This chapter briefly describes the concept of Biological Immune System (BIS) and Artificial Immune System (AIS). It also discusses different strategies used for implementing Artificial Immune System.

The key job of immune system is to guard the body from foreign particles called antigens. The biological immune system has great capability of recognizing patterns which is used to discriminate between foreign particles entering the body known as non-self or antigen and the body molecules. Biological immune systems (BIS) have several characteristics such as uniqueness, autonomous, recognition of foreign bodies, distributed detection, and noise tolerance (Castro and Zuben, 2000) which can be used in various applications.

Artificial immune system (AIS), which is inspired by biological immune systems, has materialized during the 19’s. They are encouraged by many researchers to devise and make immune-based models for various applications in different domains. Artificial immune systems can be described as a computational paradigm that is motivated by theoretical immunology, observed immune functions, principles and mechanisms (L N D Castro J. I., 2003).

4.1 Biological Immune system

The key role of the biological immune system is to guard human bodies against infectious non-self (foreign) agents (such as cancer cells, germs and other parasites) called pathogens. Immune response is driven by the identification of a related molecule known as antigen. In general, the biological Immune system basically works according to the following two mechanisms (1) Innate immunity and (2) Adaptive Immunity. Al-Enezi et. al. (Al-Enezi, Abbod, & Alsharhan, 2010) suggested that Innate immunity works against foreign elements that generally enter in the body whereas, adaptive immunity, also known as acquired immunity allow initiation of attack against any intruder that innate system cannot remove.
- **Innate immunity**: Innate immunity is inborn. Innate immunity plays an imperative role in the launching and guiding of immune responses. Dedicated cells have developed to identify and bind to common molecular patterns of micro-organisms. Being static in nature, Innate system is not a system for complete protection (Castro and Zuben, 2000).

- **Adaptive immunity** is directed towards specific invaders; which may not encountered previously and gets customized by exposure to invaders. Acquired immunity mainly composed of white blood cells known as lymphocytes that assist the process of identifying and destroying foreign agents (Castro and Zuben, 2000).

### 4.1.1 Clonal Selection

F M Burnet (1959) proposed a theory known as Clonal selection. The theory elucidates the key reaction of adaptive immune system against antigenic stimulus. It basically states that only those cells will reproduce themselves which are competent enough in identifying an antigen while the cells which are not capable of, are not considered for reproduction. Clonal selection functions on both B-cells and T-cells. In case of B cells, when antibodies of B-cells connect with an antigen, they are triggered and set apart into plasma or memory cells. Earlier to this development, clones of B-cells are generated and undergo somatic hyper mutation. This results in introduction of diversity into the B cell population. The Plasma cells generates antigen-specific antibodies that work against antigen. Memory cells remain with the host and promote a rapid secondary response (L N D Castro J. I., 2003).

### 4.1.2 Negative Selection

This is an approach to guard body in response to the self-reactive lymphocytes. It makes use of the immune system's capability to recognize unfamiliar antigens while do not respond to
the self cells. All through the development period of T-cells, receptors are gone through a pseudo-random genetic reorganization process. Then, they go through a expurgate process in the thymus, known as negative selection. In Negative Selection method, T-cells that respond against self-proteins are ruined and those T-cells that do not attach to self-proteins are only permitted to leave the thymus. These qualified T-cells then flow throughout the body performing immunological functions and shielding the body against unfamiliar antigens (A SOMayaji, 1998).

4.1.3 Immune Network Algorithm

Jerne (Jerne, 1974) has introduced the idea of immune Network theory. The key concept behind this theory was that the immune system preserves a network, which is formed by the interconnection of B cells, for recognizing antigens. These B-cells interconnect with each other in such manner that leads to the stabilization of the network. To form the network, two B cells connect with each other if the affinities values they share surpass a predefined threshold value. The potency of the connection established by the interconnection of these B-cells is directly proportional to the affinity value they share.

4.2 Artificial Immune system

As a new branch in Computational Intelligence, Artificial Immune Systems (AIS) emerged in the 1990s. A variety of Artificial Immune System (AIS) models have been proposed by the researchers. These models are effectively used in various applications like: pattern recognition, fault detection, computer security, and other domains of science and engineering. Clonal Selection, Negative Selection, Immune Network Model are most popular models
implemented as Artificial Immune System models. Among various methods taken from the biological immune system (Dasgupta, 2006).

4.2.1 Clonal Selection based algorithms

Al-Enezi et al. (Al-Enezi, Abbod, & Alsharhan, 2010) (2010) defines Clonal Selection which is based on the whole mechanism of antigen identification, cell creation and differentiation into memory cell. Several artificial immune algorithms have been developed emulating the clonal selection theory. Figure 4.2 shows the block diagram of the clonal selection algorithm.
Castro and Zuben (2002) developed a clonal selection algorithm known as ‘CLONALG’. CLONALG produces a population of N antibodies, each entity of this population point out a arbitrary solution for the optimization process. For each iteration, new population is produced by selecting k number of existing best antibodies, and then these antibodies are cloned and mutated to generate new population of new candidates. Newly
produced antibodies are then assessed and based on some predefined criteria; certain percentage of these antibodies is selected for next generation. In the next step these newly generated antibodies replace some worst antibodies of older generation.

4.2.2 Negative Selection based algorithms

The Negative Selection is one of the mechanisms of the biological immune system that has encouraged most of the developments in the field of Artificial Immune systems and their applications in various domains. During the process of T-cell maturation, if a T-cell in thymus identifies any self cell, it is removed and it is not considered for the immune functionality. Similarly, the negative selection algorithm creates detector set by eradicating any detector candidate that is similar to any element from a group of self samples.

Algorithms based on Negative selection have been used in variety of applications areas, such as intruder detection, anomaly detection etc. Forrest et al. (S Forrst, 1994) proposed a negative selection algorithm. The main idea behind this algorithm is to produce a set of detectors by initially making random candidates and then dumping those that identify training self-data, and then these detectors can later be used to detect anomaly.

Igawa and Ohashi (K Igawa, 2009), proposed a new negative selection algorithm named Artificial Negative Selection Classifier (ANSC) for multi-class classification. It introduces a cutting method to reduce the effect of noise. It combines the clonal selection method with negative selection algorithm to resolve issues like incomplete information, over fitting and random searching that avert negative selection algorithms from being used for classification problems.
4.2.3 Artificial Immune Network models

Based on the immune network theory proposed by Jerne (Jerne, 1974), which was presented in the previous section, many researchers have developed models that use ideas and concept from the immune network theory to solve problems in different application areas. J Timmis & M Neal (J Timmis, 2000), proposed an Artificial Immune NEtwork (AINE) to perform data analysis task. It uses artificial recognition ball (ARB) to represent identical B-cells. Two B-Cells are linked together if the affinity between two ARBs is below a network affinity threshold (NAT). In (J Timmis and Neal, 2001) a Resource Limited Artificial Immune System (RLAIS) based on AINE is developed. The main improvements in their proposed approach are the predetermined total number of B-cells existing in ARBs with centralized control. In their proposed model each ARB contends to assign resources from the pool. The ARBs with no resources are removed from the network. The cloning and Mutation process and the interactions of B-Cells are done at the ARB level.

4.3 Conclusion

In this chapter we have discussed the basic idea and concepts of Artificial Immune System and different techniques based on AIS.

There is no reported work on applying AIS techniques for disambiguation purpose. The study of Artificial Immune based techniques have encouraged us to incorporate them with Association rule mining approaches, which can be very useful in generating effective rules.

In chapter 5, we will discuss how these approaches can be used to resolve lexical ambiguities present in an SRS document.