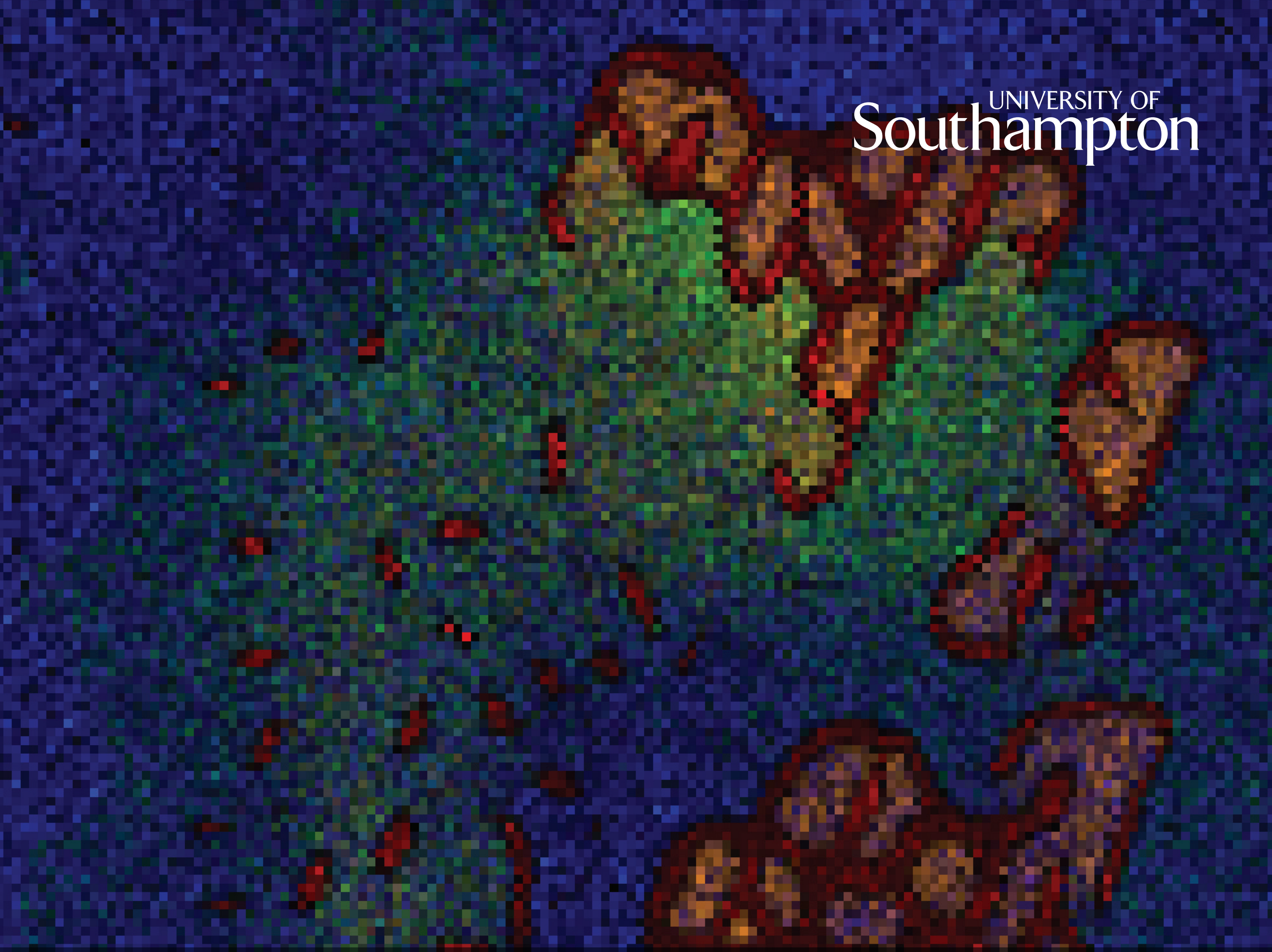

UNIVERSITY OF Southampton

Autumn Edition 2012

Complexity

ICSS DTC Newsletter

Welcome to the first issue of "Complexity", the newsletter of the University of Southampton Doctoral Training Centre for Complex Systems Simulation. In the three years the DTC has been in existence, 54 students have been recruited from a vast array of specialisms; from Social Sciences to Physics, Marine Biology to Economics. In that short time, those students have submitted nearly 20 first author papers to different peer-reviewed journals and presented their work at nearly 40 different conferences across the world. This newsletter is intended to present a small fraction of these achievements.

