JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

QUANTUM MACHINE LEARNING

[1]NANDINI M,[2]DR. SUDHA M S,[3]SHAIK SHABBEER,[4]TODAWALE THOFIQ
[134]STUDENT,[2]ASSOCIATE PROFESSOR
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING,
CAMBRIDGE INSTITUTE OF TECHNOLOGY, KR PURAM, BENGALURU-36, INDIA

Abstract: Quantum computers are a revolution in technology that makes use of "Principles of Quantum Mechanics" to perform computations at high speed over classical computers. The fundamentals are of physics, mathematics, computer science and information theory. This research paper range over the primitive concepts of quantum computers, their working that is the quantum properties it follows like superposition, entanglement and interference, architecture, hardware, software, design, types and algorithms, some idea of quantum computations, advancements, and potential applications. Later, concluded all the importance, advantages and disadvantages of quantum computers. Quantum Information Processing and Quantum Computers have been receiving a lot of attention over few years.

Index Terms **- Qubits, Superposition state, Entanglement, Interference, Quantum Mechanics, Shor's Algorithm, Quantum Supremacy.**

I. INTRODUCTION

Now a days there is an exceptional growth for VLSI domain. This technology is basically to increase the integration of over 10,000 transistors on a single chip, allowing for more sophisticated logic functions and improved efficiency. But how small can we make a transistor?? Ultimately transistor is an atom, one atom that could control the flow of electricity.
The computers that compute on atoms rather than transistors. Transistors are based on one or zero (on or off state). In reality everything is a matter made up of structural, functional and fundamental basic unit called atoms. The atoms are made up of sub-atomic particles electrons, protons, neutrons. These particles are waves in nature. To discuss about the waves that make a molecule we need set of new mathematics and there comes in quantum computers.
'Quantum Computers' in 1980 Paul Benioff demonstrates the theoretical viability of quantum computing by describing the first computer model based on quantum mechanics. The first quantum computer was created by ISACC CHUANG in 1998. It was 2-qubit computer loaded with data and output connections. Quantum computers are based on electrons and their quantum mechanics. The electrons have so much of vast computational power because they could be in two places at same time that's what gives quantum computer their power. They compute not just in one universe but in multiverse, the parallel universes. In a regular computer we have ones and zeros which you store in binary form and you compute them, operations are done on these binary codes. Let's consider an elementary particle that's spinning. If it's spinning is pointing up or down that's Ones or zeros. But in the quantum world, it turns out that particles like electrons are actually spinning in all directions at the same time. If we don't really measure it, the electron may be performing many calculations at once if it is spinning in multiple directions simultaneously. The foundation of a quantum computer is the manipulation of particle states. similar to electrons, such that several computations are carried out concurrently during the computation and a measurement is only made at the conclusion of the computation. We take use of the fact that particles may do several tasks concurrently due to the properties of quantum physics; this allows us to create parallel universes. A system that may be viewed in one of n potential states is called a n dimensional quantum system. Examples of such systems are a particle can be in one of n positions; a system might have one of n energy levels; a photon might have one of n polarization directions. This makes a quantum computer so powerful.

II. LITERATURE SURVEY:

Noson, Yanofsky, and others [1] A simple introduction to some of the concepts in quantum computing is provided in this research study. Using basic toy models, the article first explains the fundamental concepts of quantum computing and quantum physics.

Devitt S. J., Paler A, et al. [2] We present an overview of the fundamental concepts and theories pertaining to quantum computation in this study. Large-scale quantum computation and communications are theoretically grounded in these ideas, which are also the impetus for a number of recent experiments aimed at building small- to medium-sized arrays of programmable quantum bits. Quantum information may be directly linked to these ideas.

Ying M, Yuan Feng et.al [3] In this paper quantum circuits are mainly drawn as circuit graphs, and a formal language for quantum circuits that has a function similar to that of Boolean expressions for classical circuits is still missing. We demonstrate some basic algebraic principles for quantum circuits represented in this language.

