Chairs' Welcome for GECCO'17 Workshop "Evolution in Cognition"

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1 WORKSHOP TOPIC

Even though evolution by means of natural selection is a simple process, it has resulted in the vastness of life forms that today exist and ever existed, and which include complex traits such as the cognitive capacity of humans. Having noted the potential of evolution's creative power, scientists have attempted to mimick this process through the use of Evolutionary Algorithms (EAs), an efficient and robust set of computational tools for optimization, which also offers a methodology for the generation of innovative solutions to novel problems.

But evolution is not limited to organic life and computer algorithms. Evidence exists that selective processes play an important role in the development of the human brain, as proposed by [1, 5]. An even more radical proposition has been made this decade by Szathmáry, Fernando and others [7]: They introduce the hypothesis of the Neuronal Replicators (NR), whereby the brain effectively implements evolution in combination with learning in order to solve complex cognitive problems. In short, a population of cognitive units (the NRs) propose a variety of solutions to a given problem. Amongst these, the best solution is chosen and taught to the other units that had less optimal solutions. Then each of these will generate the new "generation" of solutions by introducing variation on the previously learnt one. Iterating this process is effectively an evolutionary process and can solve or optimize a given problem [17].

This hypothesis has also inspired the application of the evolutionary approaches to artificial cognitive agents, since their optimizing potential and creative abilities promise an ideal framework that complement, aid in understanding, and facilitate the implementation of cognitive processes. Moreover, understanding the implementation of cognitive evolutionary architectures can serve as a means for better understanding cognition in humans and other higher organisms.

Despite the recent advances in the theory of the NR [4, 6, 17], this hypothesis about the interaction between evolutionary processes and cognition over physiological time scales has not gained much attention. Therefore we posit that it is important to depict the current state of the art of evolution in cognition and to determine the main outstanding challenges in this area. Thus, we have organised this workshop aimed at bringing together different theoretical and empirical approaches that can potentially contribute to the understanding of how evolution and cognition can act together in an algorithmic way in order to solve complex problems.

We welcome approaches that contribute to an improved understanding of evolution in cognition using robotic agents, in silico computation, as well as mathematical models.

2 WORKSHOP PROGRAM

The workshop consists of invited talks by prestigious speakers from different scientific fields related to the workshop topic complemented by short presentations of ongoing work.

2.1 Invited talks

Eörs Szathmáry: Selection and Evolution in Brain Function, *Evolutionary Systems Research Group, Center for Ecological Research, Hungarian Academy of Science, Tihany, Hungary,* and *Center for*

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the Conceptual Foundations of Science, Parmenides Foundation, Pullach/Munich, Germany.

The role of selection in the functional development of the brain has been firmly established. Evolution is more than selection, however: it requires generations of replicators of some sort, without which no real Darwinian behaviour (in terms of cumulative adaptations) is to be expected [7]. Direct evidence for evolution in the brain is lacking, although there exist hypothetical models that are compatible with all known facts at the level of the required component mechanisms. Evolution combined with traditional neural mechanisms (such as Hebbian learning) can algorithmically achieve more than either mechanism on its own [17]. Implications of this vew for language and insight learning will be discussed [14].

Eörs Szathmáry, together with his mentor and colleague John Maynard Smith, has contributed to the recent reshaping of evolutionary theory by putting major evolutionary transitions in focus [15, 16]. He has produced highly visible papers tackling the origin of life and the genetic code, the classification of replicators and language origins .

Kenneth Stanley: Quality Diversity: A New Frontier for Evolutionary Computation, *Evolutionary Complexity Research Group, Department of Computer Science, University of Central Florida, Orlando, FL, USA and Uber AI Labs, San Francisco, CA, USA*

Ken Stanley is an associate professor at the University of Central Florida and also recently a Senior Research Scientist at Uber AI Labs after the sale of his company Geometric Intelligence to Uber. His research focus is neuroevolution, which is a combination of evolutionary computation and neural networks. He is an inventor of popular algorithms and encodings including NEAT [13], CPPNs [11], HyperNEAT [12], and novelty search [8]. In this talk he will highlight the emerging research area called Quality Diversity (QD) that aims to return not a single optimal solution, but rather a repertoire of diverse yet high quality options. From a cognitive perspective QD algorithms can provide new insights into the processes behind forming and elaborating a repertoire of skills. A review and study on various QD algorithms from Ken's research group can be found in [10].

Jean-Baptiste Mouret: Offline evolution for fast online adaptation in robotics, *Inria Nancy - Grand Est / CNRS / Université de Lorraine, Nancy, France*

In spite of impressive advances in learning algorithms, current robots still need hundreds of trials to adapt to new situations. By contrast, animals benefit from the millions of year of evolution that shaped their instincts and biases, which often allow them to adapt in a few minutes. In our group, we work on learning algorithms that allow robots to adapt more like animals, that is, in a few minutes [3]. To do so, we first evolve a repertoire of thousands of high-performing solutions using an illumination algorithm [9] (also called a quality diversity algorithm [10]); when adaptation is needed, the robot exploits a data-efficient adaptation algorithm (Bayesian optimization) to search for the best solution of the repertoire, that is, evolution designs the search space and provides the prior knowledge that makes fast online adaptation possible. In this talk, we will present experiments in which a 6-legged robot adapts to damage in less than 2 minutes [3], and more recent results [2] that makes it possible to contemplate deploying trial-and-error adaptation algorithms for mission in places that are truly too dangerous for humans.

2.2 Short presentations

- Learning Highly Diverse Robot Throwing Movements through Quality Diversity Search, Seungsu Kim and Stephane Doncieux
- Cognitive Cultural Dynamics, Harold P. de Vladar
- Context Nodes in the Operation of a Long Term Memory Structure for an Evolutionary Cognitive Architecture, Richard J. Duro, José Antonio Becerra, Juan Monroy, Luis Calvo

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