The Calculemus Project

Putting it All Together - The Calculemus Project

One of the original goals of AI was to automate human-level intelligence. While this is a long way off, it is likely that such competence is not going to be achieved by a single algorithm or even a single program. Rather, it will probably take an agency of intelligent systems, where each system comprises many programs designed to perform specific tasks. While we have a hyper-linked global knowledge base (the internet), there is no comparable network of programs which tasks and subtasks can be passed around until a solution to a particular problem is found. However, there are certain projects which aim to combine systems so that the whole is more powerful than the sum of the parts.

One such project is called Calculemus, which aims to combine mathematical software in such a way that the combined systems perform better than any of the stand-alone programs. For example, a general aim of the Calculemus project is to improve automated theorem provers by enabling them to perform computations (very few provers actually look at examples of the concepts which they are trying to prove a theorem about). Conversely, another aim is to improve computer algebra packages by giving them enhanced deductive power (to prove, for example, that the side conditions of a integral hold, or to formally verify that an algorithm performs as specified).

The Calculemus project was awarded a grant under the European Union Fifth Framework Programme, with nine universities in six countries participating (Saarbrücken, Edinburgh, Karlsruhe, RISC, Eindhoven, IRST, Bialystok, Genoa and Birmingham). Another major UK player is St. Andrews, although they are not officially mentioned in the EU grant. Each institute brings unique experience to tackle the difficult problem of integrating mathematical software.

The first hurdle to overcome with any project to combine systems is the language(s) to employ. Various proposals for a mathematical language are on the table, including XML, OmDoc and OpenMath. Once the programs can talk, there is a need to define the notion of a mathematical service, so that the programs can work together productively. Projects such as the Open Mechanised Reasoning Systems are working towards this. In addition, the practicalities of brokering mathematical communications over networks are being researched.

Secondly, there is a need to share stored information between the programs, and libraries are required to provide contexts for the integration. The MBase and Mizar databases are being researched under the Calculemus umbrella, and much energy is being expended on the development of authoring tools to compile large libraries of mathematical knowledge in a standardised format.

Finally, experts in the implementation and application of the systems to be combined are required, and there are Calculemus partners with much experience of both computer algebra systems and automated theorem provers. Also, it is important to identify applications, in particular challenge problems from mathematics and beyond which can be solved more efficiently with a combined approach than with stand-alone methods.

Although only part of the way into the project, there are already some promising results. A system which is rapidly becoming very important to Calculemus is the MathWeb software bus. Thanks largely to the efforts of Jürgen Zimmer from Saarbrücken on a Calculemus crusade to various universities, MathWeb now enables 23 systems to talk to each other. Such interaction is beginning to pay off, as demonstrated by two projects we are undertaking in Edinburgh. Firstly, we have enabled the Lambda-Clam theorem prover to perform calculations by calling the Maple computer algebra package. This has enhanced Lambda-Clam so that it can now prove some results about Fibonnaci numbers which were not possible before. Secondly, we have integrated the HR automated theory formation system with Maple, the Otter theorem prover and the MACE model generator. Various applications have spun off from this, including: producing new theorems for the TPTP library of test problems for provers; finding invariants of algebras; and finding conjectures about Maple functions (where Otter is used to discard those conjectures which can be proved too easily).

Letters

Calculemus is a training network, with much emphasis on the training of "Young Visiting Researchers" (of age 35 and under). Any young researcher from an EU country can be employed to work at one of the nine nodes for up to a year at a time. This is an interesting and exciting project, and if you are interested in contributing to it, please visit: http://www.calculemus.net, and consider attending the 2002 Calculemus Workshop (http://www.ags.uni-sb.de/~calculemus2002/) and/or the 2002 Autumn School (http://www.eurice.de/calculemus/autumn-school.html).

Simon Colton
Universities of Edinburgh and York

Letter to the Editor

Dear Sir,

I would like to make some immediate responses to the letter from Kyran Dale (AISBQ. 107) In addition to some rhetorical stuff, what I take him to be saying is:

(1) Steve Grand (and many others, including the whole of GOFAI) are wrong to think that they are on the royal road to AI/A-Life. Indeed, they are "hopelessly" over-ambitious in believing this.

(2) No-one else is on the royal road either. But the first steps must be at the level of "hundreds" of simple elements in a complex system — e.g. the nematode worm.

(3) The behavioural - and therefore cognitive - capacities we are interested in are hugely difficult to understand/implement. (Even in bees.)

(4) There's too much hype in this area. Some of this is down to the media, some to self-aggrandisers, but it is a general problem for AI and A/Life.

What I'd like say about that is: (a) As for (1) and (2), many others would say so also. They may or may not be right. But - for what it's worth - I think they have a plausible case. I myself am constantly pointing out, both in speech and in print, the crudeness of achievement and the over-optimism of most (yes, MOST) people in AI/A-Life (yes, ALL of them). But that doesn't mean that I think nothing of interest has been learnt. I think Kyran Dale is far too quick to imply that this is the case, and also - or maybe "and therefore" - far too quick to assume that Steve Grand won't get anywhere either. This is, in fact, a long-standing scientific (and philosophical) dispute right at the foundations of AI/A-life. On this occasion, it's been triggered by a debate between two specific individuals, but it's a serious debate in which we should all be interested.

(b) Point (3) is, surely, absolutely incontrovertible. Indeed, another thing I often say is that the main lesson of AI is how unexpectedly difficult these things are. That insight is a *real* advance, even if it's been gained at the cost of repeated semi-successes or even failures over the last 60 years.

(c) Point (4) is again hard to disagree with in the general sense. Admittedly, someone who doesn't know anything about the field (which doesn't include the readers of AISBQ) might read his piece as simply a personal attack on Steve Grand. But AI/A-Life in general has been - rightly - accused of this from the start. Steve Grand is in very good company - Newell & Simon, Minsky, McCarthy, and Rosenblatt.

If anyone can achieve what Steve Grand is setting out to do (which, as I say, I doubt) then it is he. However, even if his project turns out to be a complete dead end, it should be welcomed. As Karl Popper usefully pointed out these dead-ends aren't actually 'dead': they are "conjectures" which can turn out to be followed (perhaps many years later) by fruitful "refutations" - but the process (the "scientific research programme") was an advance. Not only did it (eventually) show us what *is not* the case, but it (throughout) showed us what *might be* the case.

Kyran Dale twice refers to people applying for funding, grants, etc. Steve Grand has never done this. He has the courage to devote his own money - indeed, almost all of it - to his research. Steve Grand is very unusual - not least, in this. Most of us have neither his vision, nor the computing/engineering skills, still less the commitment and courage. I salute all four. I suspect that Kyran Dale, in non-incandescent mode, would do so too. His rhetoric is not a model of tact.

Maggie Boden, University of Sussex