Int. Journ. of Unconventional Computing, Vol. 17, pp. 235–238
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LETTER TO EDITOR

Hormonal computers?

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Today, biomimetic approaches to unconventional computing have been exploring neurotransmitters' roles. But hormonal aspects of artificial cognition are still unexplored. And from a cognitive perspective, such a complex biochemical combination allows fundamental mechanisms of information processing, from abductive tasks to attention or intentionality. This paper will explore the theoretical ways by which hormonal computers could open a different way to create not only innovative machines but also programming ways of dealing with such bioinspiration.

Keywords: Biocomputing, hormones, neurotransmitters

1 BIOINSPIRED COMPUTING AND NEUROTRANSMITTERS

Bioinspired computing is a research field that has provided interesting and successful results imitating mechanisms that we can find in the living taxa (Adamatzky, 2021; Jones, 2015; Rout et al., 2020; Siddique & Adeli, 2020). From minuscule slime mold (Adamatzky, 2016) to human brains (Rhodes, 2020). Neural networks are a clear and extremely successful example of bioinspiration, especially in the current technology of Deep Learning.

But there are other mechanisms employed by humans to manage their cognitive performance. Previously, I with a team of Russian engineers have explored the possibility of including neurotransmitters as mechanisms for managing computational architectures (M. Talanov et al., 2016; Max Talanov et al., 2018; Vallverdú et al., 2015). The models we've obtained for each neurotransmitter allow us to consider how its implementation in a computer system can help the system to optimize some of the functioning procedures. In

one of our researches, we presented the results of simulation of excitatory Hebbian and inhibitory "sombrero" learning of a hardware architecture based on organic memristive elements and operational amplifiers implementing an artificial neuron. This was a first step towards the deployment of robots with a bio-plausible simulation, currently developed in the neuro-biologically inspired cognitive architecture (NeuCogAr) implementing basic emotional states or affects in a computational system, in the context of our "Robot dream" project. The long-term goal was to re-implement the dopamine, serotonin, and noradrenaline pathways of NeuCogAr in memristive hardware (Max Talanov et al., 2017).

Anyhow other available mechanisms present in human cognitive processes may help to the design of a new set of unconventional computers: hormones

2 HORMONAL COMPUTERS

Despite the interest that the creation of hormonal computers could arouse, the truth is that there are no records of existing research in this field. There are several studies on modeling computationally hormones, as an *in silico* experiment, but not connecting this research with computer developments or architectures. If there is no previous research, why do we need hormonal computers? If current architectures, even unconventional ones, work relatively fine, which is the necessity of creating a new kind of computer, this time inspired by hormonal regulation? Because it would add a second-level code integration into computing processes.

In humans and mammals, hormones are a group of chemicals that travel through blood regulating specific physiological and behavioral tasks, like reproduction, development, feeding, sleeping, among a long list. Steroids and a long list of hormones (close to 60) regulate human cognition and action in subtle ways that are combined with neural activity. From a cognitive perspective are a second-layer decision level, to add to the brain activity. Hormones signal other biochemical reactions and provide the agents with other resources for managing their interactions with the world. The subtle diversity in their presence explains for example the diversity in agents' moods and behaviors, as well as its imprinting into human cognitive performance (Lupien et al., 2007).

There are several benefits for introducing hormonal-like mechanisms in computational architectures:

i. Like hormones, artificial hormones could manage new computer tasks without modifying the main running code. It happens the same in humans when hormonal variations modify general cognitive patterns without

affecting directly brain tasks. Nevertheless, a general computational architecture should allow the existence of such different layers.

ii. Hormonal computers could be designed to be activated in case of specific situations, without the necessity of adding specific orders into the system.

iii. Hormonal computers could help to explore the role of the variations of hormonal valences in cognitive variations. The contemporary studies on creativity(Csíkszentmihályi, 1995) show us that there are no rules for creativity, but that such processes are related to some character estates, like stubbornness.

iv. Hormonal computers could be more efficient in HRI, including models of analyzing and emulating emotions, mimicking better the emotionally shaped cognitive processes of human beings

v. Hormonal computers could help us to use para-functional mechanisms to obtain new task results.

