SELF-ORGANISING SENSOR WEB USING CELL-FATE OPTIMISATION

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ABSTRACT

The Sensor Web as an open complex adaptive system exhibits many characteristic that are common to self-organising systems. One of the characteristics of the Sensor Web is that of self-adaptivity in a changing environment. The changing environment may be doing so both dynamically and stochastically. When presented by a dynamic and stochastic changing environment, such as a sensor resource unexpectedly going down, a self-adaptive system should exhibit robustness. Cell-fate optimisation and signal regulatory networks provide a mechanism for self-organisation of agents in environments that are dynamic, distributed and possibly stochastic. Cell-fate optimisation and signal regulatory networks are shown to be effective mechanisms not only for addressing robustness but also for addressing adaptivity in the sensor web in general.

Index Terms— Cell-Fate Optimisation, Signal Regulatory Networks, Sensor Web, Self-Organising, Self-Adaptive System

1. INTRODUCTION

Self-organising can be defined as the spontaneous creation of a globally coherent pattern out of local interactions [1]. This self-organisation is achieved at the macro level as a result of an increase in entropy at the micro level [2]. Some characteristics of self-organising systems include distributed control and robustness to change. Complex adaptive systems are characterised by heterogeneous components, a complex network structure, a large number of nodes, adaptability, and the ability to self-organise [3,4]. Cell-fate optimisation is a biologically inspired complex adaptive system that allows for optimisation in dynamically and stochastically changing environment [5]. Signal regulatory networks provide a self-organising mechanism [6]. The principles of signal regulatory networks are used to drive cell-fate optimisation. Thus producing a framework for the development of self-organising complex adaptive system.

"The Sensor Web is an open complex adaptive system, organised as a network of open sensor resources, which pervades the internet and provides external access to sensor resources. By open sensor resources, we include any open system, including sensor networks, that is a source of sensor data or sensor meta-data [7]." Considering the distributed nature of the Sensor Web and the fact that it exists in an open environment, the Internet, many of the sensor resources that make up the Sensor Web are autonomous in nature and beyond centralised control [7]. Thus any issues relating to non-functional requirements must be dealt with in a decentralised and distributed manner. Also the sensor resources that make up the Sensor Web often have the added benefit of being task-able. By task-able it is infered that users or other sensor resources of the Sensor Web are able to steer or drive sensor resources to begin observing or change what they will be observing in the future [8]. This task-ability is directly related to the adaptive nature of the Sensor Web and allows for various feed-forward and feed-backward networks to be formed and underpins some of the intelligence that is required for the Sensor Web to function [9].

If the Sensor Web is to be used as a mechanism for decision support in disasters, as a data source for repeatable science, or as a reliable source of geospatial data in general, then issues relating to robustness will arise. The paper looks at the issue of robustness as it relates to open, distributed, dynamic and possibly stochastic environments. Specifically the environment of this nature chosen is that of the Sensor Web being used as a reliable source of geospatial data. It is postulated that the use of cell-fate optimisation and signal regulatory networks will facilitate robustness in the Sensor Web.

3. METHODOLOGY

An experiment is set up in which a prototype is used to show how the ideas relating to cell-fate optimisation and signal regulatory networks can be applied to increasing robustness in the Sensor Web. The experimental system is subjected to various tests including random node removal, addition and relocation to assess robustness and recovery time.

4. CONCLUSION

The paper described how cell-fate optimisation a biologically inspired technique underpinned by signal-regulatory networks a self-organising mechanism can be used to add adaptivity to the Sensor Web. The purpose of the adaptivity is to allow the sensor web to exhibit robustness in the face of a dynamically and stochastically changing environment. It was shown that not only does this mechanism address robustness but also addresses adaptivity in the sensor web in general.

Using self-organising techniques such as cell-fate optimisation underpinned by signal regulatory networks provides a framework for extending the capabilities of the Sensor web beyond a simple data delivery system to full functioning self-adaptive, intelligent macro instrument capable of intelligent sensing of the environment.

5. REFERENCES

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