Towards Empirical and Scientific Theories of Computation

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Aim of this talk is to defend Lakatos-Feyerabend-Kuhn Study of Method

In the spirit of Feyerabend, imagine this talk as taking place on a Brechtian stage.

- **In the background sweepers are continually appearing and sweeping** *antinomies, anomalies, disproofs and paradoxes* **off the stage.**
- **A character wearing empiricist medals keeps trying to get on stage but is immediately pushed off.**

This is my view of the current situation in the study of computational method, antinomies are being ignored.

Difficulty Discussing Method or Antinomies in Computational thinking

Difficulty with methodological talks about computation is that when one brings up antinomies, the reply is:

1. **Show us a construction in ZF set theory that disproves AI.**

2. **Or how can there be any antinomies in CS - look at the world full of computation around you.**

Following Finsler in Viewing Mathematical Foundations Empirically

Book: *Finsler Set Theory: Platonism and Circularity*, **Booth, D. and Ziegler R. (eds.), 1996.**

Finsler called himself a platonist but empiricist is a more modern description.

Finsler contrasted with Hilbert's theory of mathematical proofs (1923, p. 50):
- A Proof is an array which must be graphically representable in its entirety.
- A formula is [mechanically] provable it is an axiom or arises by substitution.

Finsler (1926, p. 55): ´[a] proof becomes free from objection as soon as it is transferred from the formal symbolism into pure thoughts .. abstracted from its formal expression.'

Finsler's Arguments were not accepted because there were too General?

Finsler (1944, p. 63: ´[in 1926] I showed that in formal systems of a general kind one can specify propositions which are not decidable by means of formal proofs within the systems, but which nevertheless can be decided by their conceptual content.'

– Finsler's result preceded, but Goedel's incompleteness results were accepted because they were specific to particular formal systems (Russell's originally).

– Finsler's truth outside of formal systems, meant existence outside objects generated from ZF axioms was possible.

– Finsler's work on fixing the antinomies in set theory (ZF) using circle free sets not discussed here.

Feyerabend's view of Bohr's anti-formalism versus Sommerfeld

The difference between Bohr and Sommerfeld is best described as the difference between a mathematical physicist who is content with formally satisfactory and factually adequate equations and a philosopher who looks beyond success and who realizes the need for a sense of perspective, even in the face of the most surprising confirmations. (p. 271)

Also quotes Bohr caution on quantum theory in 1923, 'always to remember the [limited] domain of application of the theory, especially at the present state of science'

From Feyerabend, P. 'Niels Bohr's World View' in *Realism, Rationalism and Scientific Method, Phil. Papers. vol. 1*, **247-297, 1981.**

Empirical View of Computational Thinking (now CS?) from Physicists

Fourier in 1812:

´The deep study of nature is the most fruitful source of mathematical discoveries.´

Felix Bloch from AHQP Kuhn interview (p. 34, par 6, 1929-1931 work):

´I had the impression that group theory is something tremendously import. Later on, I didn't think so much of it any more, but at the time I did.´

Physicists from 1938 Warsaw Conference Discussion

Topic Bohr atom versus mathematical formalization of QM.

A student of French attendee M. Detouches named Mlle. Fervier had devised a different logic of QM for which inner products and therefore quantum entanglement does not exist.

But also defense of current CS research programme:

Professor Kramers thought there was a difference between essentially mathematical and an essentially physical attitude. The mathematical attitude tried to scheme out, to simplify and to abstract in order to find out which were the logical elements in the processes of calculation.

Mathematical Foundations Existence as 'can be generated' to CS

– In late 19th and early 20th century worry was about accessibility of infinity so questions were limited to objects that could be generated from finitely many finitely describable axioms.

– Later 20th century focus become on independence questions from variations of the ZF axioms.

–Computer Science (CS) accepted this method uncritically as the Church Turing Thesis (CT).

–Only recursively enumerable objects (as sets) can be computable and from the CT thesis only Turning machine recognizable objects can be computed.

