

A Grand Challenge for Computing Research

Journeys in Non-Classical Computation

GC7 web site: <http://www.cs.york.ac.uk/nature/gc7/>

GCC'06 Conference Record

Susan Stepney, Colin Johnson

Summary of progress since GCC'04

Publication of the Challenge statement

The 30 page statement of the Grand Challenge 7 (also available from the GC7 web site) has been published, in two parts, in the *International Journal of Parallel, Emergent, and Distributed Systems*. The first part [1] summarises the challenge itself, and the classical paradigms being challenged; the second part [2] describes the various journeys and waypoints identified.

International Workshop, April 2005

In April 2005, the Department of Computer Science at the University of York, and Microsoft Research, hosted the International Workshop on The Grand Challenge in Non-Classical Computation.

The Workshop hosted 80 international delegates, from Canada, Denmark, France, Germany, Italy, New Zealand, Norway, Poland, Russia, Spain, Switzerland, UK, and USA. The Workshop comprised a series of stimulating keynote addresses from leading international researchers, accompanied by interactive panel sessions and group discussions, covering a range of important topics in the new and emerging ideas of non-classical computation. The keynote speakers were Christopher Alexander (University of California) on *Harmony Seeking Computations*, Sam Braunstein (University of York) on *Quantum Computing*, Luca Cardelli (Microsoft Research) on *Abstract Machines of Systems Biology*, and Przemyslaw Prusinkiewicz (University of Calgary) on *Languages of Morphogenesis*.

Although there were no formal paper presentations at the Workshop, each delegate was invited to submit a two page position paper proper to attending. These papers, and other details of the Workshop, can be found at <http://www.cs.york.ac.uk/nature/workshop/>. Based on these stated positions, and on the run of discussions at the Workshop itself, several delegates were invited to submit full papers for inclusion in special issues of the *International Journal of Unconventional Computation*. In order to keep alive the stimulating discussions of the Workshop, invitees were given the freedom of preparing longer position papers, or discussion papers, in addition to the more usual technical papers. The first of these special issues is now in press.

International Conference on Unconventional Computation, September 2006

Based on the success of the Workshop, the organisers have been invited to run UC'06, the 5th International Conference on Unconventional Computation, in York in September 2006. Details can be found at the conference website <http://www.cs.york.ac.uk/nature/uc06/>

Summary of discussions at GCC'06

Is there really any commonality between the various Journeys?

An important question for this Grand Challenge is whether there is really anything in common between the various topics that are being studied. By defining something negatively (non-classical computation) we do not guarantee that there is anything in common between the approaches to computation.

One useful output from the challenge would be a map of what assumptions we make in classical computing (we have done this already to some extent in part I of the *IJPEDS* paper, above), and how we can drop these assumptions in a coherent way. If we drop all assumptions then we may end up saying “everything is computing”. Some sets of assumptions might be droppable together in a coherent way, some might be orthogonal to others, some might interfere with each other if we drop them all together. Where along the line of dropping assumptions does the term “computation” cease being a useful description of the process? What is left of computer science when you forget about computers?

One formal approach to something like this is by Gandy [3]

Next steps could include putting together an “umbrella” research project comprising an study across a range of individual Journeys, to extract their commonalities and expose their fundamental differences.

Intellectual tools from computer science

How will this Grand Challenge impact on other sciences?

We already import a lot of *technical* tools from computer science into other sciences: e.g. optimisation, simulation, numerical analysis techniques. However, computer science is also a set of *intellectual* tools. In particular we have good ways to deal with: levels of abstraction; processes of refinement; compositional systems; bridging the gap between discrete and continuous systems; describing systems with state and behaviour; ...

There is a small flow of such ideas already: model checking in systems biology; process calculi for describing business processes. However, these are mostly very unfamiliar outside their specific domain. Overall we don't really have a strategy for introducing our “ways of thought” into other areas.

So, how can we package these ideas? Do we need a “scientists engagement with (other) sciences” to play a higher-level role comparable to what “public engagement with science” has played in recent years?

How can this Grand Challenge engage with Andrew McGettrick's meta-challenge of providing ideas that could excite schoolchildren about our area of science?

Next steps could include setting up small focussed working groups, and an EPSRC network, to tackle these and related questions.

References

- [1] S. Stepney, S.L. Braunstein, J.A. Clark, A. Tyrrell, A. Adamatzky, R.E. Smith, T. Addis, C. Johnson, J. Timmis, P. Welch, R. Milner, D. Partridge. Journeys in Non-Classical Computation. I: A Grand Challenge for computing research. *IJPEDS* 20(1):5-19. March 2005
- [2] S. Stepney, S.L. Braunstein, J.A. Clark, A. Tyrrell, A. Adamatzky, R.E. Smith, T. Addis, C. Johnson, J. Timmis, P. Welch, R. Milner, D. Partridge. Journeys in Non-Classical Computation. II: initial journeys and waypoints. *IJPEDS* 21(2):97-125. April 2006
- [3] R. Gandy. Church's thesis and principles for mechanisms. In J. Barwise *et al*, eds. *The Kleene Symposium*. pp.123-148. North-Holland, 1980.