Welcome

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In this issue, a current student from each of the three cohorts talks about their research and experience of studying at the DTC. We also review the Second Student Conference on Complexity Science (SCCS 2012) and take a look at one of the many informal discussion groups attended by DTC students across the University, in this case, a group examining the applications of complexity in the Earth System. Last, but by no means least, we have an interview with Professor Seth Bullock, the Director of the DTC with interesting insights into the ethos of the DTC and what he looks for in a potential student.

I hope Complexity gives a flavour of the vibrant community of students here and the amazing breadth of fascinating research we undertake, all with the common theme of simulating Complex Systems.

Sophia Wheeler, Editor

"Our DTC creates an environment where scientists can learn about tools that apply to a variety of systems, such as chaos theory, hysteresis, phase transitions, etc., and work in a multi-disciplinary team whilst doing so."

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Front cover: A colony of protocells (red membranes) are forced to grow away from a prevailing cloud of toxic catalysts (green). Stuart Bartlett

Student Spotlights:

Stuart Bartlett

3rd Year

Stuart joined the DTC as part of the first intake of students in September 2009.

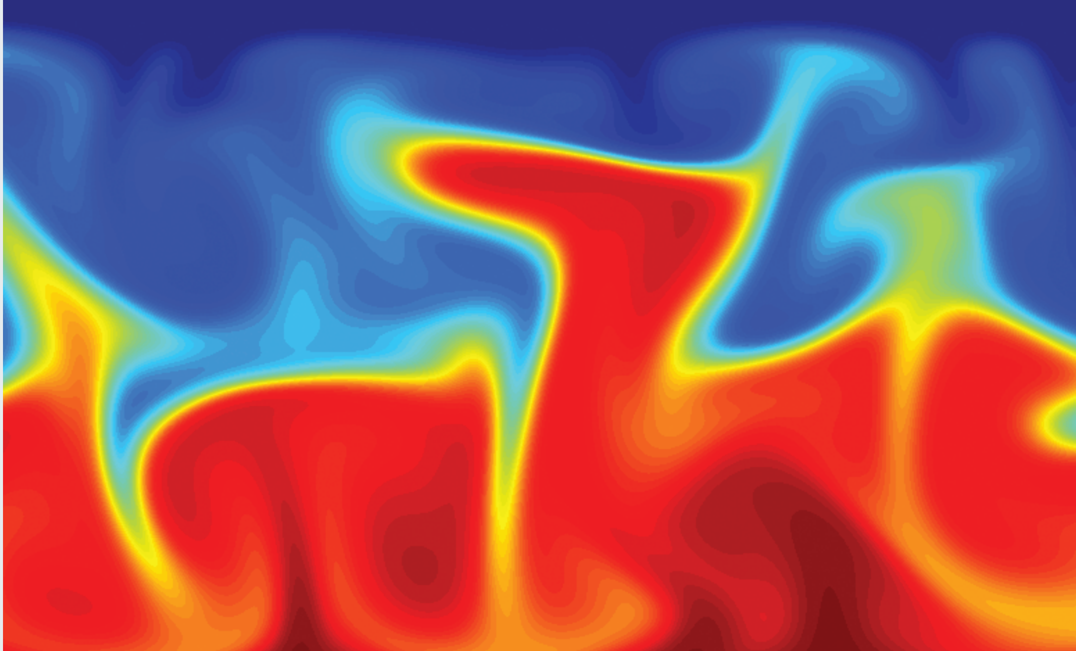
Having entered into a PhD programme with the freedom to direct one's own research, for some time it was almost bewildering trying to establish exactly what I would investigate. Coming from a physics background I had initially assumed I might delve deeper into fluid dynamics or perhaps into astrophysics or cosmology. However it became clear to me in the early stages, as I was introduced to the full breadth and sweep of complexity science, that my greatest fascination lay in the nexus between biology and physics. Having carried out research projects on lipid homeostasis and protocell formation, I finally decided that I would focus on the general problem of the transition to life.

The origin of life on Earth being a well-established field, I chose to try and take a more abstract approach and essentially ask: "What kind of systems can become living?" Before embarking on the perilous journey that this question compels, one must at least try and define 'living'. It seems life essentially just directs and controls a set of energy transformations such that it can maintain and expand the apparatus required to continue performing those transformations. In this way, life can be defined in terms of its abilities to dissipate free energy, i.e., that a living system dissipates at a rate significantly faster than an equivalent dead system.

