance, in [12] dendrite spine is examined as a quantum computing device. Moreover there is huge experimental evidence on phenomena (beyond neuron size) which supports quantum explanation [3, 10].

Non-physical level refers to human information activity which cannot be explained on basis of established physical concepts and statistical theory. It is assumed that such activity is executed beyond any physical artefact/part of human body [5, 6, 8]. Although the experimental evidence [5] is matter of discussion and open questions, we should consider such evidence as part of human information capabilities as evidence shows.

5. CONCLUSION AND FUTURE WORK

We have listed main open problems of computer science, discussed alternative approaches which are promising the solutions. But in spite of quantum, DNA alternative efforts open problems/walls remains open. Hence we focused on human information capabilities as other alternative approach and presented the working hypothesis which is offering the positive contribution on discussed problems. We have also presented the abstract human information model which is essential for future investigation in hypothesis verification.

In future work the main research aim remains hypothesis verification, mostly based on *human information activity* experimental evidence, model approximation and design of patterns ("*algorithmic-rules*") for NP-hard (mostly artificial intelligence) problems which are solvable in terms of $\boldsymbol{H}_3$ statement.

REFERENCES

[1] L. Adleman. *Molecular Computation of Solutions to Combinatorial Problems*; Science, 266, pp. 1021-1024, 1994.

[2] K. Asanovic, R. Bodik, et al. *The Landscape of Parallel Computing Research: A View from Berkeley*, [white paper], 2006.

[3] S. Hameroff . *'Funda-Mentality': is the conscious mind subtly linked to a basic level of the Universe*? Trends Cognitive Sci, 2:4–6, 1998.

[4] H. Hu, M. Wu. *Nonlocal effects of chemical substances on the brain produced through quantum entanglement*, Progress in Physics 2006, v3, pp. 20-26, 2006.

[5] R. B. Jahn. *On the Quantum Mechanics of Consciousness, with Application to Anomalous Phenomena*. Foundations of Physics, 16(8), pp. 721–772, 1986.

[6] C. G. Jung. *Psychic conflicts in a child*. Collected Works of C. G. Jung, 17. Princeton University Press. 235 p. (p. 1-35), 1970.

[7] H. Neven, G. Rose, W. G. Macready. *Image recognition with an adiabatic quantum computer I. Mapping to quadratic unconstrained binary optimization*, eprint arXiv:0804.4457, 2008.

[8] R. Sheldrake. *An experimental test of the hypothesis of formative causation*. Rivista di Biologia – Biology Forum, 86(3/4), pp. 431-44, 1992.

[9] P. Shor. *Polynomial-Time Algorithms for Prime Factorization and Discrete Logarithms on a Quantum Computer*, Proceedings of the 35th Annual Symposium on Foundations of Computer Science, Santa Fe, NM, Nov. 20--22, 1994.

[10] R. Penrose. *Shadows of the Mind: A search for the missing science of consciousness*, Oxford University Press, Oxford, 1994.

[11] K. H. Pribram. *Rethinking Neural networks: Quantum Fields and Biological Data*. Proceedings of the first Appalachian Conference on Behavioural Neurodynamics. Lawrence Erlbaum Associates, Publishers, Hillsdale, New Jersey, 1993.

[12] A.F. Rocha, et al. *Can the human brain do quantum computing*? Medical Hypotheses, Vol. 63, Issue 5, pp. 895-899, DOI: 10.1016/j.mehy.2004.03.044, 2004.

[13] H. Zenil et al. *On the possible computational power of the human mind*. In Essays on Epistemology, Evolution, and Emergence, World Scientific, 2006.