Quantum Computing: The Future of Computing

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***Abstract* - Quantum Computing is current and energizing field at the crossing point of arithmetic, software engineering and physics. It concerns a usage of quantum mechanics to enhance the effectiveness of calculation. By the introduction of Quantum Physics, numerous new territories were opened for innovative work in the realm of science and innovation. One such field is Quantum Computing and Communication where there is space for every one of that was at one time a fantasy in the field of computing and correspondence. Ultra-rapid, resistance to listening in, security, and name it and it might be conceivable. Quantum computers are great at controlling high-dimensional vectors in vast tensor item spaces. The subject of quantum computing unites thoughts from established data hypothesis, software engineering, and quantum physics. The hypothesis of quantum data and computing puts this criticalness on a firm balance, and has prompted some significant and energizing new bits of knowledge into the normal world.**

Energized by expanding PC control and algorithmic advances, machine learning procedures have turned out to be capable apparatuses for discovering designs in information. Quantum frameworks deliver atypical examples that established frameworks are thought not to create productively, so it is sensible to propose that quantum computers may beat traditional computers on machine learning errands. The field of quantum machine learning investigates how to devise and actualize quantum programming that could empower machine learning that is speedier than that of established computers. Late work has delivered quantum calculations that could go about as the building pieces of machine learning programs, yet the equipment and programming challenges are as yet extensive. Quantum Machine Learning is an interdisciplinary research zone joining quantum mechanics with techniques for ML, in which quantum properties consider an exponential accelerate in the calculations. This field is as of now one of the fundamental research ranges in organizations like Google and Microsoft, because of the insurgency that they could give in information administration. In this paper we have tried to show the fundamental relationship between Quantum Computing and Machine Learning.

Keywords: Quantum Computing, Quantum mechanics, Software Engineering, Quantum Physics, Machine Learning, Quantum Machine Learning.

INTRODUCTION

Quantum computing, otherwise called atomic computing is the exploration territory tenacious on improvement of the computer innovation in view of quantum theory and standards. The quantum theory portrays the conduct and nature of vitality and substance on the quantum, which is nuclear and subatomic, level. Advancement of the quantum computer, if practical, would check a jump forward in computing limit far superior than from the math device to a present day. Super computer, with presentation develops in the billion-crease domain and more remote than. By following laws of quantum physics, the quantum computer, would increase enormous preparing power through office to be in various states, and utilize every single conceivable change at the same time to perform assignments. The subject of quantum computing unites thoughts from established information theory, computer science, and quantum physics. This survey expects to compress not simply quantum computing, but rather the entire subject of quantum information theory. Nature - including particles like caffeine - takes after the laws of quantum mechanics, a branch of physics that investigates how the physical world functions and no more crucial levels. At this level, particles carry on in interesting routes, going up against more than one state in the meantime, and connecting with different particles that are exceptionally far away. Quantum computing bridles these quantum wonders to process information in a novel and promising way.

BRIEF HISTORY

Now, it is essential to understand Quantum Theory before we are going to apply it in our Information Technology and Communication Networking (ICTN) which becomes quantum computing. Actually, in 1990 Max Planck has introduced the concept of quantum theory in which he has introduced the idea that energy exists in individual units, to which he has given the name quanta, as does matter. Then after, many scientists have worked for more than 30 years to have modern understand of quantum theory.

Quantum computing:

Quantum computing, otherwise called nuclear computing is the examination zone relentless on advancement of the computer innovation in light of quantum theory and standards. The quantum theory portrays the conduct and nature of vitality and substance on the quantum, which is nuclear and subatomic, level. Advancement of the quantum computer, if practical, would check a jump forward in computing limit far superior than from the math device to a cutting-edge supercomputer, with presentation develops in the billion-overlay domain and more remote than. By following laws of quantum physics, the quantum computer, would increase enormous preparing power through office to be in different states, and utilize every conceivable stage all the while to perform errands.