I am investigating the behaviour of simple dissipative structures in systems with progressively more degrees of freedom. What this means in practice is that I am simulating systems that form spatial patterns as they dissipate energy gradients supplied to them. Starting with simple convective fluid systems, I shall introduce extra components and processes to my simulations. Adding extra chemical species, reactions between species and inhomogeneity in boundary conditions, I shall essentially be combining aspects of the two most widely studied pattern-forming systems: convection cells and reaction diffusion spots. I will be looking for characteristics we normally associate with life and assessing whether the dissipative properties of the system undergo significant changes when the structures begin to appear life-like (e.g., exhibit reproduction, adaptation etc).

The connections between free energy flows, entropy, information and life are mysterious enticing and numerous. Within the community that this problem encompasses, there is an inspiring sense that the answer is surely at our fingertips but nevertheless out of reach. There's no doubt that in the coming years we'll see some crucial revelations as complexity science and biological thermodynamics grow and mature.

Stuart Bartlett was awarded first prize at the Annual Student Conference 2012 for his presentation on 'Life and Dissipative Structures: Their Relationship'.



Jacob Selmes

Agents, Interaction and Complexity

School of Electronic and Computer Sciences

2nd Year

Addressing uncertainty in decentralised coordination of unmanned aerial vehicles for disaster response.

The efficient collection of information in a disaster zone is important if the correct response decisions are to be made. Increasingly, small and cheap unmanned aerial vehicles (UAVs) are being used to collect this information.

My research is investigating ways to allow these UAVs to coordinate autonomously, freeing up their human controllers to make the more important decisions. I am particularly interested in scenarios in which first responders are able to request spatially distributed image collection tasks using PDAs, and a team of UAVs then respond autonomously to complete these tasks.

A decentralised solution is desirable in these situations – it achieves global behaviour via local interactions and so scales efficiently to large numbers of individuals, is robust to individual component failure, and is highly adaptable to dynamic changes such as UAV failure or the addition of new tasks on the fly. As well as a complexity approach to behaviour, our solution must use minimal computation and memory resources to reflect the limited capacity of a typical UAV. This is a considerable restriction, and so I am modelling the complete system as a Distributed Constraint Optimisation Problem (DCOP), which describes a set of agents each in control of a variable. The goal of a DCOP algorithm is to maximise (or minimise) the global function value by finding the optimal value assignment of the variables in the system. However, uncertainty being a fundamental property of the real world, I must consider the role it plays in such a model impacting on aspects such as localisation, heading and battery life.

My work attempts to incorporate this variability into the effectiveness of DCOP algorithms, without sacrificing robustness or efficiency, and I hope to implement my novel algorithms on real hardware as a visiting student at the Australian Centre for Field Robotics in Sydney next year.

Jason Hilton

Agents, Interaction and Complexity

1st Year

Jason has just finished the first year, taught component of the DTC programme. He is interested in gaining understanding of socio-economical systems from different modelling techniques.

My background is in social science, so my first year at the DTC has been both challenging and exciting in that I have had to embrace new ways of thinking about social systems. Complex systems simulation methods are exciting to social scientists who are interested in understanding underlying causal methods in social systems because they offer the ability to better understand the ways in which population-level patterns can result from individual level behavioural 'rules' and interactions.

The flexibility of the DTC programme allowed me to pick first year optional modules that equipped me with skills relevant to my future research. I was able to get to grips with the principals behind the design of intelligent software agents, as well to refresh my understanding of traditional microeconomics methods to better understand where these are inappropriate. I undertook a research project on the Easterlin effect , which was a good opportunity to practice coding my own simulation and investigate links between behaviour on the macroscopic and microscopic scale.

I am lucky enough to have already been involved in the Care Life Cycle project during my first year at the DTC. The project aims to apply Complexity Science methods to the problem of understanding the future demand for health and social care needs in the UK. First-hand experience of project work has given me a greater appreciation of the processes involved in designing simulations, and encouraged me to think how these might be linked to the real-world policy making.

Perhaps the most exciting part of my first year, however, has been the opportunity to share ideas with my peers in the DTC who are physicists, evolutionary biologists, and game theorists. This has meant massive potential for cross-fertilisation and has really opened my mind to new methods and ways of thinking about systems.

In the immediate future I will continue with work related to the Care Life Cycle. I have not yet decided on a specific project to tackle for my thesis, but I have certainly found lots more things to be excited about in the past year! One of the topics I am considering is understanding how changes in connectivity of social and economic networks relate to demographic change (and care requirements).

