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Study of Nature Inspired Computing

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ABSTRACT

Nature in itself is the best example to solve problems in an efficient and effective manner. During the past few decades, researchers are trying to create computational methods that can help human to solve complex problems. This may be achieved by transferring knowledge from natural systems to engineered systems.

Keywords: — Nature inspired computing, Complex systems and emergence, Biological inspired computing, Nature-inspired models of instruction.

I. INTRODUCTION

Nature inspired computing draws on the principles of emergence, self-organization and complex systems [1, 2]. It aims to develop new techniques, algorithms and computational applications by getting ideas by observing how nature behaves to solve complex problem. Research on NIC has opened new branches such as evolutionary computation , neural networks, artificial immune systems. Robotics researchers, inspired by nature, have developed robotic salamander, water strider robot, mechanical cockroaches, self-configuring robots, and so on.

The nature-inspired computing group creates and applies algorithms based on natural phenomena such as the human brain, evolution and swarms of insects. These algorithms can be applied to a wide variety of problems and those investigated by this group include diverse problems in robotics, engineering and bioinformatics.

II. COMPLEX SYSTEMS AND EMERGENCE

Complex systems are systems that exhibit emergent behaviour [2]. Their main characteristics are:

1) The system has internal structure composed of many interacting components.
2) The system has emergent behaviors that arise from the interaction of subsystems and are not deducible from analysis of each subsystem.
3) Systems can adapt to inputs and evolve (Adaptation and evolution).
4) Uncertainty is pervasive in complex systems.

Examples of complex systems include anthills, human economies, markets, climate, nervous systems, immune systems, cells and living organisms, human societies, cities, galaxies as well as modern telecommunication infrastructures and the world-wide web (see figure 1).

Fig. 1. Example of complex systems: nervous system (brain).

Natural ants are also complex systems. Ants are simple insects with limited memory and capable of performing simple actions. However, an ant colony, Gene Expression Analysis with Neural-Genetic, hyperheuristics, Neural Networks for Flood Simulation and Forecasting
expresses an complex collective (global) behavior providing intelligent solutions (emergent phenomena) to complex problems such as (see figure 2):

1) Carrying large items.
2) Forming bridges.
3) Finding the shortest routes from the nest to a food source.

Fig. 2(a). Complex collective behaviour: ants carrying large items

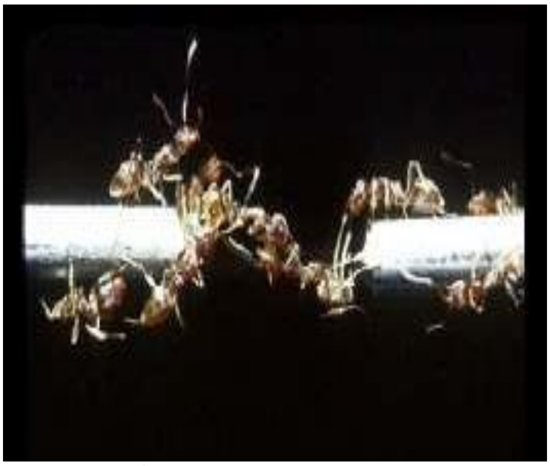

Fig. 2(b). Ants forming bridges.

A. *Ant Colony Optimisation (ACO)*

The first ACO algorithm, proposed by Marco Dorigo in 1996 [3] was Ant System and since then a number of modifications have been proposed to improve performance of the algorithm. ACO is inspired by the way that populations of ants in nature can find a short path between the nest and a food source by sensing the pheromone trails of previous ants. The computational algorithm requires ants to traverse a topology which is either a direct representation of the problem (e.g. in the travelling salesman problem) or a landscape of variable choices known as a construction graph. We have adapted the algorithm to work with the specific challenges of Genome-Wide Association Studies.

Subset-Based ACO: Standard ACO works by laying pheromone on the links between variables choices, which works well for combinatorial problems. However, for subset based problems (i.e. selecting a small number of *N* from a larger set), this method does not work well and incurs high computational complexity. We have therefore made use of a method first proposed by Leguizamon and Michaelawicz (1999) [4] which lays pheromone on the variables (SNPs) themselves rather than the links between them, reducing the search space considerably and speeding execution[5]

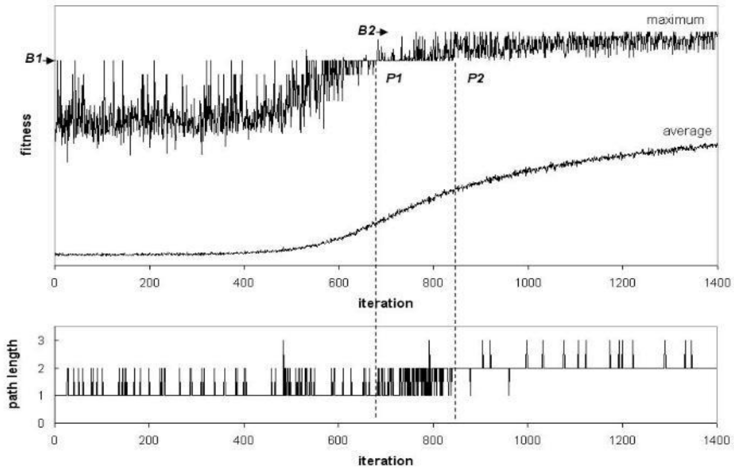

Fig.3. Pheromone trail for initial ACO algorithm over time note the inflectionecial purposes.

