TITLE AND ABSTRACT FOR TALK IN ZURICH

The talk will be given in the philosophy department of the University of Zurich on Monday 11th March 2019

Details are provisional and illustrative because I expect the presentation to be highly interactive, partly because I’ll offer an unfamiliar combination of topics, linking philosophy, biology (especially evolution), mathematics, AI/robotics, linguistics, psychology, neuroscience and physics/chemistry.

How can a physical universe produce mathematical minds?
And why are they so hard to replicate in current AI systems?

SPEAKER
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EXTENDED ABSTRACT:
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This is a progress report on a long-term project. Most theories of learning assume there’s a fixed type of world to be understood by learners, whereas biological evolution, in collaboration with its products, is metaphysically creative, constantly extending the diversity and complexity of the world to be understood, using ever expanding forms of compositionality, requiring increasingly complex mathematical mechanisms in understanders. Extending the types of learners adds to the mathematical complexity of what needs to be understood, especially in recently evolved learners trying to understand themselves. Human mathematical competences are not yet understood well enough, to be modelled or replicated (despite fashionable claims), though Immanuel Kant identified some key aspects of the task in 1781, summarised in [1].

Background: Evolution -- the blind mathematician
It is not widely appreciated that as evolution produces increasingly complex organisms, with increasingly complex behaviours, it uses increasingly sophisticated mathematical discoveries. There are infinitely many different mathematical structures of different kinds, including: Boolean logic, the natural numbers (0, 1, 2, 3, 4, ....), the positive ratios (1/2, 1/3, 2/3, 1/4, ....), Euclidean geometry, the topological subset of Euclidean geometry, negative feedback and other
information-based control structures, the probability space for "throws" of N perfectly balanced six-sided dice, and Turing’s "universal" machine.

These structures exist whether or not physical instances of them exist, and whether or not any thinkers notice their existence.

Among the mathematical structures "discovered" and used by biological evolution are designs for increasingly complex organisms, for types of mechanism used by such organism, and types of information used for control. E.g. use of negative-feedback control loops to keep systems within safe parts of their state-space, or move them toward desirable states or away from undesirable states is commonplace in organisms, though human engineers did not discover and use such control structures until millions of years after they began to be used.

Not all such information-based control mechanisms need to use precise numerical values. E.g. sometimes it is enough to be able to detect whether something is changing, or whether it is increasing or decreasing, or whether the rate of increase or decrease is changing, or whether one object is moving toward or away from another. (Evolution can be more broad-minded than some science teachers.)

[ I use "information" in the sense of novelist Jane Austen, not Claude Shannon, as explained here: http://www.cs.bham.ac.uk/research/projects/cogaff/misc/austen-info.html ]

In more complex organisms, evolution discovered the power of layered epigenetic mechanisms that use different mathematical structures (including new combinations of simpler structures) at different stages of development. As a result, recently evolved sophisticated learners have multi-stage, "meta-configured" genomes [2], whose later stages of gene expression produce more complex, more recently evolved, more mathematically complex and abstract, discovery and learning mechanisms with different evolutionary histories. The best known example of this is the collection of different developmental transitions in (signed, spoken and written) language "learning" capabilities. (Strictly, these are language creation capabilities, which is why there are so many different human languages.)

A meta-configured genome repeatedly produces new learning powers within each individual, some of which depend not only on later stages of biological evolution, but also on prior stages of cultural evolution, and other changes in the environment, including changes in other species, as illustrated by evolved symbiosis.

In particular, some of the more recent parts of the human genome produce enormously varied adult competences, including inventive powers that cannot result simply from a uniform learning mechanism presented with examples of invention[3].

Despite impressive recent results, nothing in current AI matches or explains the evolved types of spatial intelligence found in squirrels, weaver birds, elephants, human toddlers and ancient mathematicians, e.g. Archimedes, Euclid, Zeno, and others. (That’s why I’ll refuse to use a self-drive car in cluttered busy urban environments.) Current psychology and neuroscience also lack the required explanatory power.
These claims will be supported by a collection of examples, including spatial reasoning competences of pre-verbal toddlers, squirrels, nest-building birds, and others.

Partly inspired by Immanuel Kant and Alan Turing I’ll outline a research programme, the Meta-Morphogenesis project, aiming to fill deep gaps in our scientific and philosophical theories, including perhaps chemistry-based extensions to Turing-computability[4], which Turing himself implied might be needed in his PhD Thesis.

   A collection of examples:
   http://www.cs.bham.ac.uk/research/projects/cogaff/misc/impossible.html


[3] Compare uses of spatial intelligence in our ancestors to make deep mathematical discoveries (e.g. in geometry and topology) and recent advances in theoretical physics that those ancient thinkers could not have produced.


Video of related talk
20 min video of unscripted talk to a collection of artists at Eastside Gallery November 2018

Additional references (all work in progress)
The Turing-Inspired Meta-Morphogenesis Project
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/meta-morphogenesis.html
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/construction-kits.html
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/super-turing-geom.html
Compositionality in evolution’s products:
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/sloman-compositionality.html

An account of how Science and Philosophy (Metaphysics) share a deep concern for investigation of what sorts of things are possible and how they are possible, can be found in Chapter 2 of my 1978 Book (The Computer Revolution in Philosophy), now online, partially updated:
http://www.cs.bham.ac.uk/research/projects/cogaff/crp/#chap2

Some of these ideas are related to, and have been influenced by, the Birmingham FraMEPhys project, @FraMEPhys.

The Meta-configured genome idea was developed in collaboration with Dr Jackie Chappell
https://www.birmingham.ac.uk/staff/profiles/biosciences/chappell-jackie.aspx