Research

The Sum of Knowledge

Dr Scott Rickard, Director of CASL speaks to Louise Holden about this unique and exciting collaborative research laboratory at UCD.

What do you get if you cross a volcano and a human heart? A new geography of knowledge. At the UCD Complex and Adaptive Systems Laboratories (CASL) a geologist and a biologist may breach frontiers of science over a cup of coffee. The idea may sound simple, take scientists of different disciplines and put them in one building but already the results and the promise of this project are exhilarating.

"We have worked in disciplinary silos, our ideas and research remaining within our own specific areas," says CASL Director Scott Rickard. "CASL is unique in Ireland, and rare in the world, in that it brings together researchers from many areas, all looking for connections. Colocation is crucial to this project."

There are 200 researchers now housed at the CASL; computer scientists, mathematicians, electrical engineers, geoscientists, financial academics and biomedical scientists. They have come together in their new home at the Belfield campus to share knowledge to the tune of three master themes: Simulation & Modelling, Communication and Knowledge Discovery in Data (see panel).

"The move into CASL has catalysed collaborations between diverse academics," says Rickard, who took up the directorship with some unanswered research questions stemming from his graduate work at the Massachusetts Institute of Technology

"I have been studying Costas arrays," he explains. "In the 1960s engineer John Costas developed new sonar codes using sequences of musical notes that contained no repeated patterns. Electrical engineers, like me, extended his findings and applied them in other areas such as communication technology. Motivated by some practical concerns in the communication problem, I had noticed some patterns having to do with prime numbers, but I'm not a number theorist so I couldn't pursue my finding without decades of further study."

It was at the CASL that Rickard worked with Professor Roderick Gow, UCD School of Mathematics. Rickard had tried to collaborate with the eminent number theorist before, but the fifteen-minute stretch between their two faculties thwarted his efforts. At the CASL, Rickard and Gow could further their collaboration in the lift or over coffee. They have since discovered the theory behind Rickard's observations and Gow has linked Costas arrays to esoteric results in number theory known as Class Numbers. The collaboration has fathomed a deep relationship between two very different mathematical fields.

"There was a pent up need for the CASL," says Rickard. "By putting people within metres of each other collaborations spring from all sorts of encounters, and they progress much more rapidly."

Rickard gives the example of how a number of CASL investigators are working on localisation, or the problem of determining the locations of sound sources. Professor Christopher Bean, UCD School of Geological Sciences has been studying localisation in an effort to 'read' the acoustics in and around volcanoes; separating out the vibrations and murmurs, identifying them and using the data to understand and predict volcanic activity. Meanwhile, computer scientists at the CASL are trying to localise the position of people using electromagnetic technology. In a third manifestation of this theme, biomedical researchers have been trying to employ vibration localisation to detect arterial blockages.

Now, the CASL is hosting a series of 'localisation days' or '20:20:20 Thursdays', as Rickard likes to call them. Each group gets twenty minutes to talk about their localisation research, and ideas are shared and cross-fertilised. As a result, a new project has been born, a novel technique for acoustic source separation that combines the Professor Bean's acoustic readings of volcanic activity with attempts to read the vibrations of blood flow to the heart.

"Before Chris got involved, our efforts to read blood turbulence were failing," says Rickard, who has been working on the technique with a team of cardiologists for a number of years. "He was able to tell us why our approach couldn't work, and help us to discover what would work. Who would have thought that a geophysical scientist and an electrical engineer could successfully collaborate on a cardiovascular health project? You couldn't plan that. It was our proximity that made it happen."

Out of the various collaborations at the CASL, new disciplines are starting to emerge. It happens, says Rickard, when experts from unlinked areas try to find a common language. "There can be huge language barriers between scientists from discrete disciplines," says Rickard. "In order for them to work together they have to forge a common language. That takes time and a lot of learning happens in the process. As a result of one such collaboration we have developed a new graduate programme in Computational Biomedicine. It is a new discipline born of the efforts to communicate across disciplines. We are training the next generation of scientists to be multi-lingual."