Wang Can, Chen, Ming-cheng, Lu Chao-Yang et.al [4] We demonstrate some basic algebraic principles for quantum circuits represented in this language. Rigid thinking regarding distributed quantum computing and quantum communication protocols is based on these rules.

Gotarane Vishal & Gandhi Sushant et.al [5It makes sense to execute the majority of processing on the conventional computer because it performs worse than the quantum computer in a few specific areas. In general we'll modify a classical computer to design a quantum computer which will have some kind of quantum circuit attached to it and some kind of interface between conventional and quantum logic.

Mikhail Dyaknov et.al [6] The quantum computers are capable of providing breakthroughs in many disciplines, even in drug discoveries, optimization of complex systems and artificial intelligence. It will even change the cultural, intellectual, industrial, and economic environments.

There is a huge difference between the incredibly advanced theory of quantum computing, which depends on manipulating hundreds to millions of qubits in order to compute for a better future, and the simple but challenging experiments that have been conducted with relatively few qubits.

III.QUBITS

Qubit or Quantum bit is a basic computational unit of quantum information. Quantum computers perform operations on qubits. One qubit represents all the possibilities of an electron spinning in all the direction at same time. Qubits can take a state of zero, one, or both. The state in which a qubit can get a combination of the both ground state (zero) and excited state (one) is known as SUPERPOSITION STATE. The probability of getting zero or one in this state depends upon the qubit.

In a classical computer the bits are independent from each other. The state of one bit is not influenced by the state of any of the other bits. However, qubits in quantum computers have the ability to entangle with one another, combining to form a single, massive quantum state. We call this ENTANGLEMENT. Take two qubits in distinct superposition states as an example, but aren't entangled yet. The probabilities are currently independent to each other. 1st qubit with probability of zero 30% and probability of one 70%, 2nd qubit with probability of zero 75% and probability of one 25% but when we entangle them, we have to throw away those independent probabilities and calculate a probability distribution of all the possible states. We can get tired either 00, 01, 10, 11 here is because the cubits are entangled, if you change the probability in any of one cubit, it changes the probability distribution for the whole system. This is true no matter how many qubits are present with any probability of zero and one. Qubit, technically called a block sphere. Qubit doesn't actually look like a sphere. This is way of visualizing the state of a cubit. In reality the state of a qubit is describe more over like abstract entity known as a QUANTUM WAVE FUNCTION.

Wave functions are the fundamental mathematical description of everything in quantum mechanics. When you've got many qubits in Tangled together, all of their wave functions are added together creates INTERFERENCE wave function describing the state of the quantum computer. When we add these quantum waves together these can constructively interfere (coherence) and combine to create a larger wave, or destructively clash to neutralize one another (decoherence). The quantum computer's total wave function determines the various probabilities of its states. Hence, by varying the states of individual qubits, we may alter the likelihood that distinct states will emerge during quantum computer measurements.

IV.DECOHERENCE

Since Everything is made of particles, such as electrons, which are waves in nature, coherence is determined by mechanical nature when these waves vibrate in harmony. Everything vibrates at a different frequency when anything is out of coherence or in decoherence, creating "noise." Disturbances from the outer world taint it. The computer is worthless for achieving a quantum mechanical state after you lose coherence. Use and capitalize on such peculiar quantum features in a unique way. It seems sense that the system has to be cut off from its surroundings. It interacts with the environment, so the craziness of quantum mechanics kind of goes away. In order to overcome this, the temperature must be lowered to a point where everything vibrates almost simultaneously and slowly once more. It doesn't interfere with the quantum computation, and in fact, it operates at a temperature of 10 millikelvin, or 0° Kelvin, which is equivalent to -273.14°C, the lowest temperature that can exist in physics. Considering that we are essentially operating in a magnetic vacuum. Therefore, take into consideration that these settings, these rigs, and these systems that we created are likely the most rarefied settings in the universe. You wish to create this macroscopic entity and maintain its quantum mechanical behavior with a quantum computer, which implies. separating it with extreme caution from the outer world, all contacts, and its own inner workings. Upon measuring the computer, we extract just one state, even if it has the potential to be a super visiting of millions of states simultaneously. Constructive interference is used to improve the possibility of crackdowns while utilizing a quantum computer to solve computing problems, and destructive interference is used to reduce the likelihood of providing the wrong response.