B. *Gene Expression Analysis with Neural-Genetic*

This long-term project studies the use of neural network and evolutionary algorithm hybrids for the analysis of gene expression (microarray) data,[6] with particular emphasis on the processing of cancer datasets. The neural-genetic technique has been used on classification and gene network inference problems and in single and multi-objective formulations. [7]

Hyperheuristics are a set of techniques that optimise at the level above metaheuristics (such as evolutionary algorithms and particle swarm optimisation) and find good combinations of heuristics to apply to a set of problems.[8] In this project, we are investigating new hyperheuristics for continuous & mixed encoding multi-objective problems and are applying them to problems in the water industry, including the mitigation of discolouration risk.[9]

III. BIOLOGICAL INSPIRED COMPUTING

Biological inspired computing is a subset of nature inspired computing. There are three key differences between traditional computing systems and biological information processing systems: components of biological systems respond slowly but implement much higher-level operations. The ability of biological systems to assemble and grow on their own enables much higher interconnection densities.[10] One of the most inspiring natural intelligence is the human mind itself. There are many theories of how minds work. This is a big question that will it ever be possible to make a machine which posses mind. If we consider the overall structure of the human brain and the elements we find out are nerve cells or neurons. Neurons process electrical signals constituting all brain activities which are connected up into complicated networks. It is this simultaneous cooperative behavior of very many simple processing units which is at the root of the enormous sophistication and computational power of the brain.

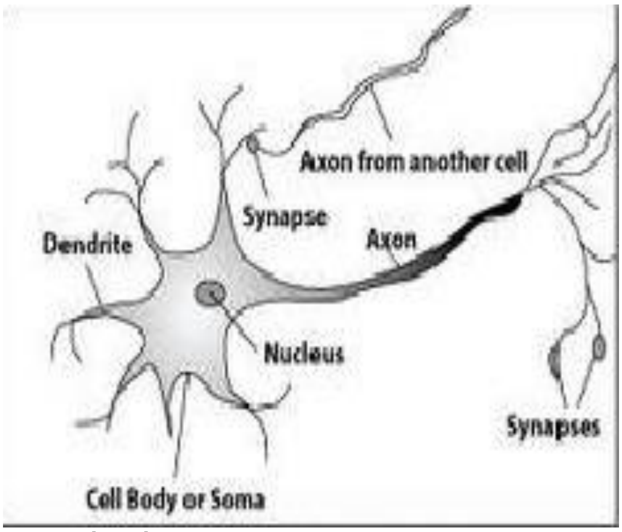

Fig.4. Biological Neuron

IV. NATURE-INSPIRED MODELS OF INSTRUCTION

The most established "classical" nature-inspired models of computation are cellular automata, neural computation, and evolutionary computation. More recent computational systems abstracted from natural processes include swarm intelligence, artificial immune systems, membrane computing, and amorphous computing. In fact, all major methods and algorithms are nature-inspired metaheuristic algorithms [11] including cellular automata, evolutionary computation, swarm intelligence and others.

There are two types of modeling approaches for studying natural phenomena: the top-down approach (involving a complicated, centralized controller that makes decisions based on access to all aspects of the global state), and the bottom-up approach, which is based on parallel, distributed networks of relatively simple, low-level agents that simultaneously interact with each other. Most traditional artificial intelligence (AI) research focuses on the former approach. Nature Inspired Computing focuses on the bottom-up approach and emphasizes individual Simplicity over the collective complexity of the task being performed. However, to apply such an approach to a problem, the components of the system have to be designed in such a way that the society be able to fulfill its requirements with a reasonable efficiency. Inspiration from natural self-organized systems (see figure 4) is a way to solve this conception issue.


Fig. 5(a). Social behaviours: bird flocking


Fig. 5(b). Social behaviours: fish schooling

V. CONCLUSION

Nature-inspired Computations have already achieved remarkable success. Nature Inspired Computing makes use of nature to develop new techniques for problem solving, usually conventionally-hard problems.

REFERENCES

[1] 1. Wilner, M., Bio-inspired and nanoscale integrated computing, Wiley, 2009.

[2] 2. Yoshida, Z., Nonlinear Science: the Challenge of Complex Systems, Springer 2010.

[3] 3. M. Dorigo, V. Maniezzo, et A. Colorni (1996) Ant system: optimization by a colony of cooperating agents, IEEE Transactions on Systems, Man, and Cybernetics--Part B , volume 26, numéro 1, pages 29-41.

[4] 4. G. Leguizamon and Z. Michalewicz, (1999) "A new version of ant system for subset problems," Proceedings of the 1999 Congress on Evolutionary Computation(CEC 99), vol.2, pp.1458-1464, 1999.

[5] 5. Sapin E, Keedwell EC. (2012) "T-ACO - Tournament Ant Colony Optimisation for High Dimensional Problems", *ECTA 2012 - 4th International Conference on Evolutionary Computation Theory and Applications*, Barcelona, Spain, 5th - 7th Oct 2012

[6] 6. Keedwell E., Narayanan A., (2003) "Genetic algorithms for gene expression analysis"