Grand Challenge 5 - The Architecture of Brain and Mind

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1 Caveat

This note is meant to be helpful to Grand Challenge 5 by offering one mathematical solution to the general problem of relating mind to body in a way that bears on the biological issues of brain function and the symbolic/non-symbolic debate in AI. There are two significant spin-offs of this: one into the practice of physical measurement, and the other into the Philosophy of Science. The author is very happy to engage with Challenge 5 researchers. However, this note is very early in the publication cycle and refers to three papers that are about to be submitted for review. It is not appropriate, therefore, to disclose the detail of these papers, though an indication of their contents may properly be given here and at the workshop.

2 A Solution to the Mind-Body Problem

From a purely mathematical point of view, the mind body problem was, in retrospect, easy to solve. Any geometry provides a theory of bodies and, if the Strong Thesis of AI is correct, the Turing Machine is a mind. Having gained this insight, it was a fairly straight-forward technical problem to unify Projective Geometry and the Turing Machine[1]. This gave rise to a new theoretical computer called the Perspex Machine. (This machine is greatly simplified in the papers to be submitted.) The Perspex Machine operates in a 4D spacetime of real, homogeneous coordinates augmented by the strictly transrational numbers infinity and nullity[2], but every point in this space contains a 4×4 matrix, or Perspex, giving rise to a 20D space. The choice to use Projective Geometry plays a pivotal role in the machine. Amongst other things it allows the machine to model vision and bodily motion in a simple way. Critically, the canonical form of the projection prevents time from flowing backwards. The Perspex Machine can operate simultaneously, as many minds, and as each of these individual minds in forward flowing time, but it cannot operate so as to contradict the causality we perceive in the universe. Thus, the perception of forward flowing time is an inherent part of the machine.

In some ways the Perspex Machine is too powerful to model human minds. The continuous nature of homogeneous space allows the machine to operate at every point in a 1D string, 2D membrane, 3D space, or 4D hyperspace. This allows it to compute infinite series in finite time and to solve other super-Turing problems. However, one can set up the space so that it contains computations at only discrete points. In this way it can mimic serial and parallel computers, albeit in a super-Turing way. Restricting the machine further, so that it operates at only rational (and strictly transrational) points in space finally models a Turing Machine. Thus the (trans)rational points in space model symbolic computations and the irrational points model non-symbolic computations. The continuity of 20D space ensures that points that are close to each other compute similar functions and because the Perspex Machine operates irrespective of the kind of number it moves smoothly between symbolic and non-symbolic computations. This has two significant spin-offs.

Firstly, it is a property of numbers that any (trans)rational approximation to a numerical function either arrives at it immediately, or else approaches it as a saw-tooth. In other words, it goes through paradigm shifts. It is possible to derive necessary bounds on the time between paradigm shifts in precision and probabalistic bounds on the time between improvements in accuracy. This is significant, because it applies to any Turing computation. In particular, the paradigm shift formulas (in the submitted papers) give lower bounds on the speed at which paradigm shifts must occur in written (i.e. symbolic) theories, but they do not apply to continuous things, such as scientific instruments. That is, an object can be improved continuously, but the theory describing it must undergo paradigm shifts at a minimum rate - otherwise the theory has either arrived at an exact description or it has stagnated at a sub-optimal description. Thus, the Perspex theory of mind and body makes an interesting contribution to the Philosophy of Science.

Secondly, the paradigm shift formulas apply not only to minds, but by a duality, to bodies. They give a computational procedure for very significantly improving the accuracy of a very wide class of physical measurements on physical bodies. (Again this is in the submitted papers.) Thus, the Perspex theory of mind and body potentially makes an enormous contribution to science and to technological advancement.

These two examples stand as a result of Grand Challenge 5 - research on the mind-body problem has, arguably, advanced our understanding of how science progresses via paradigm shifts and our ability to test scientific hypotheses by making physical measurements. This latter might have significant economic advantage.

These abstract results can be made concrete by projecting a 16D Perspex and its 4D spacetime into a 3D subspace that changes over a 1D time. The result looks, a little, like a neuron.

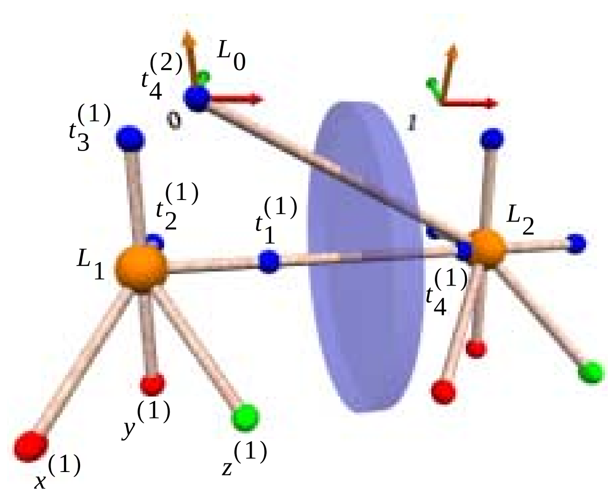

Figure 1:Perspex Neuron Over Time and Nullity (L_0**)**

The large, blue disc in Figure 1 is a graphical rendering of the time barrier between time zero on the left and time one on the right. The neuron on the left at location L_1 reads data from synapses at $x^{(1)}$ and $y^{(1)}$ (coloured red) into the body at L_1 (coloured orange) where it combines the data and writes it into the synapse at $z^{(1)}$ (coloured green). Control then jumps to *one* of the synapses at $t^{(1)}$, $t^{(2)}$, $t^{(3)}$, or $t^{(4)}$ (coloured blue). The jump from the neuron on the right at L_2 to the co-ordinate frame labelled zero *does not* denote a jump backward in time, rather it denotes a jump to the point at nullity that lies outside spacetime. (The jump to nullity is simplified in the submitted papers.)