vi. Hormonal computers could vary their speed task performance according to local conditions, and follow some preprogrammed tasks (like close the machine, slow down it, evaluate current tasks priorities…)

3 POSSIBLE APPLICATIONS

The existence of hormonal computers could lead to a new kind of computer system able to perform new tasks:

i. The creation of microcomputers implemented in human beings and reacting to specific hormonal variations inside the body, as elicitors of their designed task (hormonal pumps).

ii. The creation of computers in sleeping mode unless some specific conditions were combined. These computers could be paced in public spaces, fields, or forests to manage specific reactions of the environment.

iii. The creation of even wet computers able to interact in real-time with human internally fixed prostheses.

iv. The design of very reliable and tough systems able to take general decisions according to surrounding conditions, for example in hard conditions.

4 END REMARKS

The creation of hormonal computers is complex because of the necessity of designing new engineering architectures that allow the existence of such bio-

inspired machines. The main challenge is to design a computational framework in which artificial hormones affect classic computations, without losing any of the existing computational performings. At some extent, it implies the creation of systems that manage fuzzy situations delegating the best computational tools according to their morphological (and programmed) design.

5 ACKNOWLEDGES

This research is able thanks to an ICREA Academia grant. I also thank Heura Boix for her opportunities for thinking about the nature of computing.

REFERENCES

[1] Adamatzky, A. (2016). *Advances in Physarum Machines : Sensing and Computing with Slime Mould*. Springer. https://doi.org/10.1007/978-3-319-26662-6

[2] Adamatzky, A. (Ed.). (2021). *Handbook of Unconventional Computing* (Vols. 1–2). World Scientific. https://doi.org/10.1142/12232

[3] Csíkszentmihályi, M. (1995). Creativity across the life-span: A systems view. In *Talent development 3* (pp. 9–18). http://www.davidsongifted.org/db/Articles_id_10009.aspx

[4] Jones, S. (2015). *Bio-inspired computing : recent innovations and applications.* Clanrye Intl.

[5] Lupien, S. J., Maheu, F., Tu, M., Fiocco, A., & Schramek, T. E. (2007). The effects of stress and stress hormones on human cognition: Implications for the field of brain and cognition. *Brain and Cognition*, *65*(3), 209–237. https://doi.org/10.1016/J.BANDC.2007.02.007

[6] Rhodes, O. (2020). Brain-inspired computing boosted by new concept of completeness. *Nature 2021 586:7829*, *586*(7829), 364–366. https://doi.org/10.1038/d41586-020-02829-w

[7] Rout, M., Rout, J. K., & Das, H. (2020). *Nature inspired computing for data science*.

[8] Siddique, N., & Adeli, H. (2020). *Nature-Inspired Computing: physics and chemistry -based algorithms*. Routledge.

[9] Talanov, M., Vallverdú, J., Hu, B., Moore, P., Toschev, A., Shatunova, D., Maganova, A., Sedlenko, D., & Leukhin, A. (2016). Emotional simulations and depression diagnostics. *Biologically Inspired Cognitive Architectures*, *18*. https://doi.org/10.1016/j.bica.2016.09.002

[10] Talanov, Max, Gafarov, F., Vallverdú, J., Ostapenko, S., Gazizov, M., Toschev, A., Leukhin, A., & Distefano, S. (2018). Simulation of serotonin mechanisms in NEUCOGAR cognitive architecture. *Procedia Computer Science*. https://doi.org/10.1016/j.procs.2018.01.072

[11] Talanov, Max, Zykov, E., Erokhin, V., Magid, E., Distefano, S., Gerasimov, Y., & Vallverdú, J. (2017). Modeling Inhibitory and Excitatory Synapse Learning in the Memristive Neuron Model. *Proceedings of the 14th International Conference on Informatics in Control, Automation and Robotics*. https://doi.org/10.5220/0006478805140521

[12] Vallverdú, J., Talanov, M., Distefano, S., Mazzara, M., Tchitchigin, A., & Nurgaliev, I. (2015). A cognitive architecture for the implementation of emotions in computing systems. *Biologically Inspired Cognitive Architectures*. https://doi.org/10.1016/j.bica.2015.11.002