Christian Jacob
Marcin L. Pilat
Peter J. Bentley
Jonathan Timmis (Eds.)

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Artificial Immune Systems

4th International Conference, ICARIS 2005
Banff, Alberta, Canada, August 2005
Proceedings

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Preface

Your immune system is unique. It is in many ways as complex as your brain, but it is not centred in one location, like the brain. It is not a single organ—it consists of many different cell types, diverse methods of intercellular communication, and many different organs. Its functionality is blurred throughout you—we can't extract the immune system, or point to where it begins and ends. The immune system is not separable from the system it protects. It has integral links to every organ of our bodies.

This has radical implications for the field of Artificial Immune Systems (AIS), that we are only now beginning to comprehend. One of the first insights is that modelling the immune system, or developing any kind of immune algorithm, is difficult. The immune system is one aspect of biology that we find difficult to apply simple reductionist explanations to. We can very successfully extract sub-processes of the whole and create immune algorithms based on those processes. But we are always aware that we are missing the whole story. This is leading to more holistic views of immune algorithm development: theoretical analyses of how the sub-components contribute to the whole, and identification of missing elements. Artificial immune systems are now beginning to incorporate ideas of innate as well as adaptive immunity, more complex intercellular communication mechanisms, endocrine and neural interfaces, concepts of tissue and broader ideas of organism and environment.

So perhaps the most exciting implication for the future of AIS is that these researchers are on the forefront of unconventional computing—merging the boundaries between biology and traditional computation to achieve new emergent, embodied and distributed processing capabilities.

This year, ICARIS received 68 submissions, and through a peer review process, 37 were selected for publication, giving an acceptance rate of 53%. ICARIS goes from strength to strength, with an increase in numbers of submissions from 2004, but having a lower acceptance rate. This year we continued the theme of streams, hosting technical, conceptual and immunoinformatics papers. However, this year we added a new stream called applications, which was dedicated to the application of AIS techniques in more real world environments. ICARIS is now considered the place to publish leading AIS research, and is becoming more interdisciplinary each year, something we as organisers are very pleased with.

Building on the success of the tutorials introduced in 2004, we again held four tutorials:

- Dr. Emma Hart presented an introductory tutorial on Artificial Immune Systems.
- An exciting Immunoinformatics session was delivered by Dr. Darren Flower.
- Dr. Mark Neal inspired us by a tutorial on bio-inspired approaches to robotics.

– Last but not least, we are very grateful for Dr. Stuart Kauffman's insightful tutorial on the analysis of complex systems.

We were also delighted to have Prof. Stephanie Forrest from the University of New Mexico deliver the plenary lecture. Thank you very much for an exciting keynote!

ICARIS 2005 was hosted in Banff, in the province of Alberta, Canada. It is not without pride that we think we have chosen one of the most spectacular sites Canada has to offer. Banff, located in Banff National Park, is at the heart of the Canadian Rocky Mountains. At the Banff Centre for Conferences ICARIS 2005 participants enjoyed breath-taking scenery, with wildlife in the backyard and majestic mountains all around. What a venue to discuss inspiring and exciting science!

It would not have been possible to organise this conference without the excellent work of the programme committee, our publicity chairs Simon Garrett and Namrata Khemka, our conference secretary Camille Sinanan and the tutorial speakers. Finally, we would like to express our thanks to all authors who submitted and presented their research papers. Without your valued contributions ICARIS would not be as alive as it is today.

We hope you enjoyed ICARIS and find the papers in these proceedings useful and stimulating.

August 2005

Christian Jacob
Marcin Pilat
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Peter J. Bentley

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Fugue: An Interactive Immersive Audiovisualisation and Artwork Using an Artificial Immune System

Peter J. Bentley, Gordana Novakovic, and Anthony Ruto

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Abstract. Fugue is the result of a collaboration between artist, musician and computer scientists. The result is an on-going project which provides a new way of communicating complex scientific ideas to any audience. Immersive virtual reality and sound provide an interactive audiovisual interface to the dynamics of a complex system – for this work, an artificial immune system. Participants are able to see and interact with immune cells flowing through a lymphatic vessel and understand how the complex dynamics of the whole are produced by local interactions of viruses, B cells, antibodies, dendritic cells and clotting platelets.

1 Introduction

Science often involves abstract formalisms, typically mathematical, of the tangled complexity of the phenomena under study. Communicating these ideas is not easy, whether between colleagues or to the general public. To aid in such endeavors there is a significant need for scientists to employ more direct methods – audio and visual – of representing the systems with which they deal. In scientific education, it has become clear that traditional formal methods of study are increasingly alien to students who have grown up in a world dominated by digital media; at least initially, they require more familiar means of accessing science. Likewise, in communicating science to non-scientists, the constraints of the printed page or the talking head mean that is often necessary to simplify the subject matter to the point where too much is lost or excluded.

Our intention in this work is to examine a new approach. We propose that the best way of enabling both scientists and non-scientists to understand a complex functioning system is not just to present it to him as a spectacle, but to engage him as a participant, and to enable him to interact with the system in a multisensory way, directly appreciating cause and effect, variability, intrinsic dynamics, periodicity, and so on. To achieve this, direct input from an artist and a musician is used to guide the visual and audio experience. In other words: we propose to exploit artists' knowledge of the relation between interactivity and perception, and harness it in the communication of scientific complexity.