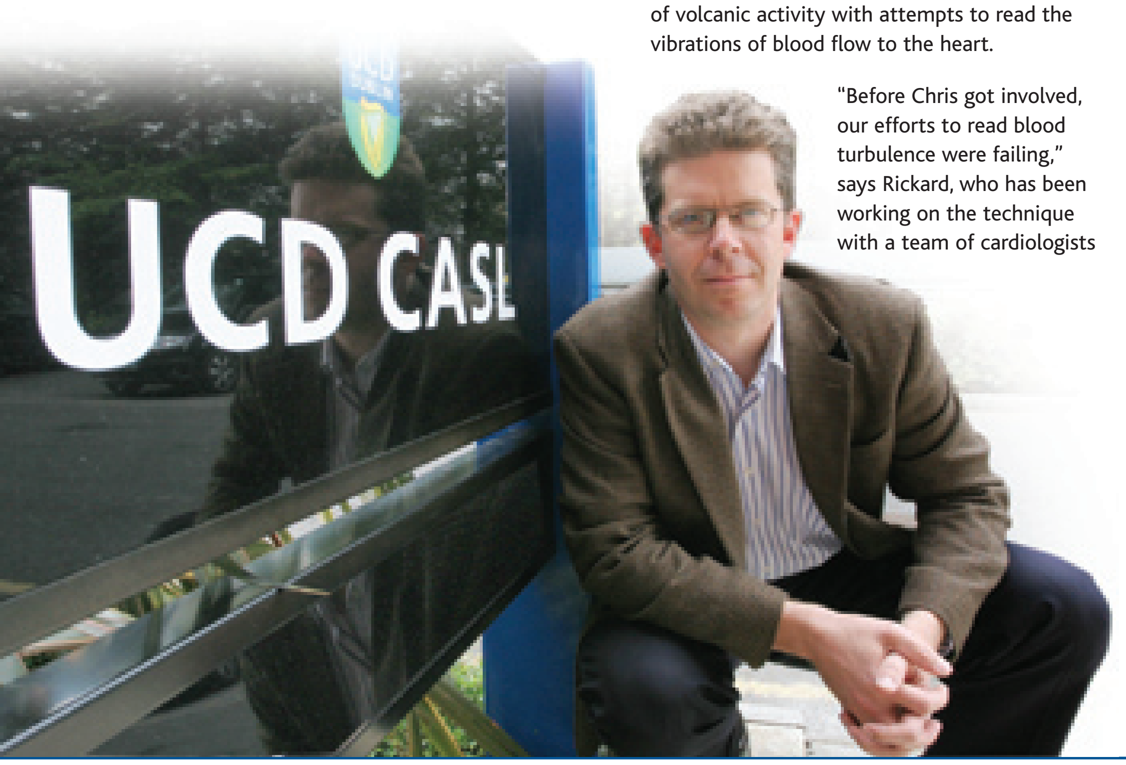
In the future, Rickard predicts, scientific breakthroughs will increasingly be developed by scientists trained in this multi-disciplinary way. Could this engender a new generation of Renaissance men and women, capable of the kind of 'un-disciplined' thought that led to the explosive creativity of a Da Vinci or a Michelangelo?

"It's hard to imagine that a single human mind can ever perform the kind of cross-disciplinary feats that the old scientists achieved," says Rickard. "We have learned so much, there is so much to know – one person can hardly traverse it all. However, through centres like the CASL, we can bring groups of thinkers together to simulate the brains of the old scientists in a new, information-rich context. We can connect all the bits of the brain again, by bringing the sum of the knowledge into one place."

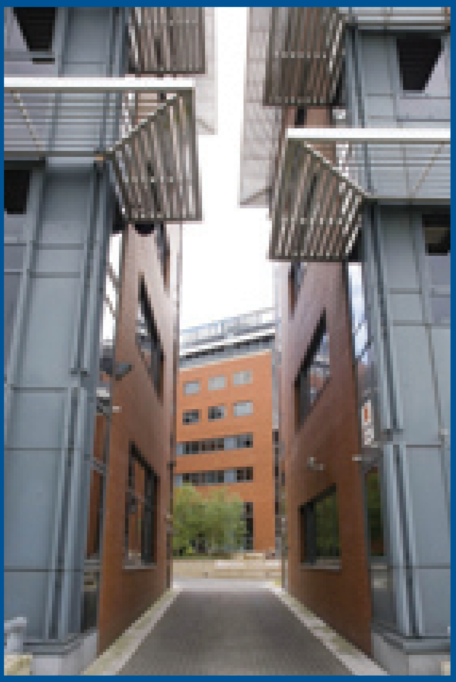
And what of other disciplines – art, social science, the humanities – in what part of the CASL's collective consciousness do they belong? "I have a vision of a scientific method that can incorporate many more disciplines, and the secret lies in computation, the new microscope of science," Rickard muses. "Through computation we can model all sorts of human situations that we could not explore using the pillars of theory and experiment. Computation allows us to collapse markets, stage riots, and model patterns of human behaviour that we could not create otherwise. With computation as a third pillar of scientific enquiry we will be able to draw in an even wider diversity of disciplines."

For now, those of us concerned with the arts and humanities can satisfy ourselves with the poetry of crossing a volcano with a human heart.

Louise Holden is a journalist with the Irish Times and is currently enrolled on the MEd programme at UCD.



Dr Scott Rickard



Master themes at the CASL

Principal investigators and researchers from a wide range of areas are working together at the CASL on three big themes that cross the disciplinary divide

Simulation

All systems; from atomic to astrophysical, biological to financial; have similar underlying structures from a computational perspective. They are all subject to turbulence, risk, volatility, stability, and chaos. These underlying systems may be hard to map using traditional analytic approaches but computational simulation can lead to understanding and provide valuable predictions. "To study how a market collapses, you can't crash the market," says CASL director Scott Rickard. "But you can simulate the crash using computation."

Communication

The mobile society requires increased communications with higher data requirements - channels of communication are filled to the point where they can no longer reliably deliver the flow of information. The CASL brings together communications researchers from mathematics, electronic engineering and computer science with expertise in Finite Field Theory, Coding, Cryptography, Networks and FPGA Design, to develop, design and build robust and private systems.

Knowledge Discovery and Data

Information technology is yielding vast reservoirs of data, which cannot be processed as quickly as they are produced. The Genome Project, for example, is turning over much more information about the human genome than researchers can possibly analyse. Principal investigators at the CASL are looking at computational solutions to data processing, which may be applied across disciplines from biology to finance; helping us to make more profitable use of the fruits of our information age.