DTC Retreat – Beyond a PhD

Each year all the DTC students take a day to get together at a venue outside the University. This year the retreat was held at the lovely setting of Marwell Zoo and focused on "What next? After your PhD."

The retreat was a great opportunity to renew links with other DTC students, many of whom are now based in different building around campus. It was also beneficial in widening horizons beyond the narrow focus of an individual thesis to consider how we can use the skills and expertise we are developing now, whether in academia, big business or as entrepreneurs.

The workshop delivered by the Careers Service showed it's never too early to start making sure any gaps in the CV are effectively plugged and there was excellent advice as to how to use the extra-curricular activities we already undertake to demonstrate capabilities that potential employers prize. This was followed by a group discussion which revealed the diverse and valuable mix of skills, expertise and experience we have already acquired and can build upon.

A panel of four experts, whose professional experience included working at the nature-inspired systems group at BT labs and leading a Unilever research group using adaptive systems in rural India, led a lively discussion on lessons they had learned. They had all spent time working between disciplines and seen many research areas boom and wane during their careers. We left with a perspective on how many scientific methods had come to rest in the realm of Complexity Science, and how these tools would become commonplace in future research.

DTC Students showcase their work

Each summer the students of the DTC get the unique opportunity to present their work at the Student Conference on Complexity Science (SCCS). This is a conference for students, organised by students, and this year it was the turn of the Bristol Centre for Complexity Sciences to host the event. The venue was the University of Gloucestershire. The conference is an exciting time of year when everyone is able to get together not only with colleagues from their own DTC but also with fellow early career researchers from the other complexity DTCs and elsewhere.

With a range of projects presented in over half a dozen research areas, the SCCS is probably one of, if not the most, diverse student conferences in the UK, attracting students from a range of universities. From understanding algorithmic trading to bio-acoustic monitoring of endangered species, the discussions that arose as a result of the presented work often lead to ideas and suggestions from diverse fields. This is where the multidisciplinary nature of working in a DTC really becomes apparent.

As each cohort moves through the PhD process it can be difficult to keep track of what one's peers are doing. Which conferences have they attended? At what stage is their research? The SCCS is also a great place to catch up on these important questions.

As well as a full timetable of poster sessions, student presentations and keynote talks the SCCS 2012 also offered plenty of opportunity for socialising outside of the normal working conditions. This year special sporting events were offered in honour of the Olympic year.

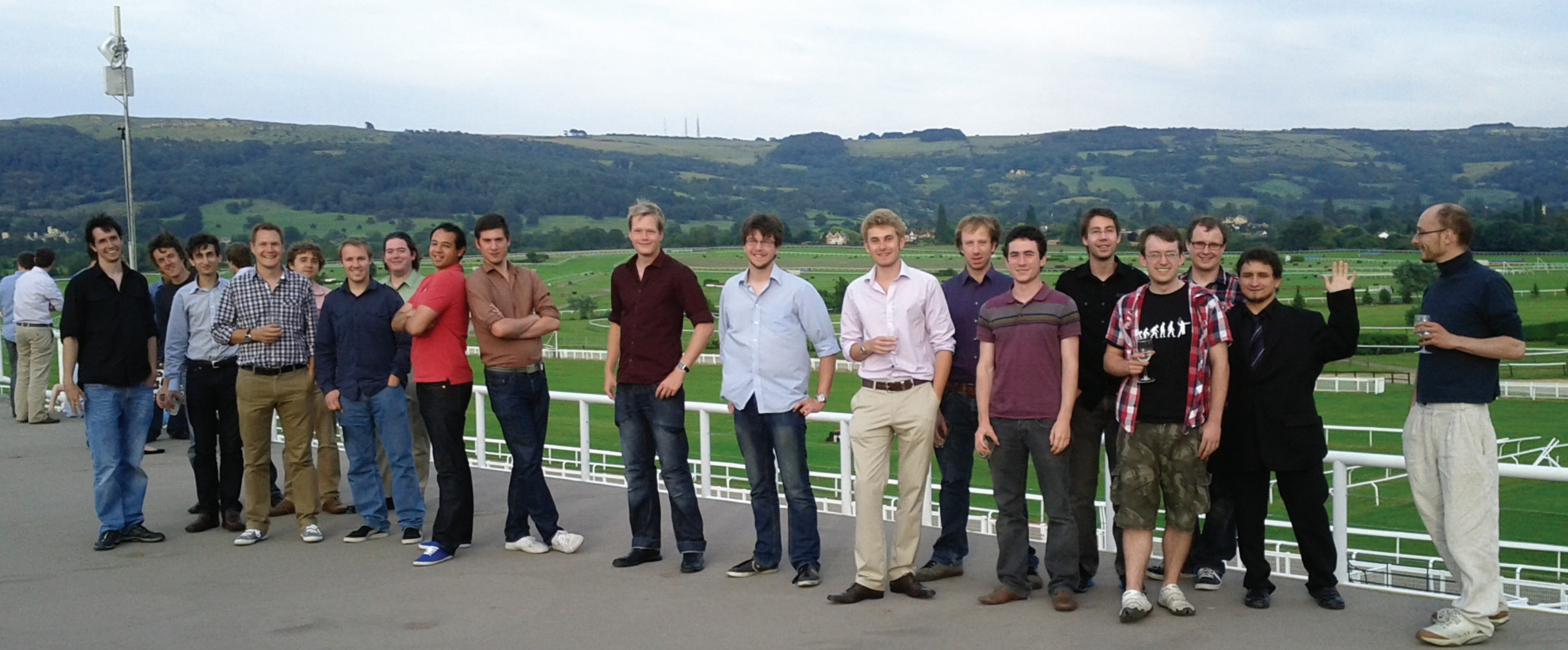
SCCS is a great place for students to get exposure to the process of effectively communicating their work. With a low pressure, student dominated environment, the experience of speaking to a large crowd and the subsequent feedback is extremely helpful. Of course, for those with experience at presenting there was still the challenge of making ideas accessible for an audience with a broad range of backgrounds.

