

Collaborative Bio-Inspired Algorithms

Lecture 6: Artificial Immune Systems

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Outline

AIS Background

History

Of interest because?

Thinking about AIS

Basic Immunology

The Immune what?

Engineering Artificial Immune Systems

Interdisciplinary?

What are AIS?

A definition:

AIS are adaptive systems inspired by theoretical immunology and observed immune functions, principles and models, which are applied to complex problem domains [4]

But what AIS means and encompasses is changing . . . more on that through the lectures

A bit of history

- ▶ Seminal paper in 1986 by Farmer *et al* from theoretical immunology roots [5]
 - ▶ Compared immune networks with neural networks
 - ▶ Suggested we might look at the IS as a computational system
- ▶ Varela made further comparisons between immune, neural systems [11]
- ▶ 1990 – Ishida first use of immune algorithms to solve problems [8]
- ▶ Forrest *et al* – Computer Security mid 1990's [6]
- ▶ Hunt *et al*, mid 1990's – Machine learning [7]

History ...

- ▶ Started quite immunologically grounded
 - ▶ Bersini's and Varela [1] Forrest's and Perelson [6]
- ▶ Kind of moved away from that, and abstracted more
- ▶ Now there seems to be a move to go back to the roots of immunology and greater interaction ...
 - ▶ "The immune system computes" Cohen, 2008 [3]
 - ▶ "what might we gain by thinking about immune computation" Cohen, 2008 [3]

but ...

how do we manage this interaction to make it worth while for all concerned ... ?

Why is this interesting ...

Table: Immune systems and computational properties

Computational Property	Systems that are:
Unique to individuals	Robust
Distributed	Scalable
Imperfect Detection	Flexible
Anomaly Detection	Exhibit graceful degradation
Learning and Adaptation	Homeostatic
Memory	
Feature Extraction	
Diversity	
... and more	

Conceptual Frameworks

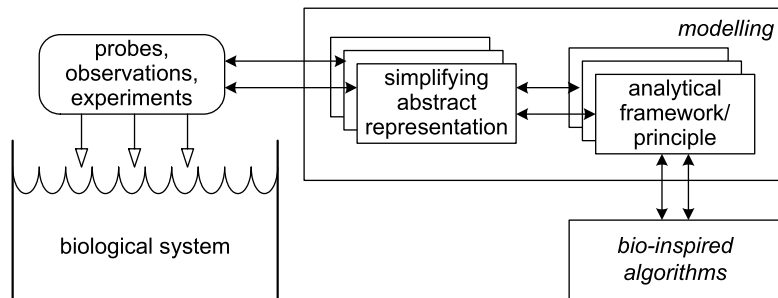


Figure: The Conceptual Framework [10]. This can be seen as a methodology to develop novel AIS allowing true interaction between disciplines where all can benefit, and, a way of thinking about the scope of AIS and how that has broadened over the years once again

What is the Immune System?

Classic View

a complex system of cellular and molecular components having the primary function of distinguishing self from not self and defense against foreign organisms or substances

Cognitive View

The immune system is a cognitive system whose primary role is to provide body maintenance [2]

Danger View

The immune system recognises dangerous agents and not non-self [9]

Classical View I

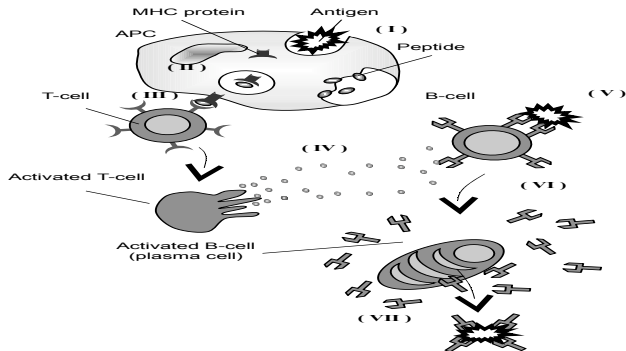


Figure: The clonal selection process of the adaptive immune system, integral to this is the ability to distinguish self from non-self, after [4]

Classical View II

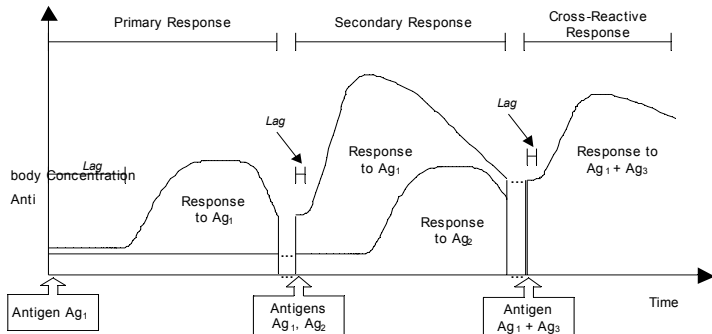


Figure: Over time, the immune system generates the ability to adapt to new, previously unseen, antigen, after [4]

Simple Framework for Engineering AIS

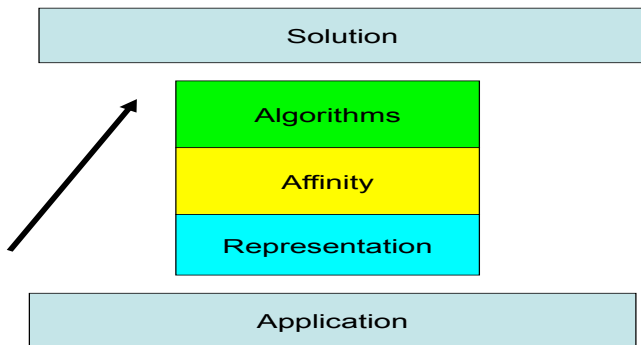


Figure: General framework for engineering AIS [4]

Engineering AIS : Algorithms I

Clonal Selection Theory:

Many AIS algorithms based on the simple clonal selection ideas. Utilised primarily in optimisation, various learning systems (supervised, unsupervised) which include email filtering, network security, on-line adaptable error detection, ...

Negative Selection:

Significant number of algorithms based on the thymic selection process of T-cells. Includes pattern recognition, network security (change detection), detector coverage ...

Engineering AIS : Algorithms II

Immune Networks:

Based on Jerne's ideas of interacting network of B-cells to retain immunological memory. Algorithms developed for optimisation, learning, context aware systems, building maps for robots . . .

Dendritic Cells:

Taken from ideas of danger theory, DC's identify "dangerous" items and present them to the adaptive immune system. Algorithms developed for network security, real-time operating systems scheduling, error detection . . .

A wider field than ever before?

Iron Cohen identifies three types of “AIS” people [3]:

Literal School

Those who try and build things to do what the IS does (e.g. security systems)

Metaphorical School

Those who use the IS as inspiration, but may be far from the what they IS actually does e.g. optimisation algorithms

Modelling School

Those who try and understand the IS through a series of models (computational and mathematical) e.g. models of self/non-self or tunable activation



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