Machine learning:

Machine learning is a field of computer science that enables computers to learn without being unequivocally modified. Machine learning is firmly identified with (and frequently covers with) computational measurements, which additionally concentrates on expectation making using computers.

Quantum mechanics, Software Engineering:

Software engineering is the use of engineering to the advancement of software in a deliberate strategy. [1][2][3] "The precise utilization of logical and innovative information, strategies, and experience to the outline, usage, testing, and documentation of software"— The Bureau of Labor Statistics—IEEE Systems and software engineering – Vocabulary [4].

Quantum Machine Learning:

Quantum machine learning is a developing interdisciplinary research zone at the crossing point of quantum physics and machine learning [4] One can recognize four distinctive methods for consolidating the two parent disciplines[5][6]. Quantum machine learning calculations can utilize the upsides of quantum calculation to enhance traditional techniques for machine learning, for instance by creating productive usage of costly established calculations on a quantum computer [7][8][9] . Then again, one can apply traditional strategies for machine learning to break down quantum frameworks. Most by and large, one can consider circumstances where in both the learning gadget and the framework under examination are completely quantum. A related branch of research investigates methodological and auxiliary likenesses between certain physical frameworks and learning frameworks, specifically neural systems, which has uncovered, for instance, that specific scientific and numerical strategies from quantum physics continue to established profound learning. [10]

WORKING OF QUANTUM COMPUTING

Traditional computers encode information in bits. Each piece can take the estimation of 1 or 0. These 1s and 0s go about as on/off switches that at last drive computer capacities. Quantum computers, then again, depend on qubits, which work as indicated by two key standards of quantum physics: superposition and ensnarement. Superposition implies that each qubit can speak to both a 1 and a 0 in the meantime. Ensnarement implies that qubits in a superposition can be associated with each other; that is, the condition of one (regardless of whether it is a 1 or a 0) can rely upon the condition of another. Utilizing these two standards, qubits can go about as more modern switches, empowering quantum computers to work in ways that enable them to tackle troublesome issues that are recalcitrant utilizing the present computers.

In Fig. 1, we tried to explained classical computing system in which there are electrical signals as inputs and electrical signals as outputs. The in-between of these two there are classical Gates which are working on input signals and generating output signals. This is known as classical computing system.

Fig. 1: Classical Computing

Where as in Fig. 2, we have tried to explain quantum computing system in which there is quantum state as an input on which quantum Gates has been applied which generates measurement results as
an output.

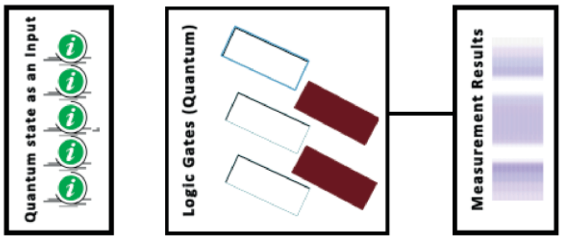

Fig. 2: Quantum Computing

The fundamental difference between quantum computing and conventional or classical computing is, in quantum computing we are architecturally using all possibilities to solve computational problems where as conventional or classical computing is the small part or subset of all these possibilities. Apart from this difference, a quantum computing system is thousands of time faster than conventional computing to solve very important types of problems. A really tough problem like the big number factorization, that would take a supercomputer years or decades to crack, can be crunched by a quantum computer in very little time at all. It doesn't stop over here. In conventional computing a program and process has to operate in sequence of the information it stored and one bit at a time, whereas in quantum computing process of all information stored in all QBITS simultaneously. It is a kind of imagination that instead of millions of desktops are running side by side rather than just one working on the same problem. Let us take an example to understand quantum computing more effectively. The classical NOT-gate, we are trying to convert it into quantum analogue. The Classical NOT-gate, the left side of above figure, flips its input bit over; NOT (1) =0, NOT (0) =1. The quantum analogue, the QNOT also does this, but it flips all states in a superposition at the same time is available on right hand side of above figure. So, if we start with 3 qubits in the state|000} +|001} +2|010}-|011}- |100} +3i|101} +7|110} and apply QNOT to the first qbits, we get |100} +|101} +2|110}-|111}-|000} +3i|001} +7|010}.

