Paper: *Quantum theory, the Church-Turing principle and the universal quantum computer*

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Quote *The fact that classical physics and the classical universal Turing machine do not obey the Church-Turing principle in the strong physical form is one motivation for seeking a truly quantum model [Deutsch (1985)].*

Overview The author of the paper "Quantum theory, the Church-Turing principle and the universal quantum computer (1984)" is David Deutsch. In the paper, the author expands on the Church-Turning physical principle: "every finitely realizable physical system can be perfectly simulated by a universal model computing machine operating by finite mean" [Deutsch (1985)]. Classical physics and universal Turing machines sway away from the principle, but quantum theory and universal quantum computers follow the principle [Deutsch (1985)]. Classical machines produce output on provided input through various functions but in a Quantum machine, the output is generally not observable [Deutsch (1985)]. But the quantum system can be simulated with all desired inputs, and the generated output and its possible measured value can be labeled [Deutsch (1985)]. Deutsch further defines a quantum model of computation with a finite processor and infinite memory that has the capability of simulating all finite and realizable physical systems [Deutsch (1985)]. The author concludes the paper by exploring further connections between computers and physics.

Intellectual Merit The paper focuses on the possibilities of the generation of the universal quantum computation model that can simulate any quantum system. Deutsch's motivation to generate a universal quantum model has been the backbone for expanding quantum computing research and the creation of quantum computers. His research further expanded on quantum entanglement and Bell's theorem. In the paper, the author defines the specification and environment for the introduced quantum model. The paper is well-written and explores previous works by other scientists. Furthermore, his paper on the quantum model has laid the foundation for the present field of quantum computing and has generated interest for further research in the field of quantum computing.

Broader Impact Deutsch's quantum model has had a great impact on quantum research and the creation of quantum computers. His ideas are well employed and celebrated in the world of quantum computing. Quantum computing has its potential in fields like quantum simulation, machine learning, computational biology, generative chemistry, artificial intelligence, cybersecurity, etc. His ideas present the expansion of computer science in the fields of Quantum complexity theory, Church-Turing principle, and Programming physics. Deutsch's work on quantum computers has revolutionized the way we perceive the world around us. His work on parallel quantum computation will further propel quantum computing and introduce a new era for computers and human beings.

Keywords Classical Physics, Universal Turing Machine, Universal Quantum model, Church-Turing Principle, Quantum computers

Open Questions

- With the parallel processing capabilities of quantum computers, how fast will the future computers get? What would be the possible limitation for the speed of the processing power of these computers?
- Another challenge in the field of quantum computing seems to be the generation of quantum algorithms. Is it possible to generate quantum algorithms for every possible quantum system?

References

D. Deutsch. Quantum theory, the church–turing principle and the universal quantum computer. *Proceedings of the Royal Society of London. A. Mathematical and Physical Sciences*, 400(1818):97–117, 1985. doi: 10.1098/rspa.1985.0070.