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Cognitive Architecture of Collective Intelligence based on Social Evidence

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Abstract
Development of collective intelligence and consciousness starts playing key evolutionary role given spread of social networks and massive Internet communications. Paper considers cognitive model and architecture capable to capture cognitive phenomena in social environments, which could be used for modeling of collective cognition as well as developing practical applications for individual interaction with collective intelligence. The model is evaluated by means of qualitative and quantitative experiments.

Keywords: cognitive architecture, collective intelligence, social evidence, knowledge, consciousness

1 Introduction

As it has been pointed out by Valentin Turchin [1], the evolution is going over so-called "meta-system" transitions from simple systems to complex ones. The same is true for intelligence, "as ability to reach complex goals in complex environments, using limited resources" (accordingly to Ben Goertzel [2]). The intelligence, from cybernetic perspective, is grounded on capacity to store information. In this regard, one of the "meta-system" transitions has been experienced with appearance of mammals with information capacity of their brains (supplied with number of neural connections in the cortex) exceeding capacity of mammalian genome (supplied with number of possible gene interactions). The other transition is being experienced right now while the tight connectivity of humans in world-wide social networks is getting close to the one of human brain. Importance of the latter transition for evolution and humanity could not be underestimated because of amount of nodes and links in modern computer networks is exponentially growing with addition of artificial agents being involved in "hybrid" human-computer networks. Each of such agents, from cloud-based services to in-pocket "personal assistants", may carry simple-to-complex forms of artificially intelligent behavior possessing increasingly growing memory capacity and interaction speed beyond human capabilities.

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The latter fact makes it critically important to understand phenomena of social interactions “en masse”, so that effects of social behavior based on collective consciousness could be well understood, predictable and manageable – from perspective of humans exposed to modern information networks.

Pioneer work on mathematical modeling of social behavior has been presented by V. Lefebvre [3], who has shown the ability of a formal model to predict development of social interactions performed by individual agents. From phenomenological perspective, the most representative analysis of possible social behavior phenomena has been done by R. Cialdini [4], where multiple cases of society-bound effects of individual behavior are considered as having either positive or negative impact on survival and benefits of single individual or entire society.

In the further work, we consider approach for building computational model encompassing knowledge acquired by entire society by means of evidence supplied by each of it members. In such a model, it is anticipated the reasoning within the model can be performed in terms of probabilistic inference or fuzzy logic such as non-axiomatic reasoning systems by P. Wang and E. Vityaev [5,6]. The environmental constraints for the computational model are imposed by intelligence definition made by B. Goertzel [2], so that intelligent behavior is constrained by available physical resources, available to either alive, artificial or “hybrid” being. This is assumed to be done on the basis of “evidence-based knowledge representation model” with resource constraints as suggested earlier by A. Kolonin [7,8]. The latter would make it possible to use this model to predict and manage behavior of animal swarms, human societies or multi-agent computer systems. Finally, we suggest to generalize the theory of functional systems (TFS) developed by P. K. Anokhin and may others to extend over representing single intelligence system [9] to describe behavioral aspects of society of such systems.

2 Approach for Cognitive Architecture

We are developing the following cognitive architecture, capable to model collective consciousness as well as individual one (as extreme case with only one member in society) based on “social evidence, constrained by resources”, as originally suggested earlier [7,8]. Primarily, this can be qualified saying that meaning of a fact or relationship for subject of cognition (individual or society) is determined as cumulative function of the meanings of all of the fact or relationship appearances for all social referees of the object, with account to extent of social connection between the subject and a referee. Secondary, this is constrained stating that amount of appearances of a fact or relationship as well as amount of social referees and strengths of social connections to them is defined by cognitive capabilities of the subject of cognition. The subject of cognition could be either individual alive being, or society or artificial system or society of such systems etc. – we will denoting it as “agent” further.

Within this approach, there are requirements to support different kinds of data processed within the cognitive architecture possessed by agent, from three different perspectives (Fig.1).

Cognitive perspective

First, from primary cognitive perspective, there would be three different segments of the graph representation of the entire set of knowledge possessed by the system. The top layer is called “foundation graph” of basic knowledge, which is necessary for any social system to be shared by all of its members in order to communicate. The middler is called “imagination graph” keeping “inferred” knowledge, based on foundation terms and relationships residing in the “foundation graph” and supported by “evidence” coming from the bottom layer. The bottom layer is called “evidence graph” which contains everyday life-time experiences possessed by the agent (left side of Fig.1).

The “foundation” layer can be called “belief system” encompassing unconditional or “commonly accepted” information regarding the surrounding environment and agent itself. It can be considered as cornerstone cognitive base, or set of “absolute truths” about the surrounding world, storing basic