Bioinspired Algorithms in Complex Ephemeral Environments

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Abstract

The concept of Ephemeral Computing is an emergent topic that is currently consolidating among the research community. It includes computing systems where the nodes or the connectivity have an ephemeral and thus unpredictable nature. Although the capacity and computer power of small and medium devices (as smartphones or tablets) are increasing swiftly, their computing capacities are usually underexploited. The availability of highly-volatile heterogeneous computer resources capable of running software agents requires suitable algorithms to make a proper use of the available resources while circumventing the potential problems that may produce such non-reliable systems. Due to the non-reliable nature of the system where the algorithms under consideration should run, they have to be ephemerality-aware, having the self-capability for understanding this kind of environments and adapt to them by means of flexibility, plasticity and

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robustness. Because of their decentralized functioning, intrinsic parallelism, resilience, and adaptiveness, bioinspired algorithms suit well to this endeavour. The papers in this special issue address a variety of issues and concerns in ephemeral and complex domains, including: signal reconstruction, large scale social network analysis, diseases detection and prevention, unit deployment and collaborative hyper-heuristics.
Keywords: Ephemeral Computing, Ephemeral applications, Ephemeral Complex systems

1. Introduction

Ephemeral computing (Eph-C) includes computing systems where the nodes or the connectivity have an ephemeral and thus unpredictable nature [1, 2]. This implies several things: a low, or no, threshold of acceptance of new nodes into an Eph-C system, which implies that nodes will be heterogeneous with a wide range of computing capabilities; second, the nature of the participation of a particular node into an ephemeral system is not known in advance, and might happen for an indeterminate amount of time, making the system inherently unreliable; third, there might be a human component that is an essential part of the system; and finally, their connectivity is arbitrary and also unknown in advance, as well as variable.

These properties will affect the functioning of distributed versions of computer algorithms, which will have to be redesigned and, in many cases, rethought from the ground up, to be able to use all ephemerally available resources and the whole range of computing devices, with different computing capabilities, available. This is one of the main challenges in the Eph-C field: porting algorithms to an inherently ephemeral, unreliable and massively heterogeneous computing substrate, without losing the essence of the algorithm and, if possible, using these characteristics so that the algorithm takes advantage from them.

Among the desired features for the algorithms under consideration —that will potentially be run on non-dedicated local computers, remote devices, grid systems, cloud systems, ubiquitous systems, among others [3, 4, 5]—we look for ephemerality-awareness, which is related to self-capability for understanding the underlying systems where the algorithm is run as well as taking decisions on how to proceed taking into account the non-reliable nature of the system. Algorithms consciously running on this kind of environment require specific properties in terms of flexibility, plasticity and robustness. The main goal in Eph-C is thus making an effective use of highly-volatile resources whose computational power (which can be collectively enormous) would be otherwise wasted or under-exploited. Think, for example, of the pervasive abundance of networked handheld devices, tablets and, lately, wearables –not to mention more classical devices such as desktop computers– whose computational capabilities are often underexploited. Hence, the concept of Eph-C partially overlaps with ubiquitous computing [4], pervasive computing [6], volunteer and distributed computing [5, 7] but exhibits its own distinctive features, mainly in terms of the extreme dynamism of the underlying resources, and the ephemerality-aware nature of the computation, which autonomously adapt to the ever-changing computational landscape, not just trying to fit to the inherent volatility of the latter but even trying to use it for profit.

Papers were invited for this special issue considering aspects of these problems, including:

- Computational creativity
- Content generation, behaviour and data analysis in video games
- Social Network analysis
- Ephemeral pattern mining
- Ephemeral clustering
- Evolutionary ephemeral-based algorithms to new and innovative domains
- Swarm ephemeral-based algorithms to new and innovative domains

- Online and streaming data analysis
- Human behavioural modeling in ephemeral environments

After several rounds of review, a total of seven papers have been accepted for publication in this issue. Next section provides a short description on the main contributions of those papers.