V.QUANTUM COMPUTING

Some commonly used techniques in quantum computations include phase kick-back, phase estimation, the quantum transform, quantum walks, topological quantum field theory. There are three classes of quantum algorithms which provide an advantage over known classical algorithms: o First, there is the class of algorithms based upon quantum versions of the Fourier transform, a tool which is also widely used in classical algorithms. The Deutsch – Josza is an illustration of this kind of method, as is the discrete logarithm and Shor's factoring algorithm. A key component of many quantum algorithms is quantum parallelism. Quantum computers can assess a function f(x) for a wide range of values of x concurrently thanks to heuristic quantum parallelism. Quantum computing uses a variety of methods, including the Quantum Fourier The Quantum Phase Estimation Algorithm, Variational Quantum Eigen-Slover Algorithm, Quantum Fourier Sampling, Quantum Factoring and Finding Hidden Structures, Gover's Algorithm, Quantum Random Walks, Hamiltonian Simulation Algorithms, Computing Knot variants, Shor's Algorithm, Deutsch-Jozsa Algorithm, and many more based on various techniques.

VI.SHOR'S ALGORITHM

Popular algorithm with a wide range of quantum computing applications. Shor's algorithm is a quantum method for determining a big integer's prime factors. It is not shown that factoring big numbers in polynomial time is not possible with a classical computer. The reason it is so difficult to find them is the vastness of the search field for potential causes. Moreover, there isn't a practical classical procedure for determining the factors of big integers. We employ this mathematical feature for safe websites, emails, bank accounts, and Internet encryption because of this. You may simply decode and examine the information if you are aware of these elements. If not, however, you will have to work from our first, which even on the most powerful computers in the world cannot solve. Because of this, Peter Shaw officially released a fast quantum method in 1994 that could discover the factors of huge numbers.

VII.QUANTUM SIMULATION

Quantum simulation is simulating things like chemical reactions or how electrons behave at different materials with a computer air contact. Computers also have an exponential speed of over classical computers because classical computers really struggle to simulate quantum systems. Simulating quantum systems with his few as 30 particles is difficult even on the world most powerful supercomputers. We also can't do this account computers yet, but as they mature a main goal is to be able to simulate larger and larger quantum systems. To produce fertilizer in a way that emits way less carbon dioxide, as fertilizer production contributes to about 2% of global carbon emissions.
Other potential applications of quantum simulation include improving solar panels. Improving Patrick's developing new drugs or chemicals or materials for aerospace in general. Using quantum simulation would eliminate the need for the far more time-consuming and costly process of physically creating and testing a wide variety of materials in a lab. Instead, a large number of materials could be quickly prototyped within a quantum computer and all of their physical properties tested. This could be done much more quickly and with significant time and cost savings. However, it is important to emphasize that each of these are possible uses for quantum computers. because we don't have any count computers that can solve real world problems better than our normal computers yet. But these are the kinds of problems that called computers would be well suited too other applications outside of quantum simulation. For optimization problems, machine learning in AI, financial modelling, weather forecasting.

