COMPSCI 289 – Theoretical Computer Science (TCS)

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TCS

TCS lies at the intersection of computing science and mathematics and focuses on foundations of computing.

According to ACM SIGACT

> *TCS covers a wide variety of topics including* **algorithms**, *data structures,* **computational complexity, parallel and distributed computation, probabilistic computation, quantum computation, automata theory, information theory, cryptography**, *program semantics and verification,* **machine learning, computational biology**, *computational economics, computational geometry, and computational number theory and algebra.*

Early TCS

1. 820 CE: Al-Khwārizmī solved linear and quadratic equations; *Algoritmi*, his name in Latin , led to the term "algorithm".
2. 1931: K. Gödel's incompleteness theorem.
3. 1930s: K. Gödel, A. Church, R. Péter, A. Turing, S. Kleene and E. Post developed recursion (computability) theory.
4. 1936: A. Church and A. Turing proved that some problems have not algorithmic solution.
5. 1950s: automata theory, "self-acting" abstract machines.
6. 1960s: computational complexity: the amount of resources (time, space) required for running algorithms.
7. 1960s: algorithmic information theory (R. Solomonoff, A. N. Kolmogorov, G. Chaitin): the length of a shortest computer program that produces an output.

TCS at UoA: **Please replicate**

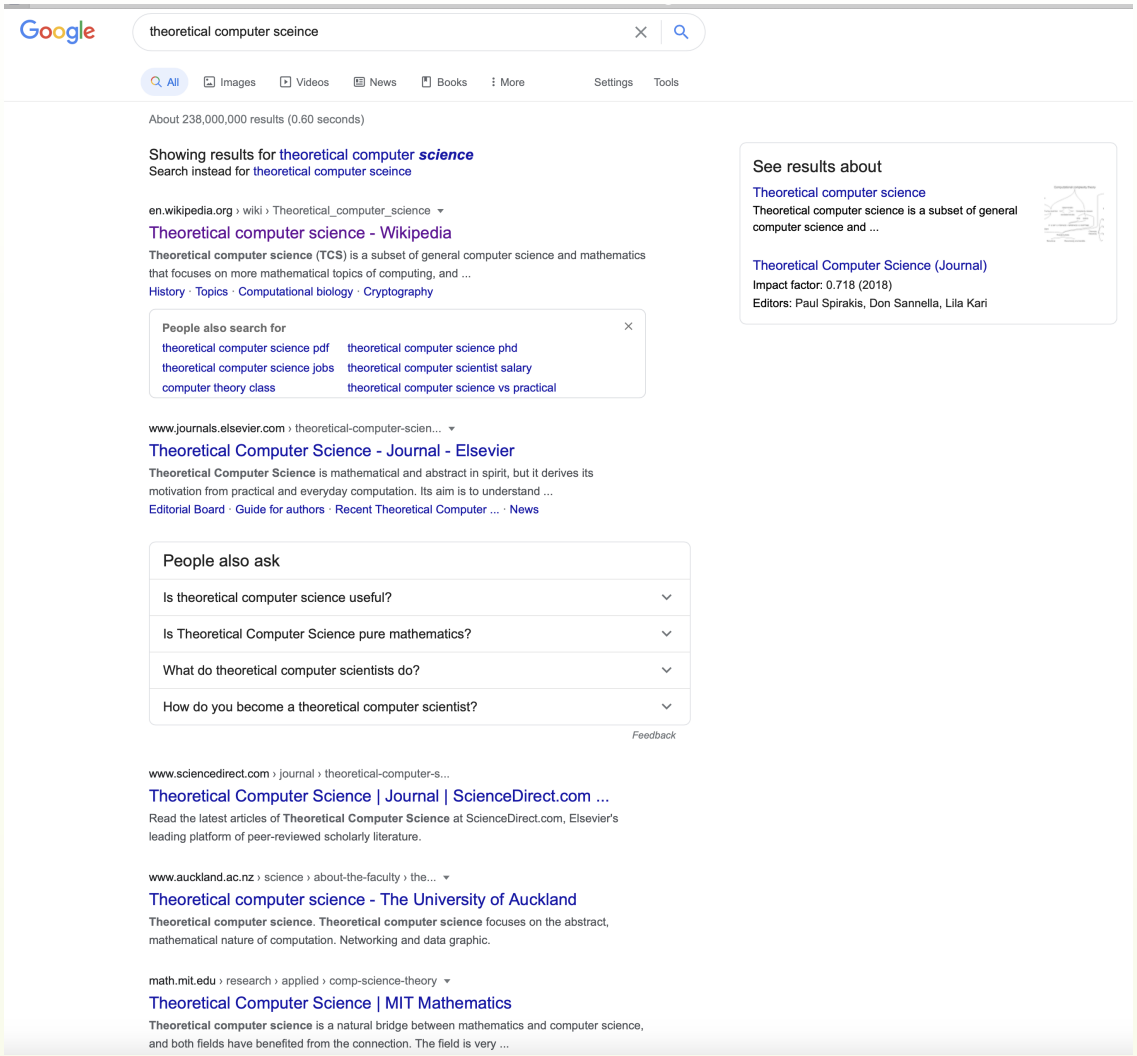

Figure: Google: 29-09-2020

UoA theory group

Centre for Discrete Mathematics and Theoretical Computer Science

Universal Turing machine

In 1936 A. Turing constructed a Turing machine which can simulate any other Turing machine.

Halting Problem

Decide, from a description of an arbitrary computer program and an input, whether the program will finish running, or continue to run forever.

In 1950 M. Davis named the problem and proved that it is undecidable: no algorithm can solve it.

More examples: Timeline of computer science, Beautiful results in TCS.

Quantum computing was introduced by Paul Benioff, Yuri Manin in 1980 and Richard Feynman in 1982.

A quantum computer is a computational device that works with qubits instead of bits and makes direct use of quantum-mechanical phenomena, such as superposition and entanglement, to perform operations on data.

There are two main models of quantum computers: the quantum gate and the quantum annealing. Quantum computers implementing the first model have up to 50 qubits, but those implementing the second model have 5,000 qubits.

It is believed that quantum computers can solve some problems faster than classical counterparts. See more in The Road to Quantum Computational Supremacy.

TCS Prizes and Awards

1. ACM A.M. Turing Award is a prize for contributions "of lasting and major technical importance to the computer field" . See also Calude video interview with Turing laureate J. Sifakis, 2020.
2. Clay Mathematics Institute Millennium Prize Problems includes an open problem in TCS (reward: US$ 1 million).