Artists and scientists are both concerned with understanding the world and our being in the world, but while the view of the scientist is rooted in consensus and endeavors towards objectivity, the artist emphasises the values of the personal and sub-

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jective investigation of philosophical questions. Such a dichotomy suggests potential conflict: does the participation of an artist in the communication of science run the risk of introducing some bias antithetical to the very idea of science? And if so, can this potential conflict be managed satisfactorily within the collaborative process? Taken together, these two questions raise a wide range of issues, and as yet there are no definitive answers. The Fugue Project aims to frame and focus the questions in the context of transdisciplinary collaboration in the area of representing the functional dynamics of one of the most complex systems known – the human immune system. This will be achieved by the creation of an immersive virtual reality immune system, which enables participants to interact with and understand various cellular behaviours inside a lymphatic vessel. The hope is that the information uncovered by this research will help to structure future more comprehensive investigations of these fascinating and important issues, for art and science.

2 Background

The human immune system is so complex that it is currently impossible to produce a tractable model of the whole. Nevertheless, computational models are increasingly been seen as important tools to aid our scientific understanding [17]. Separate from immunobiology, the field of artificial immune systems (AIS) has grown dramatically in the last five years. AIS algorithms are computer programs modeled on different aspects of the human immune system and used to tackle a wide variety of problems, from computer virus detection to data mining, to robot control [14]. Additionally, in recent years issues of public health (from simple allergies to the expansion of AIDS and recent global epidemics of extremely dangerous flu variations) have led to increased and widespread public interest in the immune system [13]. There is a clear need for the lay population to be much better informed about the operation of the one of the most complex and enigmatic biological systems. The confluence of these three factors has both inspired and enabled this research, and forms a strong context for the project.

Audiovisualisation is still a new methodology for presenting scientific findings. Only one virtual reality approach, Planetary Seismology (a Virtual Reality audio/visual representation of seismic phenomena) produced by the German scientist Dombois in 2001 [4], is available for participants at present. Only a handful of immune system visualisations currently exist. They have all been produced exclusively by scientists (Steven Kleinstein, IMMSIM, 1999 [6]; Christian Jacob, 2004 [5]), and the presentational styles are barely accessible to non-experts. (For example, IMMSIM uses a very abstract 2-dimensional lattice representation based on cellular automata.) To date, these visualisations have been presented only within a closed circle of scientists and have not been released for the general public.

Audiovisualisation offers significant advantages for understanding hugely complex systems: it offers a much wider bandwidth than vision alone, and engages both serial and parallel modes of perception. In addition, the intention is to explore the potential of contemporary Virtual Reality technologies for enabling users to actively engage with the production of phenomena, rather than merely observing them passively, within a custom designed virtual reality environment. The user will be able to control

certain parameters of the modeled immune system, and will also be able to choose the particular function, particle, or interaction to follow. There are good theoretical reasons pointing in this direction, in particular Merleau-Ponty's analysis of the role of the ear in visual perception [11]. As Dombois, the author of Planetary Seismology, wrote in 2001: 'From philosophical research (...) we can learn that the eye is strong in recognising structure, surface and steadiness. (.....) Now at the same time philosophy finds the ear strong in the recognition of time, dynamics of a continuum and tensions between remembrance and expectation.' [4]

3 Artistic Concept and Method

The development and usage of tools that support visualisation, or audification, usually involves collaborative efforts among scientists, artists, programmers and other expert staff. This is often defined as a Renaissance Team [2]. To achieve the aim of producing interactive, audiovisual representation of a highly complex biological function, that demands full engagement of both artists and scientists, our team is composed of a media artist, Gordana Novakovic (artistic concept); a computer scientist and expert in digital biology, Dr. Peter Bentley; Rainer Linz, a new music composer; Dr. Julie McLeod, and expert in immunology; and computer scientist Anthony Ruto. The aim of creating a scientific tool strongly influences the content and behaviour of the system; however from the point of view of the two artists involved in the creative process, Fugue is an integral interactive art project. Yet, from the scientific point of view, it is essential to ensure the scientific correctness of the underlying model. Will it be art, or will it be science? Our claim is that the first responses to the prototype made it clear that it may be seen as either, depending on the perspective of the user.

The basic concept tests the form of the interaction between the sound and the vision in a way that is inspired by the complexity of one of the greatest musical forms: the art of fugue. The art of fugue is a highly disciplined form of composition of complex structure and exact relationship of parts. The title – Fugue – serves as a metaphor for the transdisciplinary nature of the project, and for the method applied: of interweaving the different perspectives of artists and scientists, different aesthetics, various skills and expertise, and personal philosophies, and uniting them into evolving polyphonic synergy. The emergent, evolving nature of Artificial Immune System algorithm, repetition as a succession of variations of 'events', and the complex structural and functional interrelationship of the particular elements and processes that can be related to the counterpoint, was one of the inspirations for the fugue concept. The Artificial Immune System software creates the dynamics of the virtual immune system drama, and also constructs and implements the architecture of the fugue by providing the functional structure for the communication channels between the visuals and the sound.

On the other hand, this method is well grounded in the already successfully applied artistic method of interweaving, cross-connecting different specialists and specialisms, in an effective cross-disciplinary framework for the emergence of synergy through collaboration; a method resembling the structure of the fugue. In parallel with providing the functional structure for the communication channels between the