

Report on a Research Visit Funded by PerAda

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1 Outline of the Visit

The purpose of the visit was to engage in discussions with researchers involved in Artificial Immune Systems (AIS), in order to identify promising research collaboration topics able to explore the synergies between Artificial Chemistries (AC, my domain of research) and AIS for the design of new distributed emergent computation techniques for PerAda systems.

The duration of the visit was two weeks, scheduled as follows:

- First week: Participation in the ICARIS Conference and PerAda Workshop, Edinburgh, UK
- Second week: Visit to the University of York, UK, hosted by Prof. Jon Timmis

I summarize each of these weeks below.

2 First Week: ICARIS Conference in Edinburgh

During the first week, I attended the ICARIS conference [6] (where I also chaired a session) and the associated PerAda workshop [15], where I presented a short paper entitled “Biochemically-Inspired Emergent Computation” [20]. The paper defends the position that Artificial Chemistry [3] is a promising approach to construct PerAda systems from the bottom up. Moreover, it highlights the importance of enabling and detecting automatic transitions from lower levels of complexity to higher ones, such that complex interactions leading to highly organized collective entities such as immune systems can emerge.

During the conference I had the opportunity to get acquainted with the Artificial Immune Systems (AIS) community for the first time. There I met a number of researchers in the field, including: Chris McEwan and Emma Hart (Napier University, UK); Jon Timmis and Yang Liu (University of York, UK); Melanie Moses and Soumya Banerjee (University of New Mexico, USA); Daniel Schreckling and Tobias Marktscheffel (University of Passau, Germany); Fernando Jose Von Zuben (State University of Campinas, Brazil); Mike Holcombe (University of Sheffield, UK); Derek Smith (University of Cambridge, UK); Falko Dressler (University of Erlangen, Germany); Serge Kernbach (University of Stuttgart, Germany); Jim Bown (University of Abertay Dundee, UK).

I summarize here some of the insights captured from the talks and discussions during the conference, which may lead to future collaborative research activities.

Indeed the link between AC and AIS seems to lead to promising research directions worth exploring. At a microscopic scale, the shape space models of antigen-antibody binding in AIS have common points with ACs where the affinity between molecule binding sites has an influence on the rate of the reaction or on the type of operation performed. At a macroscopic scale, multicellular robots able to solve collective tasks in a decentralized way will most certainly need AIS to protect themselves [10, 13]. Moreover they could make use of homeostasis to maintain their internal operational health [16], and genetic regulatory mechanisms for controlling their operation in response to environmental conditions. All these elements could be integrated in an AC, in analogy to the corresponding biochemical processes in nature.

Overall, the importance of automatic transitions between complexity levels seems to be acknowledged, but little seems to be known about how this can be done in practice. The modelling of biological systems may span a range of scales, from chemical reaction networks to ecologies. PerAda systems tend to go in the same direction, as they must scale in complexity in an automatic way, e.g. in the case of large networks of interconnected devices and multicellular robots. In this context, an automatic transition mechanism would support such flexible scaling and complexity encapsulation, while capturing the essential properties at each level of scale.

3 Second Week: University of York

During the second week, I visited the University of York. My visit was kindly hosted by Prof. Jon Timmis. There I gave a talk entitled “Artificial Chemistries for Distributed Computation and Optimization” about my recent research activities, and met researchers from two groups:

- Non Standard Computation group [14]: From this group I met Susan Stepney, Adam Nellis, Ed Clark, Paul Andrews, and Adam Faulconbridge. We identified many common research interests related mainly to string-based ACs [7], complexity scaling and the automatic transitions between levels in AC [1, 4], the use of ACs for computation tasks such as optimization and control [5, 17–19], understanding the conditions for the emergence of evolutionary behavior, and the parallelization of large-scale simulations.
- Intelligent Systems group [8]: From this group I met Andy Tyrrell, Gianluca Tempesti, Michael Lones, Julian Miller, and Yang Liu. Here again, many common research interests were easily identified, such as: representations for genetic programming based on a chemistry with binding affinities [11]; solving computation tasks with artificial biochemical networks [12]; integrated fault-tolerance, development and immunity in embryonics and multicellular systems [10, 13].

Most of the researchers from these two groups are also part of the York Centre for Complex Systems Analysis (YCCSA), so I also had the opportunity to become acquainted with the activities going on there.

I also attended a very interesting talk by Dr. William Langdon (Univ. College London), who spoke about the automatic evolution of CUDA code for GPUs [9]. A variant of genetic programming based on grammatical evolution was used for this purpose. This was the first time code has been automatically ported to a parallel CUDA implementation using automatic search in the space of C programs.

Moreover, I attended a few talks given during a meeting of the CoSMoS project (Complex Systems Modelling and Simulation infrastructure) [2]. This consortium is building tools for the large-scale parallel simulation of complex systems. I also had the opportunity to engage in discussions with researchers from the CoSMoS team.

4 Summary and Outlook

The visit gave me the opportunity to meet many researchers in different fields, these contacts are promising for the future, as we have exchanged papers and are planning future collaborations.

I established solid contacts with the aforementioned research groups in York, via technical discussions and the exchange of research papers. These contacts will be pursued further towards more concrete collaborations.

The cross-disciplinary aspects of the visit were broader than expected: Besides artificial (bio-) chemistries and artificial immune systems as originally foreseen, I could also engage in discussions with people doing research in complex systems in general such as those from the CoSMoS project, specific biological processes such as fungal colony development, biologically-inspired hardware, parallel computation with large-scale clusters and with GPU hardware, etc.

I would like to encourage other researchers to participate in such exchange visits, since they constitute an excellent opportunity to engage in fruitful discussions with other researchers, to share ideas and consolidate collaboration networks in a very short time.

5 Acknowledgments

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Many thanks also to all those outstanding researchers who kindly made some time in their agenda to discuss with me in Edinburgh and York. It is hard for me to decide which of these discussions was the most interesting. This was definitely one of the best research visits I could experience so far, with prospects of long-lasting collaborations beyond the visit period. Many thanks to all those who contributed to make this happen.

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