Two fantastic keynote speakers made the conference even more enthralling. Dr. Tim Evans gave his thoughts on "netplexity", describing the value of network representation as an extremely flexible and useful way of representing many large electronic data sets, which have become widely available over the last few years.

Kevin Slavin gave another inspirational talk. He spoke of how mathematics shapes the world in which we live; and the need for understanding the complex interplay between us, as humans, and the algorithms that we create.

Saturday night saw the attendees arrive at Cheltenham racecourse for the conference dinner. First out of the gate was a drinks reception followed by a fantastic three-course meal. Speeches ensued and Stuart Bartlett was declared winner of SCCS2012's 'best talk' award for his novel talk on dissipative structures and their relationship to life. Congratulations over, students could relax, dance and merrymake. A fun night was had by all. Making friends with students from other universities enabled students to look forward to a more colourful year of work, having a wider circle of peers to exchange thoughts with, visit and offer mutual support.

It would be hard to rival the kind atmosphere found at the Student Conference on Complexity Science. With such a diverse mix of knowledge and skill sets the conversations were rife and exciting. With the transdisciplinary nature of complexity science forging links between all students with all manner of backgrounds the conference itself was evidence of how the whole is often far greater than the sum of its parts.



Students at the SCCS 2012

CTHULHU Research Discussion Group

by Maike Sonnewald

Cthulhu is a character from an HP Lovecraft short story. He's an Elder God. A sea creature with lots of tentacles, and a character that has found a home within geek culture to the extent that he's quite impossible to take seriously.

As researchers in Earth system modelling, we are surrounded by painful acronyms. Only in this field do you have such acronyms such as NEMO, FAMOUS and FLAME to name a few, so it was obvious that a research discussion group based at the National Oceanography Centre, Southampton (NOCS), but acting as an umbrella for discussing Earth Systems in general needed an acronym to top them all. Thus the "CTHULHU: The Complex earTH system nUmerical modeLling and pHysical Understanding" was born.

The NOCS is the home of the School of Ocean and Earth Science, but traditionally postgraduate students here still tend to be pigeonholed into fairly narrow disciplines only rarely looking at their part in the Earth in a non-reductionist sense. A number of us felt this was a problem, firstly because many people are interested in the Earth System as a whole, not just being limited to the aspects our projects touch upon, but also because most of us face similar problems within modelling or data analysis, irrespective of discipline. The interest in Earth Systems and curiosity about tools applied in other disciplines led to the creation of CTHULHU. We have established a platform where interested and passionate students can come and share thoughts and ideas about how we try and improve our understanding of the complexities within the Earth System.

The NOCS is a great place to have multi-disciplinary interests. It's full of people with interesting ideas and energy. I am currently representing the ICSS in the CTHULHU project, whilst other students involved come from other fields including Paleo and Physical Oceanography. The next step I hope to achieve with this group is to open up more of a dialogue between NOCS and other parts of the university (particularly the ICSS), helping students and staff with expertise for applying tools within computing or signal analysis to get in touch with interested people with expertise within Earth Systems.