–Artificial Intelligence then uncritically assumed no human thinking outside CT can exist.

Dijkstra and Knuth Formalist View

Dijkstra: 'Only mathematical proofs of program correctness can show the absence of bugs.'

Knuth: 'Like mathematics, computer science will be somewhat different from the other sciences, in that it deals with artificial laws that can be proved, instead of natural laws that are never known with certainty.'

Dijkstra archive at U of Texas. and p. 171 of "Quantum Computation and Quantum Information", by M. Nielsen and I. Chang.

Three Antinomies in CS

1. **Problems with concrete Complexity theory method: Coopers unexplained more efficient directed graph predominator algorithm than Tarjan's proven optimal algorithm.**

2. **Finlser meaningfulness antinomy to NP completeness. Span dependent jump instructions proven to be NP complete but not true for meaningfull programs.**

3. **Another NP completeness possible antinomy - existence of algorithms whose efficiency is not improved parallelization in spite of large investment. Non deterministic TM programs are the ultimate parallelization.**

Finsler's anti-formalist view of computability in re Russell's Paradoxes?

Finsler (1923, p. 40 [problem is the smallest number that cannot be defined with fewer than 100 English language syllables:

1. **Finitely many numbers each one definable with fewer than 100 syllables.**
2. **Finitely many symbols so finitely many combinations of 100 syllables or less.**
3. **Of these combinations only a small portion represent meaningful numbers.**
4. **There are other numbers that can be formally listed, among which is a smallest, so it exists.**
5. **But, if it exists, use the phrase 'The smallest number that be defined with 100 syllables in the English language'.**

Some Future Successor to Turing Machines should be able to deal with This

Another Antinomy - Computers have made the potentially infinite accessible.

Consider the uncountable list (table) of propositions. There is one proposition for each real number

      real a is rational
      real b is rational
      real c is rational
      <etc.>

It can't be described finitely but makes perfect sense. Table has meaning and content for human thinking. The calculation will not complete in finite time, but the algorithm is well defined.

A number of Disingenuous external events explain lack of research programme competition
(Mostly Documented in Lakatos Archive at LSE)

1. **Early 1960s - letter from Polya to Imre Lakatos - Stanford University (SU) Philosophy as Suppes style set theory uninteresting - 'nothing going on over there.'**
2. **1965 International Colloquium takes place in London - quasi empirical mathematical foundations believed - Lakatos moves to to phil. of science.**
3. **1969-1971 - First Ayn Rand and then Hubert Dreyfus attempt to have Paul Feyerabend fired from UC Berkeley - first step in the end of the study of method.**
4. **Some unfortunate early deaths - 1972 George Forsythe founder and chairman of SU CS died. 1974 Lakatos died in his early 50s.**

Disingenuous continued ...

1. Firing students and young professors who would not work at the SU AI Lab. In 1960s me for preferring SLAC, Diane MacIntyre preferred an education lab. Niklaus Wirth tenure denial. 1978-1979 Jeff Barth lasted as an SU assistant CS professor 1 year before being forced to work at AI Lab or resign.
2. 1972 Mathematical Foundations establishment rejected a paper by Kurt Goedel.
3. 1970s EE take over of CS and replacement of written Ph.d. qualifying exams with job interview oral 15 minute scored conversations.
4. Early 1980s, Knuth's students held a seminar with a very old George Polya claiming to take over his mantel as the future of heuristic mathematics.
5. Modern form - 2010 attack on Thomas Uebel for defending Left Vienna Circle empiricism by S. Richardson from SU Philosophy (issue more complicated).

Conclusion - possible advantages of empirical CS

1. **Important to have computational knowledge on a firm intellectual and empirical footing with elimination of theories accepted from consensus and science where methodological testing and research programme competition can occur.**

2. **Because physical thinking is so closely tied to computational thinking, may lead to new theories and research programmes in physics.**