2. Content of this issue

The issue starts with a position paper [8], which provides a comprehensive description and analysis of the main challenges and trends on the concept of Eph-C computing, and how bio-inspired algorithms are are particularly well suited to this problems, thanks to natural features as decentralized functioning, intrinsic parallelism, resilience, or adaptiveness, among others. Although Eph-C exhibits some features close to amorphous and volunteer computing, namely *inclusion, asynchrony, resilience, emergence, and self-adaptation*, their combination becomes a distinguishing factor. The paper also review specific examples of algorithms and methods designed to tackle over massively heterogeneous and complex domains, focusing on big data and social data analysis, computer gaming and computational creativity, as three of the countless applications that can benefit from the results that may be obtained with the combination of bioinspired algorithms and Eph-C.

The authors in paper [9], proposes a new greedy algorithm to reconstruction performance from signal sparsity estimation . Achievement of good reconstruction performance by most of existing greedy algorithms is possible only when signal sparsity has been known well in advance. However, it is difficult in practice to ensure signal sparsity making the reconstruction performance of the greedy algorithms stable. Moreover, some greedy algorithms with previous unknown signal sparsity are time-consuming in the process of adaptive adjustment of signal sparsity, and thereby making the re-construction time too long. Based on the restricted isometry property criterion, signal sparsity is estimated before atoms selection and the step size of atoms selection adjusted adaptively based on the relations between the signal residuals in each iteration. The research, which solves the problem of sparsity estimation in the greedy algorithm, provides the compressed sensing available to the applications where the signal sparsity is unknown. It has important academic and practical values.

In paper [10], a novel algorithm, based on the evolutionary algorithm called ITÖ, is designed to solve the Influence Maximization (IM) problem (this new algorithm is denoted as ITÖ-IM). There are three properties and two operators in ITÖ-IM: the formers include particles radius, particles activeness and environmental temperature, the later ones are drift operator and fluctuate operator. The particle radius is mainly used to simulate the characteristics of particles in Browns motion, and it is inversely proportional to the particles activeness. The environmental temperature controls the motion ability of particles. During the searching process, the particles in ITÖ-IM can cooperate with each other to effectively balance the contradictions between exploration and exploitation exited in most of meta-heuristic algorithms.

Next paper [11], proposes a novel system based on IoT sensors, cloud computing and fog computing, to distinguish, classify and monitor the users infected with Mosquito-Borne Diseases (MBDs). The objective of this system is to control the outbreak of MBDs at an early stage. In the proposed system, similarity factor is calculated to differentiate among MBDs and then a J48 decision tree classifier is used to classify the category of infection for each user. The alerts are instantly generated and sent to user's mobile from fog layer in case of any abnormality. Radio Frequency Identification (RFID) is used to sense the close proximity between users. Temporal Network Analysis (TNA) is applied to monitor and represent the current state of the MBDs outbreak using close proximity data.

Paper [12] presents a genetic algorithm strategy to improve the deployment of roadside units in VANETs. The authors propose to model the problem as a Maximum Coverage with Time Threshold Problem and the network as a graph, and perform a preprocessing based on the betweenness centrality measure. Moreover, the authors show that by using a simple genetic algorithm with few interactions, it is possible to achieve better results when compared with other strategies.

The work presented by authors in [13] shows how the spreading of social networks in our current society has aroused the interest of the scientific community in hard optimization problems related to them. Community detection is becoming one of the most challenging problems in social network analysis. The continuous growth of these networks makes exact methods for detecting communities not suitable for being used, since they require large computing times. In this paper, the authors propose a metaheuristic approach based on the Iterated Greedy methodology for detecting communities in large social networks. The computational results presented in this work shows the relevance of the proposal when compared with traditional community detection algorithms in terms of both quality and computing time.

Finally, paper [14] explores how ephemeral environments could be exploited to efficiently construct meta-heuristic algorithms by virtue of a collaborative, distributed nature-inspired hyper-heuristic framework specifically designed to be deployed over unreliable, uncoordinated computation nodes. To this end, the designed framework defines two types of nodes (trackers and peers, similarly to peer-to-peer networks), both reacting resiliently to unexpected disconnections of nodes disregarding their type. Peer nodes exchange their populations (i.e. constructed algorithms) asynchronously, so that local optima are avoided at every peer thanks to the contribution of the other nodes.

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– Check: `http://ephemech.wordpress.com` and `http://deepbio.wordpress.com`.

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