

Case study

INI spawns collaborations that span a lifetime

Case Study: Computer Vision

In the words of William T. Freeman, Professor of Electrical Engineering and Computer Science at MIT and an academic whose research specifically concerns machine learning and computer vision: “We’re still in the ‘alchemy’ stage of computer vision, where it works but we’re not sure why. It’s the ‘chemistry’ stage that I’m looking forward to.” This seems a provocative assertion, especially given the myriad applications already in use: it’s through the advancement of computer vision - broadly defined as the science of teaching computers how to “see” - that there exist such varied technologies as facial recognition software, the automated management of traffic systems, barcode scanning devices, the automatic stabilisation and ‘intelligent’ focus of images captured by digital recording devices, and much more. The future of the science is equally revolutionary, promising the widespread adoption of driverless cars and the prospect of robotic arms capable of manipulating a diverse range of objects without ever having experienced them before. At its heart, as with so many scientific disciplines, computer vision involves geometry, applied mathematics and computer science. And this is where two notable affiliates of INI become key players in the history of the field.

In 2012 INI Deputy Director Dr Christie Marr presented a talk to EPSRC Council, during which she focused on the recurring theme of how research interactions at the Institute have changed not only the field of mathematics itself, but also the career trajectories of programme organisers and participants alike. It was afterwards that the then Council Member Professor Andrew Blake, Founding Director of the Alan Turing Institute and former Managing Director of Microsoft Research Cambridge, reminded Dr Marr: “You do realise that the Isaac Newton Institute also changed my working life? That was where I met Michael Isard”.

His words were a potent reminder of their field-changing work and career-spanning collaboration, including co-authoring the seminal book *Active Contours* (Springer 1998). Dr Michael Isard, now a Research Scientist in Google’s Brain Group, and Professor Blake met when Isard had barely finished his undergraduate degree. Already showing the potential to be a shining star, having just graduated from Cambridge with a double first in mathematics, Isard wrote to Blake, an Organiser of the 1993 INI programme on Computer Vision, expressing his interest in the subject. Blake took Isard on as a Research Assistant



Isard (left) and Blake (right) in 2016. Photo: Neeltje Berger, Microsoft Cambridge.

for the programme.

In his writing at the time Isard identified the challenges that lay ahead of them with remarkable prescience: "... what 'intelligent' behaviours can we endow a machine with, applying techniques from computer science, mathematics and psychology, given the computer hardware of the moment or the near future?", he asked. "Traditional Artificial Intelligence sought from the computer a single, unambiguous answer to a complex problem such as: 'Where is the person in this picture?' or 'What sentence has just been uttered?' Most areas of computer science still follow this paradigm, but it has become increasingly apparent, beginning in applications which require control or sensing of the physical world, that it is crucial to acquire a precise understanding of uncertainty as it applies to a problem and its answer."

Isard and Blake's collaboration began at INI when Isard had barely finished his undergraduate degree.

"...there is a far larger class of programs which interact with a notoriously ambiguous input source: the human user. People like to use ambiguous commands and get sensible results, and probabilistic methods which can exploit prior information to codify the meaning of 'sensible' are a promising tool to allow this

kind of user interaction."

Isard's stated aim was "to apply my background in mathematics and computing to research probabilistic methods, and move towards the goal of an intelligent machine which will really 'do what I mean, not what I say.'" Between August and December 1993, the duration of the INI Computer Vision programme, Isard and Blake developed a trained tracker, a combination of software and hardware that was "more agile and resistant to background clutter" than any previously developed, and only a few months later co-authored their first paper together. The final report from the Computer Vision programme concluded that: "The main success of our programme will be in establishing a coherent theoretical view on computer vision".

Five years later, Isard completed his Oxford doctoral thesis under the supervision of Professor Blake. Entitled "Visual Motion Analysis by Probabilistic Propagation of Conditional Density" it described the Condensation algorithm, a random-sampling algorithm for motion estimation which had not previously been applied in computer vision. With human-computer interface applications such as gesture and face recognition as his key interests, Isard observed that the algorithm had significant applications including the visual motion estimation of natural objects moving in heavy clutter, and that subsequent extensions would allow tracking using non-linear motion models,



A self-portrait of Michael Isard taken using his own lab tracking software.

and the ability to combine low-level image-processing with high-level prior knowledge of shape and motion. In the intervening 19 years, both men have earned their reputations as field-leading researchers in this ever expanding discipline, working in the prestigious research wings of firms as influential as Microsoft and Google. With dozens of patents to his name and over 100 publications with almost 20,000 citations, Isard has continued his work on computer vision but also works on machine learning more broadly interpreted and distributed systems. Blake has been elected a Fellow of the Royal Academy of Engineering, the Institute of Electrical and Electronics Engineers and the Royal Society and has been awarded the Silver and the Gold (MacRobert) Medal of the Royal Academy of Engineering and the Lovelace Medal by the British Computer Society.

The genesis of Isard and Blake's working relationship showcases perfectly the opportunity that INI offers early career researchers to forge collaborations with senior colleagues over an extended period. But perhaps the most inspiring part of the story is that Blake, the more senior of the two, firmly believes that this collaboration has impacted as much on his career as it did on Isard's.