Artificial Immune Systems—An Emergent Technology for Autonomous Intelligent Systems and Data Mining

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Abstract. Artificial Immune Systems (AIS) are still considered with an attitude of reserve by most practitioners in Computational Intelligence (CI), much more some of them even considering this emergent computing paradigm in an infancy stage. This work aims to prove why AIS are of interest, starting from the real-world of applications that is asking for a radical change of the information systems framework. Namely, the component-based framework must be replaced with an agent-based one, where the system complexity requires that any agent to be clearly featured by its autonomy. The AIS methods build adaptive large-scale multi-agent systems that are open to the environment, systems that are not at all fixed just after the design phase, but are real-time adaptive to unpredictable situations and malicious defects. The AIS perform the defense of a complex system against malicious defects achieving its survival strategy by extension of the concept of organization of multicellular organisms to the information systems. The main behavioral features of AIS — as self-maintenance, distributed and adaptive computational systems — are defined and described in relation to the Immune System as an information system. A comparison of AIS methodology with other Intelligent Technologies is another point of the lecture. The overview of some actual AIS applications is made using a practical engineering design strategy that views AIS as the effective software with agent-based architecture.

1 Introduction

Any living organism is in fact a complex system typically featured by characteristics as evolution, adaptation and fault tolerance that cannot be implemented in real world systems using traditional engineering methodologies. The use of biologically inspired CI techniques play a crucial role in developing robust and effective applications where complex systems set their face successfully against the large diversity of unpredictable and dangerous events that exploit the weak points or systems holes. Two emerging and promising biologically inspired techniques, Artificial Immune Systems (AIS) and DNA computing, seem to be the impulse of the moment in developing the strategy of systems survival in the defence of actual information systems against malicious faults ([1], [2]). The collective effort of a large spectrum of
high technology practitioners, mainly the computer scientists, engineers acting in different technical fields, biologists and natural environment specialists, led to the interdisciplinary development approach of AIS and DNA reliant hybridisation algorithms, techniques and application. A lot of interesting, reliable and high performance applications in critical environment conditions are reliant on AIS and/or DNA techniques despite the fact that these methods are still at their incipient stage [3].

1.1 Basic Considerations Related to the Natural Immune System

The natural immune system is a system of high complexity. Its physiology is featured by a bunch of spectacular and useful functions, among them being a highly effective defence mechanism for a given host against pathogenic organisms and infections. This defence strategy acts by performing two tasks: firstly, the recognition is achieved of all cells within the host body, namely whether they are self (belonging to the body) or nonself (not belonging to the body); secondly, the distinction between body own’s cells and the foreign invader cells is followed by a classification of the nonself cells together with the induction of some appropriate defensive mechanisms for each of these dangerous foreign antigens that can be bacteria, viruses and so on. Details from different works in immunology science ([4], [5], [6]) converge to a unique simplified block diagram of how the defence mechanism of the natural immune system is structured; see Fig. 1 as from [2].

A lot of interesting aspects regarding basic immune recognition and activation mechanisms, more deep details in physiology of the immune system, innate immune system and adaptive immune system and other functional fundamentals as pattern recognition, the clonal selection principle, sel/nonself discrimination or immune network theory are to be mentioned when an overview is made on the basics of immunology. This paper is limited to just introduce the elements of immunology knowledge that are in connection with the defence mechanism of immune systems.

The defence activity of the natural immune system is achieved by the white blood cells, leukocytes, under a strategy of defence structured in a form of two distinctly implemented tasks of defence:

- the Innate Immune System (IIM) and
- the Adaptive Immune System (AIS).

The Innate Immune System (IIM) is implemented by two kinds of leukocytes, the granulocytes and macrophages. IIM combating responsibility consists of the fight against a wide range of bacteria without requiring previous exposure to them. Any is its body exposure to an antigen, the IIS response remains constant along the life time of an individual. A special combating strength features both the macrophages and the neutrophils: they are able of ingesting and digesting several microorganisms and/or antigenic particles; accordingly they are called together as phagocytes. But the macrophages are more powerful by having also the strength to present antigens to other cells, accordingly being additionally called also antigen-presenting cells (APC). The the granulocytes are cells with multiglobule nuclei containing cytoplasmatic granules filled with chemical elements (enzymes). The following three kinds of the granulocytes are known, namely: the neutrophils, that are the most abundant IIS cells;