Chapter XI

Artificial Immune Systems: Using the Immune System as Inspiration for Data Mining

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The immune system is highly distributed, highly adaptive, self-organising in nature, maintains a memory of past encounters and has the ability to continually learn about new encounters. From a computational viewpoint, the immune system has much to offer by way of inspiration. Recently there has been growing interest in the use of the natural immune system as inspiration for the creation of novel approaches to computational problems; this field of research is referred to as Immunological Computation (IC) or Artificial Immune Systems (AIS).

This chapter describes the physiology of the immune system and provides a general introduction to Artificial Immune Systems. Significant applications that are relevant to data mining, in particular in the areas of machine learning and data analysis, are discussed in detail. Attention is paid both to the salient characteristics of the application and the details of the algorithms. This chapter concludes with an evaluation of the current and future contributions of Artificial Immune Systems in data mining.

Over the years, biology has provided a rich source of inspiration for many different people in many different ways ranging from designing aircraft wings to bulletproof vests. Biology has also been used as a source of inspiration for
computation problems, which can be classified as biologically motivated computing (Paton, 1994). This is different from computationally motivated biology, where computing provides the source and inspiration for models in biology. The work described in this chapter is concerned with the former—biologically motivated computing applied to the field of data mining.

There has been much work done on the use of biological metaphors, for example neural networks, genetic algorithms and genetic programming. Recently, there has been increasing interest in using the natural immune system as a metaphor for computation in a variety of domains. This field of research, Immunological Computation (IC) or Artificial Immune Systems (AIS), has seen the application of immune algorithms to problems such as robotic control (Ishiguro et al., 1998), simulating behavior in robots (Lee et al., 1997), network intrusion detection (Kim and Bentley, 1998), fault diagnosis (Ishida, 1996) and machine learning (Hunt and Cooke, 1995; Timmis and Neal, 2000), to name a few. The immune system is a rich source of inspiration as it displays learning, adaptability and memory mechanisms that could be applied to many different computational tasks. It is proposed that the immune system, abstracted at a high level, can be thought of as a naturally occurring learning machine (Varela et al., 1988).

This chapter focuses on the use of these immune metaphor algorithms to the field of machine learning and data mining. The chapter begins with a look at the context of this work of relation to the field of data mining. Attention is then drawn to the salient features of the natural immune system that are used as inspiration to the field of AIS. The use of these features as metaphors is then detailed, by means of providing an overview of the current research within AIS, paying particular attention to a variety of machine learning algorithms inspired by the immune system. Observations are then made about the future direction for this work.

It is hoped that the reader will gain an appreciation for immunology and the way in which it can be utilized as an effective metaphor for computational techniques.

THE NATURAL IMMUNE SYSTEM

The immune system is a very complex “hunt and destroy” mechanism that works at the cellular level in our bodies. The immune system protects our bodies from infectious agents such as viruses, bacteria, fungi and other parasites. On the surface of these agents are antigens; it is these antigens that provoke an immune response. There are two types of immunity—innate and adaptive. Innate immunity (Janeway, 1993) is not directed in any way towards specific invaders into the body, but against any pathogens that enter the body. Certain blood proteins, called complement proteins, can bind to any other proteins, including those on bacteria. Immune system cells have the ability to inactivate this binding process, therefore removing the risk of the innate immune system attacking the bodies’ cells. These proteins are able to kill off certain bacteria, but the innate immune system is by no means a complete solution to protecting the body.
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