

An appraisal of Artificial Immune System

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ABSTRACT

Artificial Immune system is an important field of computational Intelligence, which models various algorithms and mechanisms. One of the Computational tools is Artificial Immune System, which emulates with the Biological Immune system to process and function. In this paper, a comparison is made between Natural Immune System and Artificial Immune System. Different Artificial Immune system algorithms are discussed along with recent applications in Artificial Immune System.

Keywords – Artificial Immune System, Computational Intelligence, Clonal Selection algorithm, Natural Immune System, Computational Intelligence.

1. Introduction

During the last decade, Immune system inspired its attention towards the novel approaches for efficient and scientific problem solving. Already existing problem solving methods could not cater to the requirements of ever demanding challenges. Hence Artificial Immune System has emerged as one of the Computational Intelligence techniques that can handle the current problems better. This paper presents a review of artificial immune system in comparison with natural immune system.

2. Computational Intelligence (CI)

Computational Intelligence, a study of intelligent agents, is the process which deals with numerical data that contains pattern recognition components. In addition, it exhibits computational adaptivity and fault tolerance. Increased Computational speed and resilience to error are the special characteristics of Computational Intelligence.

2.1. Different Types of CI

The various techniques of Computational Intelligence [3] are shown in Fig.1.

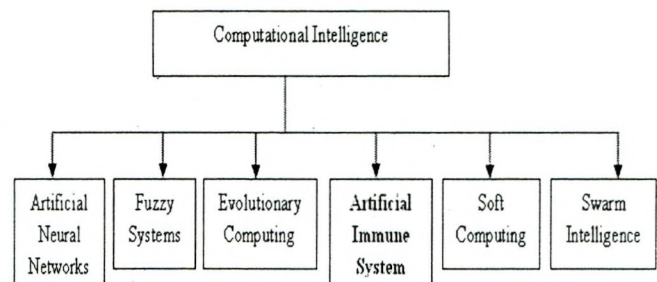


Fig.1. Different Approaches of CI

3. Artificial Immune System (AIS)

Artificial Immune system is an interdisciplinary field inspired from Natural Immune System functions and principles used for solving science and engineering problems. It is a novel approach to solve complex computational problems. AIS is the model which detects variations from the patterns that are anticipated, thereby protecting the system from intrusions.

4. Difference between Natural Immune System and Artificial Immune System

A comparison between the natural immune system and Artificial Immune system is presented in the Table.1 below:

Table 1.Natural Immune System Vs Artificial Immune System

Criteria	Natural immune System	Artificial Immune System
Immune Response	B-cells are produced as immune response against antigens	Immune system is used to capture patterns that occurs multiple times
Adaptation and diversification	Somatic hypermutation is done to remove both similar and specific antigens	Diverse of the data are done to identify patterns that are missed
Knowledge extraction and generalization	B-cells with increased affinities are used as high affinity cells.	Affinity maturation exploits the antibodies
Use of network structure	B-cells are used to create and model the network with the data being learnt.	Topological information is used to reveal the network with the data being modeled.
Knowledge of self and non-self	Immune system recognizes the antigens invading.	Anomaly detection technique is used to recognize the difference between self and non-self cells.
Integrity	Codes presents the cells cannot be corrupted	Data has to be protected from corruption
Confidentiality	Information is not corrupted	Authorized users can access the information
Availability	Though pathogens attacks, body continues its works	Authorized information could only be accessible
Correction	Attacks on the cells are prevented by immune system.	Reduces the rate of false alarms.

5. Algorithms of Artificial Immune System

Computer scientist inspired on vertebrate immune system developed the Artificial Immune System algorithms [1]. Some of the Algorithms are

- Negative Selection Algorithm
- Clonal Selection Algorithm
- Artificial Immune Network
- Danger Cell Theory Inspired Algorithm
- Dendritic Cell Algorithm

- Conserved Self Pattern Recognition Algorithm
- Toll-Like Receptor Algorithm

5.1. Negative selection Algorithm

Negative selection algorithm is one of the classical AIS algorithm used to deal with the cells entering into the body. The cells that enter are classified as self and non- self. The cells that are considered as self are discarded and the cells which are considered as non- self are detected and categorized to use different defense mechanisms. T Cell is the key immune component used in the Negative Selection Algorithm.

