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RESEARCH ARTICLE

QUANTUM COMPUTING: BEGINNING OF A NEW ERA

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Abstract

Quantum computing focuses on developing computer technology based on concepts of Quantum Theory. QuantumTheory is based on Quantum mechanics which explains the theory of energy and matter based on atomic and subatomic levels. As all of us know classical computers can only encode data in the form of 1's and O's. Encoding of bits with only two possible values limits the capabilities of classical computers. For this limitation, Quantum computers came as a rescue. Quantum computers makes use of quantum bits, also known as qubits to hold more information. This newer version of computation has advantage of being in same state at a time due to its subatomic particles one-of-a-kind ability to exist in several states. In this paper, we provide introduction to quantum computers with several recent developments in this emerging field of new era.

Introduction:

Today's classical computers, whether for personal, commercial, industrial, or other purposes, rely on binary logic, which represents everything as binary strings of 1s and 0s. This binary logic is implemented using transistor gates, regardless of how huge or complex a computer is. Only two states are possible, no other condition is recognised; each gate is either OPEN for a 1 or CLOSED for a 0 [1]. Due to the advancement in integration technology, the transistors have shrunk in size allowing for higher efficiency, higher processing density, more powerful and faster machines. This technology has resulted in transistors that are only a few atoms across. Researchers believe if the transistors are shrunk any further, electrons will begin to bypass the gates, whether they are on or off, and the transistors are likely to stop working [2]. This means that from the amount of processing power available from this technology will reach a limit, and that a new approach will be required to make future advancement. One alternative being investigated is to use light photons within the integrated circuits rather than electricity to transport information. Quantum computing is another option, that will revolutionize the whole world [3].

Quantum bit known as qubit is the smallest unit of data in quantum computing, which is based on something like the spin of a magnetic field. This, Qubit like a bit, can be set to one of two states: 0 or 1, but unlike a bit, it is not as straightforward as simply being on or off. Quantum superposition, which is a fundamental principle of quantum mechanics states that a qubit can be in any proportion of both states due to quantum level peculiarities. This is

sometimes stated as being both 0 and 1 at the same time, however this isn't exactly correct. It may be somewhere between fully 0 and completely 1 - but the catch is that once we measure a qubit, it collapses into one of the two definite states. Superposition indicates that the quantity of data that can be stored grows exponentially as the number of qubits increases, while being difficult or impossible to completely comprehend [4]. More than a million values can be stored in a group of 20 qubits at the same time. Quantum computing, on the other hand, entails additional ideas, particularly quantum entanglement. This means that, unlike regular computers, quantum computers may process data in parallel, rather than sequentially. Superposition indicates that the quantity of data that can be stored grows exponentially as the number of qubits increases, while being difficult or impossible to completely comprehend. More than a million values can be stored in a group of 20 qubits at the same time. Quantum computing, on the other hand, entails additional ideas, particularly quantum entanglement [5]. This means that, unlike regular computers, quantum computers may process data in parallel, rather than sequentially. For the time being, traditional technology is capable of handling any task that a quantum computer is presented with. Quantum supremacy refers to a quantum computer's ability to outperform its classical equivalents. Some Big Companies, including as IBM and Google, believe we're getting close, as they continue to squeeze more qubits into machines and improve their accuracy. Quantum computers are not universally regarded as worthwhile investments. Some mathematicians feel there are barriers to overcome that are literally insurmountable, rendering the big research area for quantum computing.

Quantum Applications:

Google is the first Company proclaiming the achievement to develop quantum software that can recognise cars based on landmarks, and Lockheed Martin plans to use its D-Wave quantum computer to test autopilot software that is now too complex for traditional computers [6]. Quantum computing has the potential to disrupt web security and encryption. These are built on large, encrypted key numbers that can't be read by traditional computers since it would take too long to try every possible combination. The simultaneous processing capabilities of quantum may, however, render this security obsolete, prompting the development of new "quantum-resistant" encryption systems. Other uses other than quantum simulation and encryption are emerging as more people become aware of quantum computing's potential.