Networks of Perspex neurons can, of course, perform any Turing computation, but they do so in a way that depends on their specific size, shape, and position in space. Computations can be forced to take up arbitrary shapes by undertaking sufficiently many simultaneous computations. Indeed this is necessary, so that an arbitrary body can be unified with the Turing machine, but if these “redundant” calculations are omitted the network organises itself into fibres and functional blocks of neural tissue. This is reminiscent of biological neuroanatomy. Furthermore, the network operates by growing (writing) neurons and killing (deleting) them. This is quite different from traditional artificial neurons and is reminiscent of gross neurophysiology and embryology. It is possible, for example, to trace out certain kinds of fibres by introducing a neurotoxin (halting instruction) at a neuron and recording the subsequent destruction of neurons in the fibre.

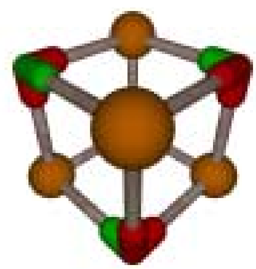

Figure 2:A Cube Described by Perspex Neurons

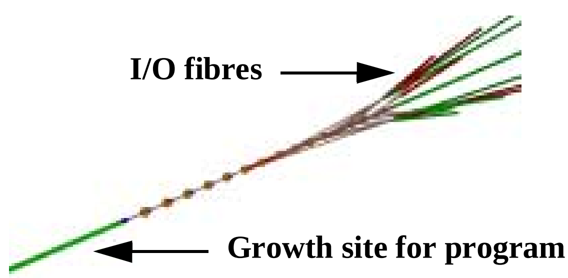

Figure 3:A Perspex Neural Network that Rotates the Cube

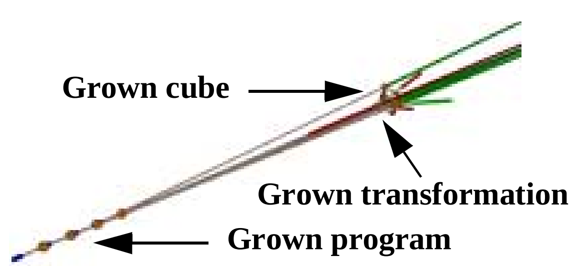

Figure 4:Neurons Grown by the Rotation Program

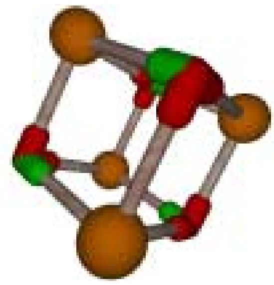

Figure 5:Grown Neurons Being a Rotation of the Cube

The geometrical properties of the Perspex Machine have been linked to high-level mental faculties[3]:

1. A *selection* is the *jump* part of a Perspex.
2. V*isual consciousness* is a partial, bi-directional mapping between perspexes.
3. Any form of *consciousness* can be obtained by synaesthesia to visual consciousness.
4. *Feeling* is the physical content of consciousness.
5. An *action* is an *instruction* being the *product* and *jump* parts of a perspex.
6. *Will* is the conscious selection of action.
7. *Free will* is will by an agent itself and no other agent.
8. Free will can be implemented by executing a perceived perspex.

(A definition of intelligence is given in the submitted papers and completes the list of mental faculties needed to implement an interesting robot. Having unified the Turing Machine with Projective Geometry, creating the Perspex Machine, it was then a small step to unify the Turing Test with the Perspex Machine, thereby providing a definition of intelligence within the machine that includes the case where the questioner and contestants in the test are some mixture of humans and computer emulations of humans.)

The adequacy of the linkage of mental faculties to the Perspex Machine is, of course, open to debate, but it can also be put to the test in AI programs and robots. The above neural network was executed on a (Turing computable) Perspex Machine implemented in Pop11. This code can be made available to the community via the world wide web.

3 Conclusion

The author is very happy to engage with the Challenge 5 researchers and offers the Perspex Machine both for its scientific value and its publicity value. It can be claimed that the machine solves the mind-body problem, that it explains why we perceive time as flowing forwards, that it is a much closer analogue to biological neurons than traditional artificial neurons, and that it provides a test bed to implement and assess free will, consciousness, feeling, and intelligence in robots. Furthermore, that it explains how science progresses via paradigm shifts, and that it might improve the accuracy of all scientific measurements.

4 Presentation

The workshop presentation corresponding to this submission is at:
http://www.bookofparagon.btinternet.co.uk/Robots/GrandChallengePresentation.2004.pdf

5 References

(1) J.A.D.W. Anderson, "Perspex Machine," in *Vision Geometry XI* Longin Jan Latecki, David M. Mount, Angela Y. Wu, Editors, Proceedings of the SPIE Vol. 4794, 10-21 (2002).

(2) J.A.D.W. Anderson, "Exact Numerical Computation of the Rational General Linear Transformations," in *Vision Geometry XI* Longin Jan Latecki, David M. Mount, Angela Y. Wu, Editors, Proceedings of the SPIE Vol. 4794, 22-28 (2002).

(3) J.A.D.W. Anderson "Robot Free Will," *ECAI 2002 Proceedings of the 15th European Conference on Artificial Intelligence* Lyon, France, ed. F. van Harmelan, pp. 559-563, 2002.