VIII.MODELS OF QUANTUM COMPUTING

Build your cubits from like a superconducting loop or individual atoms or photons will start with the models of quantum computing. The computers we used today work in the same way. They have a bunch of bits holding the binary information of ones and zeros, and we can do operations on those bits using logical gates (OR, AND, NOT, NOR, NAND, XOR, XNOR) you can build a full general use computer from just bits and gates. In quantum computing this is similar model to this called the circuit model or gate model, which is the most popular approach in the most understood model in cloud computing. In the circuit model you have your collection of qubits which are entangled with each other and then you have a bunch of gates which can perform operations on small numbers of these cubits which change the state of the qubits. Without measuring them, the quantum algorithm is built from a sequence of gates applied to the qubits in a certain order and then a measurement at the end which is where you get your state. There is hopefully the answer to the problem you are trying to solve. Simplistic why you can think of these gates is operations on the cube is that rotate the arrows to point in different directions (block sphere). These operations change the probability of the final state of each qubit when it's finally measured.

IX.QUANTUM SUPREMACY

Quantum supremacy is the point at which a quantum computer exceeds the power of a digital computer and that was reached by two groups, one in China and the other one Google. Quantum supremacy has been attained for certain discrete calculations now. In all-purpose, quantum computer and you can program does not yet exist. There's a race now between the Chinese, Google, IBM. There's a race between all the major players of Silicon Valley. The Chinese do it not with the electricity, not with electrons, but with light beams. Light beams are polarized light beams. Well, that can be used to make a transistor, an optical transistor. And with an optical transistor you can make a quantum computer.

X.FUTURE SCOPE

The future scope of quantum computers is vast and holds tremendous potential for various fields. Quantum Cryptography is one of it. Quantum computers have the potential to break many of the encryption algorithms used today, leading to the need for quantum-resistant cryptography. Research in this area aims to develop novel cryptography methods resistant to quantum computer assaults. There are still significant technical challenges to overcome, such as improving qubit stability, reducing errors, and scaling up the number of qubits. However, with continued research and development, it is expected that quantum computers will play a transformative role in various scientific, technological, and industrial domains in the future. . In recent years 2019 that GOOGLE confirmed that it had achieved quantum supremacy using its fully programmable 54-qubit processor called Sycamore. The first universal quantum computer with more than 1000 qubits is set to debut in 2023. We are in the initial stages of next revolution.

XI.CONCLUSION

The paper concludes by discussing the current state of quantum computing research and the challenges that need to be addressed to realize the full potential of this technology. It emphasizes the importance of interdisciplinary collaboration and investment in quantum research to overcome technical hurdles and unlock the transformative power of quantum computers. This is in the realm of quantum algorithms, and home motivation
behind quantum computers is. This is the core difference between classical computers and quantum computers. Classical computers are only capable of one state, which is a tie. They can be in any state at all. On the other hand, all of those states can exist simultaneously in superposition within quantum computers. In summary, this study offers a thorough analysis of quantum

computing, including its possible uses, processing powers, and future prospects. It also sheds light on the fascinating possibilities for quantum computing.

REFERENCES

[1] Yanofsky, Noson. (2007). An Introduction to Quantum Computing. 10.1007/978-94-007-0080-2_10.

[2] Paler A, Devitt S J, "An introduction into fault-tolerant quantum computing," in Design Automation Conference (DAC), 2015 52nd ACM/EDAC/IEEE, vol., no., pp.1-6, 8-12 June 2015

[3] Ying, M, Yuan Feng, "An Algebraic Language for Distributed Quantum Computing," in Computers, IEEE Transactions on , vol.58, no.6, pp.728-743, June 2009 doi: 10.1109/TC.2009.13

[4] Wang, Can & Chen, Ming-cheng & Lu, Chao-Yang. (2024). Quantum computing with time-travelling quantum gates. Acta Physica Sinica. 73. 020303. 10.7498/aps.73.20231289

[5] Gotarane, Vishal & Gandhi, Sushant. (2016). QUANTUM COMPUTING: FUTURE COMPUTING.

[6] Mikhail Dyaknov. The Case Against Quantum Computing. IEEE Spectrum. 2019 Mar 24