Artificial Intelligence (AI):

Artificial intelligence is a word that refers to the combinatoric processing of huge volumes of data to make better predictions and choices. Quantum computing could open up new possibilities in artificial intelligence (think facial recognition or fraud detection). Quantum machine learning is a new field of study that looks into how quantum algorithms might improve AI [7]. Quantum artificial general intelligence is still a long way off due to technology and software limitations, but it does make thinking machines more than a science fiction concept.

Financial Services:

Finance was one of the first businesses to embrace Big Data. A lot of the science behind the pricing of intricate assets like stock options uses combinatoric calculations. Goldman Sachs, for example, utilises a computationally intensive calculation called a Monte Carlo simulation to value derivatives, which generates estimates based on simulated market movements [8]. Computing speed has long been a source of competitive advantage in the financial markets (where hedge funds vie to get millisecond advantages in obtaining price information). Quantum algorithms have the ability to speed up a number of crucial financial processes.

Complex Manufacturing:

Quantum computers can be used to turn massive industrial data sets on operational failures into combinatorial challenges, which, when combined with a quantum-inspired algorithm, can reveal which part of a complex manufacturing process contributed to product failures. Quantum can help avoid costly failures in goods like microchips, which have thousands of steps in the production process.

In recent years, billions of dollars have been invested in quantum computing because of its potential to tackle large-scale combinatorics problems faster and cheaper. The biggest opportunity may be in discovering additional new applications that benefit from quantum's answers. There is "a role for imagination, intuition, and adventure," according to professor and entrepreneur Alan Aspuru-Guzik. Maybe it's not about the number of qubits we have; maybe it's about the number of hackers [9]." Google stated that a 54-qubit quantum processor could finish a random sampling computation in 3 minutes and 20 seconds, while IBM's Summit, the world's most powerful supercomputer, would have taken 10,000 years to do the same operation [10].

The Future of AI:

Quantum computing opens the possibility of solving extremely vast and complicated computational problems that are currently difficult to handle on conventional computers. Using brute-force methods to guess the passcode used to encrypt a piece of data using a 256-bit algorithm is an example of this [11]. AES-256 data is deemed secure since it cannot be broken via a brute-force assault (it could be done, but it would take many thousands of years with present technology, making it practically impossible). Solving such difficulties will now be possible thanks to quantum computers' ability to compute with numerous potential states. Another example is the difficulty of the travelling salesman. Finding the most efficient path between a set of geographic places is an enormously computationally difficult challenge. UPS, which spends billions on fuel for its delivery trucks, has gone so far as to limit the amount of left turns its drivers make in order to maximise delivery time and reduce fuel use, putting a unique spin on the old travelling salesman problem. This brings us to AI and machine learning. Deep learning, the most recent version of machine learning, is pushing the boundaries of what standard computers can manage. On traditional computers, large transformer models like OpenAI's GPT-3, which has 175 billion parameters, require months to train [12]. Future models will take much longer to train as the number of parameters increases into the billions. One of the reasons why users are adopting unique microprocessor architectures that outperform classic CPUs and even GPUs is because of this. But, at the end of the day, CPUs and GPUs are bound by the limits of traditional binary computers. Quantum computers promise a quantum leap in performance and capability for a variety of applications. Google is one of the first quantum computer manufacturers to enter the market. Google announced TensorFlow Quantum in March 2020, which extends the TensorFlow machine learning development library to quantum computers. Developers will be able to create quantum neural network models that run on quantum computers using TensorFlow Quantum. While executing AI applications on quantum computers is still in its infancy, numerous groups are attempting to make it a reality. For a long time, NASA has collaborated with Google, and work is also being done in the national labs.

Conclusion:

In this paper, we explained in a lucid manner how Quantum computing has grabbed the imagination of computer scientists as one possible future of the discipline after we've reached the limits of digital binary computers. The capability of Quantum computers to hold many different possible outcomes in the "quantum state," could potentially deliver a big computational upgrade for machine learning and AI problems. But Universally Some argue that the challenges of removing quantum mistakes will be too enormous to overcome. But Only time will tell if they, other countless startups and other big companies capitalizing in quantum computing technology, are correct or not ?

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