Chapter 12
An Affinity Based Complex Artificial Immune System

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ABSTRACT
This paper proposes an affinity based complex artificial immune system considering the fact that the different epitopes located on the surface of antigen can be recognized by a set of different paratopes expressed on the surface of immune cells. A neighborhood set consisting of immune cells with different affinities to a certain input antigen is built to simulate the nature immune behavior. Furthermore, the complex numbers are adopted as the data representation, besides the weight between different layers. In the simulations, the recognition on transformation patterns is performed to illustrate that the proposed system is capable of recognizing the transformation patterns and it has obviously higher noise tolerance ability than the previous system models.

1. INTRODUCTION
Along with the interest in studying the immune system increasing over the last few years, a new field of research called artificial immune systems has arisen. The artificial immune systems, which is inspired by theoretical immunology and observed immune functions, principles and models, has been applied to the various fields of engineering science to solve many complex problems, such as pattern recognition (de Castro, & Timmis, 2002), robotics (JAKIMOVSK, & MAEHELE, 2008), anomaly detection Dasgupta & Forrest, 1996; Gonzalz, & Dasgupta, 2004), data mining (Knight, & Timmis, 2001) and optimization (Hajela, & Yoo, 1999).

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In our previous works, some artificial immune system models motivated by nature immune system were proposed, such as binary model (Tang, Hebishima, Tashima, Ishizuka, & Tanno, 1997), real value system (Sun, Tang, Tamura, & Ishii, 2003), multi-valued system (Yamaguchi, Tang, Ishizuka, & Tanno, 2001; Tang, Yamaguchi, Tashima, Ishizuka, & Tanno, 1997; Tang Yamaguchi, Tashima, Ishizuka, & Tanno, 1999) clonal selection theory based network (Tang, Tashima, & Cao, 2001), and TI-TD-based model (Dai, Tang, Tamura, & Yang, 2006). Furthermore, a complex artificial immune system model, which adopts complex number data representation and affinity evaluations was also proposed to recognize transformation patterns (Wang, Gao, Li, & Tang, 2008; Wang, Gao, & Tang, 2009). These earlier papers treated the immune response as a competition process by using WTA (Winner-Take-All) rule (Hagan, Demuth, & Beale, 1995). In another word, there is only one immune cell (the winner immune cell) that is selected to respond to a certain input antigen. On the other hand, immune cells with different receptors respond to input antigen with different strength in natural immune system. This is quite different from the nature immune system model, based on which we proposed our artificial immune system previously.

In this paper, we propose an affinity based complex artificial immune system model to simulate the actual immune response. In this model, we build a neighborhood set consisting of several immune cells with higher affinities to a certain input antigen than the other immune cells based on the SOM principles. All the weights of cells located in the neighborhood set have their weights updated according to the affinities. The results of simulation on pattern recognition shows that the proposed system model can recognize the transformation patterns in high accuracy and it has obvious higher noise tolerance ability than the previous system models.

The rest of the paper is organized as follows. In section 2 we introduce some basic concepts of nature immune response mechanism. In section 3 we introduce the affinity based complex artificial immune system model based on the immune response mechanism briefly. Followed by this, we depict the algorithm in detail in section 4. In section 5, we represent the simulation on transformation pattern recognition. Finally, we give some general conclusions.

### 2. IMMUNE RESPONSE MECHANISM

Figure 1 depicts the immune response process in detail considering the affinity interactions. When an antigen invades the host, antigen present cells first internalize the invaded antigen to secrete antigenic peptides, either by phagocytosis or by endocytosis. These antigenic peptides join to major histocompatibility complex (MHC) and display on the surface of antigen presenting cell together. Th cells recognize the peptide-MHC molecules through T-cell receptors. Activated Th...