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Research article

Bio-plausible simulation of three monoamine systems to replicate emotional phenomena in a machine

Alexey Leukhin[a,*], Max Talanov[a], Jordi Vallverdú[b], Fail Gafarov[a]

[a] Kazan Federal University, Kazan, Russia
[b] Universitat Autònoma de Barcelona, Catalonia, Spain

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A B S T R A C T

In this paper we present the validation of the three-dimensional model of emotions by Hugo Lövheim the "cube of emotion" via neurosimulation in the NEST. We also present the extension of original "cube of emotion" with the bridge to computational processes parameters. The neurosimulation is done via re-implementation of DA, 5-HT and NA subsystems of a rat brain to replicate 8 basic psycho-emotional states according to the "cube of emotion". Results of neurosimulations indicate the incremental influence of DA and NA over computational resources of a psycho-emotional state while 5-HT decreases the computational resources used to calculate a psycho-emotional state. This way we indicate the feasibility of the bio-plausible re-implementation of psycho-emotional states in a computational system. This approach could be useful extension of decision making and load balancing components of modern artificial agents as well as intelligent robotic systems.

The problem

During the last two decades can be noticed an exponentially interest growth into emotions and emotion related domains of neuroscience, psychology, anthropology, sociology, and linguistics. It was proved by several researchers that emotions are tightly connected to cognition, action, and thinking (Damasio, 1999; Ekman, 2007; Ortony, Clore, & Collins, 1990; Reddy & Reddy, 2001; Scherer, Schorr, & Johnstone, 2001).

The lack of the bio-plausible psycho-emotional models has different negative impacts over different fields of the cognitive science, for example there is still not an objective quantitative model of emotions. Besides, that there is no way to objectively measure the psycho-emotional state (Bridges et al., 2015), even the most only "hardwired" one: pain (Vallverdú, 2013). On the other side, the lack of understanding of the emotional information processing prevents the use of emotional drives in artificial agents (Kugurakova, Talanov, Manakhov, & Ivanov, 2015) or intelligent robotic systems (Oatley, Keltner, & Jenkins, 2006), and becomes a fundamental limitation for the development of social AI.

Modeling following bioinspired mechanisms, We have used the threedimensional neuro-psychological model that bridges emotions or as defined by Silvan Tomkins "innate affects" (Tomkins, 1984); where affect, stands for the "strictly biological portion of emotion" with levels of monoamine neuromodulators: serotonin (5-HT), dopamine (DA), noradrenaline (NA). This model is called "cube of emotion" developed by Lövheim (2012) and it contains eight basic emotions: *enjoyment/joy, interest/excitement, surprise, anger/rage, disgust, distress/anguish, fear/terror and shame/humiliation*.

We have also extended the model with influence of virtual neuromodulators over computational processes parameters already published in the following article (Talanov, Zagulova, et al., 2017).

Our idea

We have used the neuro-psychological model "cube of emotion" (Lövheim, 2012) that bridges neuromodulatory systems of: DA, 5-HT, NA with basic emotions with the extension to bridge the neuromodulatory effects over computational system parameters: computing power utilization, computing power distribution, memory distribution, storage volume and bandwidth, and finally, memory and storage.

Abbreviations: BNST, The bed nucleus of the stria terminalis; DRN, Dorsal raphe nucleus; GPe, Globus pallidus external; GPi, Globus pallidus internal; LC, Locus coeruleus; LDT, Laterodorsal tegmentum; MRN, Median raphe nucleus; NAc core, Nucleus accumbens core; NAc shell, Nucleus accumbens shell; NTS, Nucleus of the solitary tract; PFC, Prefrontal cortex; PGI, Paragigantocellular nuclei; PVN, Paraventricular nucleus; SNc, Substantia nigra pars compacta; SNr, Substantia nigra pars reticulata; STN, Subthalamic nucleus; VA, Ventral anterior nucleus; VL, Ventral lateral nucleus; VPL, Ventral posterolateral nucleus; VPM, Ventral posteromedial nucleus; VTA, Ventral tegmental area

* Corresponding author.
E-mail address: jordi.vallverdu@uab.cat (J. Vallverdú).

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