Personally, I'm interested in improving ocean models within ocean-atmosphere coupled climate models. Having been given the opportunity to spend my first year at the ICSS DTC has given me a broader perspective on what tools are available. I think the Earth System is the most exciting system out there, both because it is what sustains our civilisation but also because it's likely to fundamentally change in the socio-economically relevant future. Tackling the challenges we face trying to understand the active mechanisms requires Herculean effort, as well as a serious shift away from the reductionist approach of viewing the system components separately.

Having an informal platform to start the daunting business of talking to experts in other disciplines, get ideas, help or just generally ask questions is something I believe we have been missing. Hopefully CTHULHU acts as just such a platform for those researchers who are as fascinated by the complexity of the Earth System as I am.

Also, there is cake!

Interview with Director of the ICSS DTC

Q Why did the EPSRC want to fund Complexity DTCs in particular?

A few years back it was obvious to the EPSRC that the UK had real, internationally recognised strength in AI, ALife, Complexity and the science growing around these ideas, but that it was extremely fragmented. Many scientists were using similar novel computing techniques, but each didn't know much about the others' work. Also, there was a real need for some kind of career path for working in a multi-disciplinary way in ALife/Complexity/simulation modelling areas. Doctoral training centres in complexity are an attempt to push those things forward.

Q Why were you excited about being involved in creating the ICSS DTC?

The reason I got involved with the DTC is because I had a fantastic PhD experience myself; I really felt like it was an intellectually important time for me.

But I found there wasn't much support for me to develop the tools I needed, such as learning how to use parallel computers or game theory; so I found getting my thesis finished in time massively stressful. The DTC model felt very in line with what I would have wanted to do when I was a PhD student in that it allows time for students to develop particular skills and explore where their passion lies before getting their research started, and provides that kind of varied research community that triggers ideas. In a nutshell, I wanted to create a PhD experience that I would have bitten my arm off to do!

Q What is the DTC looking for in a student?

Fundamentally, we look for students with whom having an academic conversation is exciting. We want people who are going to bring a lot to the DTC in an intellectually gregarious way and who are going to thrive in this kind of social situation we create. We only select students who we think will gain from being thrown together in a multi-disciplinary environment because I believe the cross-fertilisation of ideas that that creates is vital to our success.

We're also happy if each intake has a distribution of personalities, where discussion and debate, whether related to work or not, is normal. Achieving a PhD can be a difficult process. A cohesive group of students can help each other through the highs and lows.

Q What else does the DTC do to support students?

Nicki Lewin, the ICSS Manager, and I devote a lot of our time to supporting students and helping to resolve any academic or personal problems that they may be having; such as a supervisor leaving, or a student suspending their studies and then coming back. Each student also has an assigned tutor. I do think it's a vital part of my role that DTC students don't fall through the cracks – wherever they end up in the University, they should always have a DTC 'family' to come back to for support.

Q How does your work outside the DTC incorporate complex systems simulation?

Apart from teaching, and working directly with DTC students and undergrads and masters students on their research, I am involved in three other big projects:

Resilient Futures – considering the resilience of the UK's future energy and transport infrastructure to threats and hazards.

The Care Life Cycle – how will the UK's health and social care systems cope with a changing and ageing population?

UK Infrastructure Transitions Research Consortium – exploring complex systems approaches to the analysis and planning of robust national infrastructure systems..

I also used to do more theoretical biological modelling research – research into how termites build their mounds and the evolution of honest signaling in animals and the role of neuromodulation in brains – and I'm trying to keep on with those more blue-sky, curiosity-driven questions. I find some of the research that I do now, the more policy-relevant work, very different. With termites, there aren't really any 'stakeholders' and there isn't really any 'impact' – termites don't read your papers, and they don't change their policies. But modelling politically significant socio-technological systems is almost the complete opposite. There are many different groups of people with interests in the research, who give the projects a lot of direction, and they will ultimately determine whether the work is a success (or not) by being influenced by it (or not). As a consequence you need to keep in touch with them, understand them, and explain your research to them. So I now end up in meetings with people from the Home Office, the Bank of England, NATO, the NHS, etc., who care a lot about the behaviour of their complex systems without maybe being interested so much in termites, peacocks and neurons. But so far I find that I can pretty much be interested in them all.

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