Chapter 3
A Review on Recent Trends in Quantum Computation Technology

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ABSTRACT

Quantum technologies' processing capacity is built on quantum mechanics foundations, including superposition, the no-cloning theorem, and quantum entanglement. Quantum computing seeks to understand and embrace quantum effects, as well as techniques to improve and sustain them in order to achieve old computational goals in novel ways. It accomplishes this by utilising quintessentially quantum phenomena. We can't get equivalent findings using traditional computation because these processes don't have a classical analogue. There have been significant claims that quantum computers can surpass the Turing limit, however these assertions have been debunked. The Church-Turing thesis, which states that all realisable physical and dynamical systems cannot be more powerful than classical models of computation, has been the subject of numerous intensive attempts. However, quantum computing technologies' experimental insights have already been proved, and various studies are currently underway. In this article, the authors look at the most current quantum computation results and claims.

DOI: 10.4018/978-1-6684-6697-1.ch003

INTRODUCTION

Quantum computing technologies have received huge attention in academia during recent times. A high number of global technological establishments are investing in research about Quantum computing, in hopes that it would lead to the birth of the next-generation thinking machines. For instance, Intel and QuTech, a Dutch research centre affiliated with Delft University of Technology, plan to invest about $50 million in quantum computing research over the next ten years, while IBM develops on more than three decades of research in this area and currently provides a cloud platform to allow researchers and students to get hands-on experience with quantum technology. It is unsurprising that quantum computing has become the next ‘space race’, pursued with national pride and massive investments. For example, the European Commission has launched a €1 billion flagship initiative on quantum computing with substantial funding for the next 20 years. India has announced an investment of Rs 8000 Crore (about $1 billion) last year, which extends over a period of five years, and will be utilized by the Department of Science and Technology(Gyongyosi & Imre, 2019; Nielsen & Chuang, 2000). Last year, the White House Office of Science and Technology Policy, the National Science Foundation, and the Department of Energy announced a $1 billion initiative to construct twelve artificial intelligence and quantum information science research centres across the country. While quantum computing as an idea was proposed in 1980, it is high time that the technology is developed to build real quantum computers that serve practical applications by solving problems that traditional computing have proven impossible.

That being said, there has always been an ongoing debate among academicians around the globe on whether the recent quantum computing technologies has crossed the Church-Turing limit, which suggests that all physically and dynamically realisable systems cannot be more powerful than classical computation models.. Technically, all quantum computing technologies are still limited by Turing machine constraints, but claims have been made by different institutions recently, that this has been proved wrong. Here, we examine some of their claims and responses from different academic viewpoints.

A BRIEF HISTORY OF QUANTUM COMPUTING

In 1980, scientist Paul Benioff suggested a quantum mechanical model of the Turing machine, which sparked interest in quantum computing. Feynman and Yuri Manin hypothesised that a quantum computer might be able to simulate processes that a conventional computer couldn’t. In 1994, Peter Shor, in an attempt to decrypt RSA-encrypted communications, developed a quantum algorithm for factoring integers. Despite the experimental progress since 1990s, most researchers still believe that “fault-tolerant quantum computing is still a rather distant dream.” The investment in quantum computing research has increased in recent years, in both private and public sectors. On 23 October 2019, Google AI, in partnership with NASA, claimed to have performed a quantum computation calculation that was infeasible on any of the prsent classical computers, but whether this claim was valid is still a topic of active research.

To adequately assess the arguments offered, we must explore some ideas of quantum computation in order to have a basic understanding of how modern quantum computers work. A classical computer uses bits to represent the values it is working with, but a quantum computer utilises qubits, or quantum bits, to represent the values it is working with. To understand better, a bit is generally represented as 0 or 1, which should be interpreted as values 0 or 1.In contrast, a qubit can represent the values 0 or 1, or both 0 and 1 at the same time (refer quantum superposition). The binary values of a collection of