The Child Machine

vs

The World Brain

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A bit of history

• I met Ivan at the Turing Institute in 1987, 25 years ago
• Visited Ljubljana later that year
• Our connection was Donald Michie
The University of Illinois

- Ryszard Michalski invited Donald to visit Illinois for half the year
- Later got me over as a postdoc
Artificial Intelligence: the first 2,400 years

- The mechanisation of thinking dates back to Aristotle
- The motivation for much mathematics
The AI Program

"... to investigate the fundamental laws of those operations of the mind by which reasoning is performed; to give expression to them in the symbolical language of a Calculus, and upon this foundation to establish the science of Logic and construct its method; ... and, finally, to collect from the various elements of truth brought to view in the course of these inquiries some probable intimations concerning the nature and constitution of the human mind."
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George Boole (1854)
An Investigation of the Laws of Thought
The AI Program

"... to investigate the fundamental laws of those operations of the mind by which reasoning is performed; to give expression to them in the symbolical language of a Calculus, and upon this foundation to establish the science of Logic and construct its method; to make that method itself the basis of a general method for the application of the mathematical doctrine of Probabilities; and, finally, to collect from the various elements of truth brought to view in the course of these inquiries some probable intimations concerning the nature and constitution of the human mind.

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Turing's Mind Paper

• Introduced the imitation game

• Also discussed how a computer could be "educated" to the point that it could play the game
The Child Machine

“Instead of trying to produce a programme to simulate the adult mind, why not rather try to produce one which simulates the child’s? If this were then subjected to an appropriate course of education one would obtain the adult brain. Presumably the child-brain is something like a notebook as one buys from the stationers. Rather little mechanism, and lots of blank sheets… Our hope is that there is so little mechanism in the child-brain that something like it can be easily programmed. The amount of work in the education we can assume, as a first approximation, to be much the same as for the human child.”

Alan Turing (1950)
Computing Machinery and Intelligence
Incremental Learning

• Original idea for a “growing language”, based on logic, due to Ranan Banerji (1963).

• CONFUCIUS (Brian Cohen) and Marvin could accumulate learned concepts, like the child machine.

• ILP can do this but why hasn't there been more work on this?

• No one foresaw the Internet.
The World Brain
The World Brain

"...a sort of mental clearing house for the mind, a depot where knowledge and ideas are received, sorted, summarized, digested, clarified and compared."
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H.G. Wells (1937)

World brain: the idea of a permanent world encyclopaedia
Where has AI gone?

• More focussed on the world brain than the child machine

• Masses of data enable solving problems in ways we couldn't anticipate
  • E.g. Crowd-sourcing

• Data centres have enormous computing power
Do we need deep AI?

• Can a lot of data make up for a lack of structure

• Can structure be found in masses of data using "shallow" AI methods.
Where does structure come from?

- Currently human-guided
- What creates abstractions needed for structure?
Before we can determine the mode in which the expected frequency of occurrence of a particular event is dependent upon the known frequency of occurrence of any other events, we must be acquainted with the mutual dependence of the events themselves.... Now this explicit determination belongs in all instances to the department of Logic. Probability, however, in its mathematical acceptation, admits of numerical measurement.

George Boole (1854)
An Investigation of the Laws of Thought
Cumulative Learning

- It is computationally intractable to create structure from scratch
- Active learning allows the agent to choose its own examples
Concept Lattice

![Image of a concept lattice with nodes labeled R, Q, S, E, P, and T. The nodes are connected in a hierarchical structure, with yellow lines indicating relationships between nodes.]
Concept Lattice
Concept Lattice
Problems in Incremental Learning
Problems in Incremental Learning

• Is there an error?
Problems in Incremental Learning

- Is there an error?
- Where is the error?
Problems in Incremental Learning

• Is there an error?

• Where is the error?

• Is it worth fixing?
Problems in Incremental Learning

- Is there an error?
- Where is the error?
- Is it worth fixing?
- How should it be fixed?
Is there an error?

• With incremental learning it’s hard to tell what is noise and what is an error

• postpone theory repair

• maintain multiple hypotheses
Where is the error?

• Use backtracing to look for error or ...

• wait for more evidence
Is it worth fixing?

- What is the cost of repair versus the cost of living with the error?
How to fix it?

• Generalise?
• Specialise?
• Invent a new concept (predicate invention)
Why haven’t we solved these problems?

• Several PhD theses on aspects of theory repair

• Needs a strong performance element and a rich environment
Robots

- Complex behaviours in dynamic environments
- Ideal learning problem
- but ...
Robotics is hard

- Have to integrate almost all aspects AI
- plus mechanical, electrical and computer engineering
Robot Evolution
Learning agent needs an architecture

• Learning element must be embedded in a complete architecture that includes perception and action
Trainer’s Demonstration
Trainer’s Demonstration
Learning at different levels of abstraction

- Symbolic representations for long-term planning assuming the world is mostly deterministic
- Probabilistic representation for short-term control assuming uncertainty
Robot has background knowledge for walking
Robots in the Cloud

• Robot learning can be shared across the internet
Robots in the Cloud

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Robots in the Cloud

• We could all become robot trainers in the future

• Everything we teach our robot is shared with other robots through the "cloud"

• So maybe because of the world brain, there may only ever be one distributed child machine
Questions?