"Vasile Alecsandri" University of Bacău
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ON THE APPROACHES OF CLASSICAL ARTIFICIAL INTELLIGENCE AND EMBODIED ARTIFICIAL INTELLIGENCE

ELENA NECHITA

Abstract. The paper presents some key concepts of Embodied Artificial Intelligence (EAI) and their contrast to the classic, earlier Artificial Intelligence (AI) paradigms. Considering its strengths and weaknesses, we review some results of this approach, in order to conclude if EAI can further our understanding of intelligence.

1. INTRODUCTION

The papers of Anderson [1] and Chrisley [2] launched the debate on a new vision of AI. While Anderson considers the wider concept of Embodied Cognition (EC) into the framework of philosophy, psychology and linguistics, Chrisley restricts to the field of computer science, especially to that of intelligent agents. Indeed, in the light of Complexity Science, the concept of "intelligence" has been assigned new capabilities [3]: understanding of meaning, learning, analysis, making choices, interacting, autonomously adapting, setting and achieving goals, and creating. It appears that the most effective technology that allows the construction of intelligent systems that exhibit the above mentioned characteristics is multi-agent software [4].

Classical AI has shown its limitations. As classical AI approaches problems by means of the fragile models of human reasoning, it clearly appears that the limitations of these approaches are in essence the limitations of their models. AI did not produced intelligent machines, as expected.

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It is true that rational decision-making in humans relies on deductive inference. Since deductive inference involves the syntactic manipulation of symbolic representations according to rules that operate on the basis of the shapes of symbols rather than what the symbols may stand for, programs which simulate human reasoning by rule-based symbol-manipulation seem to be "on the right track" [5]. This is the approach of Symbolic AI. For example, automated theorem proving has been regarded as a success in the '60. It was quite useful for problems in logic, mathematics, computer science and social science. The most recent success in mathematics has been the proof of the conjecture that Herbert Robbins stated in 1933, namely that a particular group of axioms form a basis for Boolean algebra [6]. On October 10, 1996, the proof was found by EQP (EQuational Prover), an automated theorem proving program for first-order equational logic, after about 8 days of search (using an RS/6000 processor). But resolution is a purely formal method. After transforming the original logical formulae in the clausal form, the original meaning of those formulae is lost.

2. ON EMBODIED SYSTEMS AND THEIR PROJECTIONS IN COMPUTER SCIENCE

Classical approaches in AI regarded intelligence as an entity that was separated from a physical support. Sensors and effectors of intelligent agents were more like systems that allow input and output of data. But studies of the last decades show that intelligent behavior can arise from interraction of a large number of different autonomous elements engaged in rich interaction. The work of epistemologists [7] and neurophysiologists [8] clearly point into different directions - towards trial-and-error methods; selection through competition, cooperation, negotiation, random departures and self-organisation.

Recent approaches in AI employ the notion of "body". Four types of structures are proposed in [9] for a system to be "embodied":

a. Physical realization: the system must have a kind of physical substrate;

b. Physical embodiment: the system must be realized in a coherent physical structure;

c. Organismoid embodiment: the physical realization of the system must share some (even superficial) characteristics with the bodies of natural organisms (without being alive);

d. Organismal embodiment: the physical realization of the system must not only be organism-like, but actually organic and alive.

Even this view has been opposed, with the argument that robotics is neither necessary nor sufficient for the development of AI [10], there is already a history of the achievements with respect to a, b, and c types of agents. One can notice that more than a decade has passed since research focused on paying attention to recognising, simulating, and even incorporating emotion-analogs [11]. A more refined classification on embodiment can be found in [7].

While a and b types of agents have been realized and extensively introduced in real-world applications, and type c appears to denote the humanoid robots (those with human organism-like bodily form), type d deserves special attention.

Of course, embodiment is closely connected to "embodied cognition", as described, for example, in [12]. The idea is that "intelligence cannot merely exist in the form of an abstract algorithm but requires a physical instantiation, a body" (Pfeifer and Scheier, 1999). The first who stated that "cognition is what living systems do in interaction with their environment" was von Uexkll, who worked in the biology of cognition. According to his view (and afterwards confirmed by other scientists), differences between living organisms and man-made machines are significant (see [13] for an extensive discussion on this topic). Therefore, the notion of "organismal embodiment" limits cognition to living organisms.

3. CONCLUSIONS

Embodied Artificial Intelligence (EAI) involves results in biology, neuroscience, robotics, computer science, and psychology. If we intend to develop intelligent robots, with advanced capabilities, further studies are necessary in order to design materials for robot construction, neuron-like cell, up to models and representations of consciousness. When developing such robots and agents, sustainability must not be forgotten.

In Romania, Coneural (Center for Cognitive and Neural Studies, www.coneural.org) runs some modern research in neurobotics and computational embodied neuroscience, covering biologically-inspired robotics and artificial intelligence, evolutionary/ developmental/ epigenetic robotics, and artificial life (see, for example, [14]).

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"Vasile Alecsandri" University of Bacău
Department of Mathematics and Informatics, Faculty of Sciences
157 Calea Mărăşeşti, Bacău, 600115, Romania
email: enechita@ub.ro