Paper: *Simulating Physics with Computers*

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Quote *The rule of simulation that I would like to have is that the number of computer elements required to simulate a large physical system is only to be proportional to the space-time volume of the physical system.* pp.469. [Feynman (1982)]

Overview The paper "Simulating Physics with Computer" was written by American physicist Richard Feynman in 1982. In the paper, Feynman dives into the concepts of quantum physics and proposes the concept of simulating quantum systems using computers. Feynman expands that such simulation is possible given a finite volume of space and time with all components exactly replicated with logical operations [Feynman (1982)]. Though the concept seems theoretically sound, it may not be possible to build a system that will imitate nature as is [Feynman (1982)]. The paper further introduces a probabilistic approach for simulating nature. The success of the approach lies in the ability to be able to determine the state of a particle at a time t, given the environment [Feynman (1982)]. The designed probabilistic computer will function with the same probabilistic approach as nature. The probability of the event happening in nature is calculated by performing the same experiment repeatedly a large number of times [Feynman (1982)]. The paper further expands on a conceptual idea of a quantum system that operates in space-time, such that each point in space-time is either occupied or unoccupied [Feynman (1982)].

Intellectual Merit Feynman introduces the concept of simulating quantum systems using quantum computers. By expanding on the probabilistic approach, the author introduces a mathematical approach for simulating such quantum systems. This conceptual and mathematical connection between quantum physics and computing has opened pathways for a new era of computers. The concept has itself revolutionized the way we perceive the physical laws of nature around us. The paper is well-reasoned and rationale. Feynman's analysis of his concepts on success or failure proves his critical approach to his concepts. Feynman is one of the greatest minds and his ideas are widely supported. Though Feynman's ideas seem revolutionary, it might be a bit far-fetched to simulate time and nature itself using currently available technologies.

Broader Impact Feynman's paper introduces the principle of extending quantum physics and the possibilities of simulating it with a computer. The principle is currently being employed in the fields of quantum computing. On a deeper view, the advancement in quantum computing may induce a new era of computing. Recent advancements in quantum computing have propelled computing to new heights. Some even predict a new pinnacle in human advancement through quantum computing, and recent outcomes suggest such a pinnacle may not be a far dream. The advent of quantum computing has shown great potential in fields like quantum simulation, machine learning, computational biology, artificial intelligence, cybersecurity, etc. [Mallow et al. (2022)].

Keywords Physics, Computers, Quantum system, Probabilistic simulation, Quantum computers

Open Questions

- Though Feynman proposed concepts have been adapted to computing, much of his ideas still seem far-fetched. With modern computing propelling towards quantum computing, is it possible to simulate a truly isolated quantum system using quantum computers?
- If such natural simulation is possible what wonders will the future offer to humanity? What might be the limitation of these quantum computers?

References

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