

On the Role of the AIS Practitioner

Emma Hart¹, Mark Read², Chris McEwan³, Uwe Aickelin⁴ and Julie Greensmith⁴

¹Edinburgh Napier University

²University of York

³Microsoft Research

⁴University of Nottingham

e.hart@napier.ac.uk

Abstract

Cognisant of the gulf between engineers and immunologists that currently hinders a truly inter-disciplinary approach to the field of Artificial Immune Systems (AIS), we propose a redefinition of the term *AIS practitioner*, as an individual who identifies those components and interactions captured in computational immunology models that are responsible for a particular property of interest (POI), and distils from these a set of algorithms and principles that can be applied in an engineering domain. We outline the role of the cross-disciplinary practitioner and the potential benefits to the field.

Introduction

The Artificial Immune Systems (AIS) field, which seeks to understand immune system operation and exploit these principles in engineering contexts, has been criticized for reasoning by metaphor (Stepney et al., 2005): algorithms are based on naïve biological analogies, are poorly understood, and weakly capture their inspiring biological properties. Various frameworks have been proposed that enable the richness of emergent biological properties to be translated into useful engineered systems. The conceptual framework (Stepney et al., 2005) proposed starting with a study of the immunological system, modeling it, and leading to the development of engineering algorithms. (Andrews, 2008) notes that the framework lacks guidance on selecting biological inspiration for particular engineering domains, and that evaluating a particular domains potential requires that it first be modeled. The immuno-engineering framework (Timmis et al., 2008), through better grounded in engineering by accounting for the physical properties of engineering systems (e.g. in terms of memory, processing power etc.), suffers the same problem.

The interdisciplinary approach to algorithmic development advocated by these frameworks is essential but raises practical issues: immunologists inform modeling efforts to realistically represent and aid biological understanding; engineers desire algorithms that can be theoretically analyzed, verified and validated to demonstrate desirable properties

and applicability to the problem at hand - the biological inspiration is irrelevant. Furthermore, engineers and immunologists will rarely interact; they have differing goals.

We propose redefining the term AIS practitioner, as an individual who identifies those components and interactions captured in computational immunology models that are responsible for a particular property of interest (POI), and to distil from these a set of algorithms and principles that can be applied in an engineering domain.

The AIS Practitioner

The cross-disciplinary AIS practitioner possesses sufficient understanding to identify key modern-day engineering challenges, and appreciate how qualities exhibited by the immune system can help. They can comprehend computational immunology models, and derive therefrom the required algorithmic principles. Stripping away immunological nomenclature is vital; algorithmic components labeled T cells or lymph nodes are so abstract at this stage that they are meaningless and confusing.

We capture the AIS practitioners role as shown in figure 1. The box represents the space of abstract representations (models, simulations, algorithms, design principles) that capture a particular POI, a quality observed in the immune system and desired in an engineering solution, such as robustness, homeostasis, life-long learning, and adaptation, to name some examples (Hart and Timmis, 2008). Abstract representation complexity is represented vertically, whereas the domain of concern is depicted horizontally.

The bottom right corner represents the minimal rational representation (MRR), the minimal set of components/actors, interactions or principles responsible for manifestation of the POI, expressed free of immunological terminology. Its minimalism reflects the computational power and memory constraints of many engineering domains. The top right corner represents inefficient, sub-optimal and/or obfuscated abstract representations. Although they capture the POI, they contain superfluous interactions or components, and as such are not considered as suitable for adoption in engineering contexts. The top left contains detailed and com-

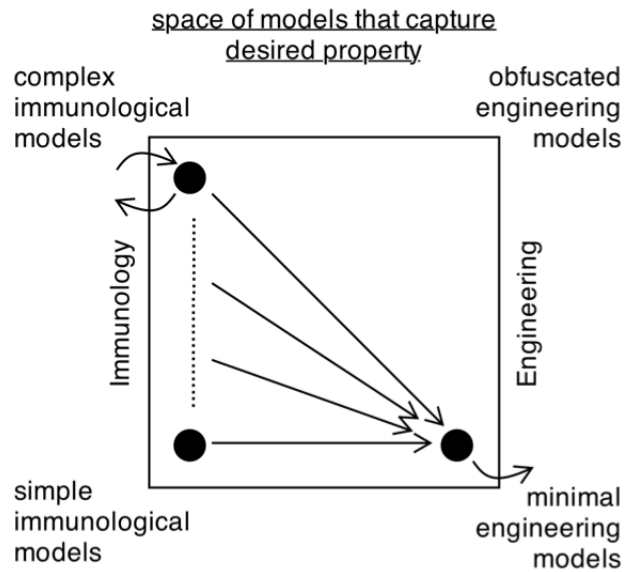


Figure 1: The space of abstract representation that capture a property of the immune system

plex models, representing, for example, large numbers of cells, pathways and spatial compartments. They may capture a great many immunological properties, in addition to the POI. The bottom left corner contains the minimal set of components and interactions responsible for the POI, and no other properties. Though minimal, these abstract representations exist in a form to benefit immunology, not in a form immediately applicable in engineering domains.

We consider the AIS practitioners role to derive the MRR, given some abstract representation occupying the left of the box. The components and interactions present that are redundant or unnecessary with respect to the POI are removed or abstracted. Depending on the nature of the POI, and the immune-inspired engineering solution being derived, the MRR may be expressed as an algorithm, or as design principles for constructing systems. The level of abstraction of the model is such that it should specify all necessary components of the system, and the interactions that take place between components. The model should be able to be validated to show that it gives rise to the desired POI, and if applicable, under what parameter ranges.

Conclusion

We have outlined a role for the AIS practitioner in defining design principles that capture particular properties of the immune system. Such principles are free from immunological jargon and thus can easily be interpreted by engineers wishing to solve a problem. We believe this will increase the usage of immune-inspired solutions to engineering problems, through facilitating access to the subject by those unfamiliar

with the biological field, and secondly, by providing principles that are readily understood in terms of their computational properties.

References

- Andrews, P. (2008). *An investigation of a methodology for the development of artificial immune systems: a case-study in immune receptor degeneracy*. PhD thesis, University of York.
- Hart, E. and Timmis, J. (2008). Application areas of ais: the past, present and future. *Journal of Applied Soft Computing*, 8.
- Stepney, S., Smith, R., Timmis, J., Tyrrell, A., Neal, M., and Hone, A. (2005). Conceptual frameworks for artificial immune system. *International Journal of Unconventional Computing*, 1.
- Timmis, J., Hart, E., Hone, A., Nea, M., Robins, A., Stepney, S., and Tyrrell, A. (2008). Immuno-engineering. In *2nd IFIP International Conference on Biologically Inspired Collaborative Computing*, pages 3–17. IEEE Press.