5.2. Clonal Selection Algorithm

In the Clonal Selection Algorithm, Clonal expansion of B-cells occurs due to the activation of original lymphocyte by the antigen. The process of affinity maturation caused by the increase of affinity induces the clonal expansion. Affinity maturation is extracted from somatic hypermutation. Only the higher affinity clones will survive.

5.3. Artificial Immune Network

In Artificial Immune Network, a network of B- Cells are interconnected to recognize the antigen. A stability is maintained in the network. If the affinity threshold exceeds, there occurs a connection between two B- Cells. The population of B- cells are initial and cloned populations.

Using the raw training data, a B- cell network is created and the rest of the data are logged to the antigen training items. From the antigen training items, antigens are randomly selected and exposed to B- cell network. Upon successful binding, B- cells are cloned and mutated. On failure of binding, a template is generated using antigen for B- cells.

5.4. Danger cell Theory Inspired Algorithm

According to Danger Theory Inspired Algorithm, danger/alarm signals are activated by injured cells. The danger signals activate Antigen Presenting Cells(APC). A danger zone is created around a danger signal. The antigens that match that of the one in the danger zone will be activated to undergo clonal expansion process. Immune responses are triggered by the danger signals. They are lower or

higher memory usage, inappropriate disk activity, unexpected frequency of file changes and so forth.

5.5. Dendritic Cell Algorithm

Dendritic Cell Algorithm is extracted from innate immunity and its primary role is similar to Antigen Presenting Cells. They perform different functions and modulation between states is classified into signals such as PAMP signal, Danger signal, Safe signal and Inflammatory cytokines.

- *PAMP Signals*- With “mature cytokines”, immature Dendritic cells causes maturation.
- *Danger Signals*- Tissue cell damages are released and causes maturation of Dendritic Cells
- *Safe Signals*- Regulated cell death is an exposure of safe signal. Mature Dendritic cells are reduced for output
- *Inflammatory Cytokines*- It is used to induce the above three signals

5.6. Conserved Self Pattern Recognition Algorithm (CSPRA)

Conserved Self Pattern Recognition Algorithm is a combination of Negative Selection algorithm which is derived from PRRs model and Antigen Presenting Cells Pattern recognition. In CSPRA, APC’s Pattern recognition and Negative Selection T- Cell are combined for anomaly detection. As compared to Negative Selection algorithm, CSPRA minimizes the false positive error rate.

5.7. Toll-Like Receptor Algorithm

Toll-Like Receptor Algorithm is a combination of Dendritic Cells and T- Cells. From the antigen store antigens are collected as immature detectors which are created by Dendritic Cells. During the collection of antigen, upon receiving a signal Dendritic Cells becomes mature. If T- Cells and mature Dendritic Cells matches, T- Cells are activated and it is classified as “Anomalous”.

6. Applications of Artificial Immune System

AIS are used in many applications [2] such as

- Abnormity Detection
- Computer Security
- Fault Detection
- Optimization & Learning
- Data Mining

6.1. Abnormity Detection

This is the most common application for Artificial Immune System. The most regular part of this application is virus and worm detection in the network.

6.2. Computer Security

Negative Selection Algorithm is used to detect virus and Trojan and also to find the infected data in the system and network. Mainly, Negative Selection, Clonal Selection and Danger Theory are applied in the computer security application

6.3. Fault Detection

In the network and systems , malfunctions are to be detected like sensor network, Client/ Server Network, etc. The Artificial Immune System algorithms such as Negative Selection and Immune Network Theory are used in this application.

6.4. Optimization & Learning

For learning application, Clonal Selection Algorithm is used to find the infections caused by B- Cells. The learning speed and quality of the result is influenced by Clonal Selection Algorithm and Immune Genetic Algorithm.

6.5. Data Mining

For pattern discovery from large dataset, and for the classification of data, clustering and association rule mining, Artificial Immune Network is used.

7. Conclusion

In this paper, we outline Artificial Immune System and its Algorithms. A comparison with natural immune system is also presented. Many techniques are still under research. However there is an ever increasing scope for nature inspired computing.

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