Bridging the gaps between the science of computing and its applications

Theme of proposal

Focus area of the project: We aim to bridge the gaps between the science of computing and its applications across many disciplines, with particular reference to emerging applications in non-traditional areas:

- highlighting and responding to the challenges faced by traditional computer science (CS) as an academic discipline in giving an account of contemporary computing applications.
- raising awareness of expertise within Computer Science at Warwick (CS@W) in areas such as algorithmics, grid computing, software reliability, security and Empirical Modelling that other disciplines can exploit.
- exposing the synergy between CS@W research (e.g. in data mining, adaptive hypermedia, agent-based systems, image processing) and applications in other disciplines (such as engineering, the humanities, and education).

Importance of this focus: There are two ways in which computer science is disconnected from its applications:

- The core vision of CS is based on 'computational thinking'. In this vision, computer programming is a specialist activity sharply separated from computer use. Advances in implementing packaged computing systems for specific classes of users have reinforced the misleading idea that CS is merely “what underlies systems for use”, and is only as interesting to the user as is the technology behind car engines to the average driver.
- Computing technology is exploited in almost all disciplines. Many of these applications promote a holistic view of the computer as an instrument to support human cognition in exploratory model-building, communication and collaboration. They relate to processes that may be live and interactive, blend use and development, and involve the negotiation of meaning. More than "computational thinking" is arguably needed to account for them.

Because computing technology is so pervasive, developing a science that does full justice to all its applications is a potent way of "bridging the gaps". Establishing a mature science of computing is recognised internationally as a fundamental challenge. It is also highly relevant to computing practice, to the relationship between theoretical and empirical perspectives in science and engineering, and to science in its broader cultural context.

Our ability to deliver: Computer Science at Warwick (CS@W) has a strong reputation for scientific and foundational research. It is the leading research centre in the UK in the theory of algorithms. The discussion of our theme will draw both on established interdisciplinary collaborations addressing scientific applications and on embryonic collaborations with business, theatre studies, medicine and education. Outside CS@W, many other rich perspectives on computing applications are being explored: phenomenological (Nandhakumar: WBS), aesthetic and experiential (Lewis, Chalmers, Jennings: Engineering), constructivist / activity theory (Johnson-Wilder, Hammond, Engeström: WIE), cognitive (Kershaw: Humanities). These resonate well with the distinctive principles and tools of Empirical Modelling (EM) developed in CS@W with a broader vision for a science of computing in mind. The EM research group has been active internationally in discussions about the future of CS sponsored by the ACM and the AHRC.

Specific barriers and issues that prevent collaboration in this area

The primary barriers to bridging the gaps between CS and its applications are conceptual in nature, and are widely recognised. The vibrant intellectual culture at Warwick is an essential resource in surmounting these barriers, but sustaining the context for discussion and orienting the contributors is the first challenge to be met.

What has been and is still being achieved by computer scientists in the role of metaphorical 'car engine' developers in conjunction with users in the role of 'drivers' is astonishing. It encompasses mathematically-based computational models that have radically transformed processes and practices across all disciplines from science to the humanities. Nonetheless, as Winograd and Flores first observed in 1987, traditional CS operates within a narrow 'rationalistic' and realist framework that has its limitations. Concepts well-suited to implementing theory-based mathematical models are not so apt when discussing such topics (all represented in research-in-progress at Warwick) as: software development methodologies in business; microworlds and constructionist approaches in education; causality and consciousness in cognitive science; and the phenomenology of serious games, nor when considering meta-issues such as ensuring the conceptual integrity and aesthetic qualities of an engineering design; assessing the intellectual transparency of a historical reconstruction; or developing a GIS that does full justice to the concept of space. UK CS has hence had a low profile in initiatives such as the EPSRC/ESRC TLRP and AHRC Methods Network programmes.

Framing a broader vision for a science of computing means challenging established perceptions, tensions and prejudices across disciplines. For instance, EM is exceptional in venturing a fundamental account of the sense-making role of the computer as a physical artefact to be directly experienced and interpreted. It has also had to rehearse the arguments to show *computer scientists* that this vision can be reconciled with computational thinking, to persuade *social scientists* that a new conceptual framework for computing can be as influential as social dynamics in developing and using complex systems, and to reassure *natural scientists* that a science of computing can admit processes in which meanings evolve in response to what is being constructed without embracing "science as social construction". These issues are very pertinent to the future EPSRC agenda. For example, agile software development must be in some sense 'constructivist' in spirit. And whilst the automation of scientific procedures will surely revolutionise science, it is implausible that Faraday would have made such scientific advances without embodying his emerging understanding in artefacts that could not have been first conceived as abstract computational models.

Methods, management and dissemination

We seek three years funding from the Bridging the Gaps scheme, with an estimated total budget of £300K, to promote activities that focus on science-of-computing-related issues that would not normally be foregrounded in research projects. We aim to establish a richer, more coherent conceptual framework for understanding computing-in-the-wild by relating current practices in exploiting computing technology to the practical uses to which physical instruments and artefacts have been put in engineering and experimental science. This will serve to redress the fragmentation of the science-of-computing agenda that stems from the natural dispersal of computing-related activities over so many disciplines in recent decades, and to stimulate substantial research proposals on new collaborations in areas such as cognitive systems, engineering design and educational environments.

The core activities in our programme will be 9 themed 2-3 day interdisciplinary workshops comprising presentations of application problems (e.g. recreating experience from archives of historical data), demonstrations of relevant computing resources (e.g. the CS@W camera-array) and associated practices (e.g. commercial archiving tools, data mining tools from CS@W), discussion of CS-related issues (e.g. computer representation of abstract vs experiential data) and hands-on exploratory prototyping exercises (e.g. the EM planimeter). Themes will be conceived through expository seminars at which researchers present their applications, both current and proposed, and computer specialists introduce computing resources, techniques and issues. We shall sponsor mini-projects (e.g. supported by student project work over the summer vacation) to explore key issues stemming from core activities in more depth.

We shall organise annual interdisciplinary conferences to explore specific challenges facing computer science in its relation to applications in other disciplines. In addition to contributions from Warwick academics in all disciplines, we shall invite external speakers to include: **academics from Informatics at University of California at Irvine (UCI)**, which is distinguished for the breadth of its links with several disciplines surrounding computer science, and enjoys a special relationship with Warwick that has some financial support from the university; **computer specialist alumni**, who are particularly well-placed to reflect on the relationship between academic CS and practical applications of computing in industry; and **experts with established knowledge of varieties of interdisciplinary computing**, such as the use of computers in technology-enhanced learning, humanities computing and serious games.

Our programme will be managed by a steering group drawn from CS, Engineering, Business Studies and Education with part-time administrative and IT support and an advisory board drawn from the constituencies highlighted in bold above. The steering group will plan the themed workshops and conferences, and select mini-projects for funding on the basis of competitive bids by academics engaged in interdisciplinary research. Funding for projects will reflect their novelty and the scientific contribution they can make to bridging the gap between CS and computing applications, irrespective of the disciplines involved. Activities will be coordinated via a dedicated website.

Impact

As explained, our programme has international interest for CS and science. Nationally, it will help to improve the alignment and the public understanding of the relationship between CS and practice, to meet the needs of the computing industry for more computing professionals, and to recruit more women CS graduates. Locally, refreshing the links between CS and computing applications in other disciplines will assist DIMAP and help to strengthen the attractiveness of postgraduate programmes university-wide. The programme will also deepen ties with strategically important international partners, such as UCI, whilst benefiting directly from their models for broadening CS.