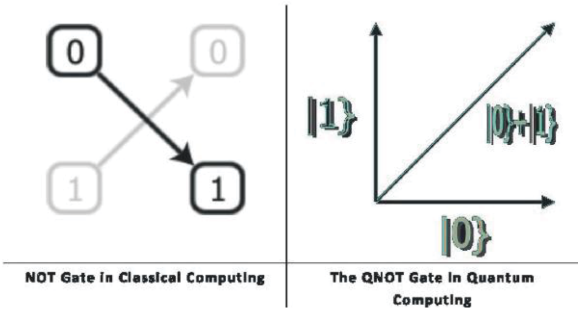

Fig. 3: NOT Gate by Classical and Quantum Computing

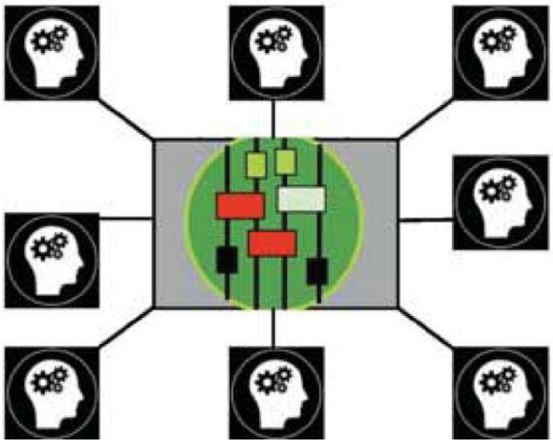

Fig 4: Quantum computing with machine learning

Quantum Machine Learning Relevance:

Many services available by Google or others are classy depends on Artificial Intelligence technologies includes Pattern. Reorganization as well as Machine Learning. If any individual takes closer look at capabilities, they can come across with the solution of hard combinatorial optimization problems, called by mathematicians. The requirement of solving such kind of hardest problem is so large server farms which are very next to impossible to build. The quantum computing is a new type of machine system can be helpful here. The laws of quantum physics and its advantages provide new computational capabilities represents as Quantum Computing. While quantum mechanics has been foundational to the theories of physics for about a hundred years the picture of reality it paints remains enigmatic. This is principally as of the scale of our regulatory experience quantum consequences are vanishingly small and can typically not be pragmatic directly. Subsequently, quantum computers surprise us with there capabilities. In Fig. 4, we have endeavored model of quantum computing with Machine Learning. In middle of the figure there is quantum Gates are available based on quantum computing and encircle of it there are machines which learns continuously from quantum gates. To understand quantum computing with machine learning let's look at an example of unstructured search.

Example with Algorithm

This is most interesting and effective example of best usage of quantum machine learning. In a banking transaction system it is very hard to detect fraudulent bank transactions. It is time consuming as well. In this situation quantum computing with machine learning can help here. This mathematical problem can be optimized by using consensus algorithms which is also known as

Boyd's system. In this algorithm we are using past data to train the model in hopes that it will work on future data. It is a pattern which means each node updates its local variable with weighted average of its neighbor's values, and each new value is corrupted by and additive noise with zero mean. The quality of consensus can be measured by the total mean-square deviation of the individual variables from their average, which converges to a steady state value. This can be prepared on a single computer, with all the data in one place. Many processors are used by machine

learning typically, each handling a little bit of problem. But for a single machine a consensus optimization approach can work better if the problem becomes too large. In this, dataset is spited into bits and disseminated across 1,000 agents which analyse their bit of data and each produce a model based on the data they have processed. By applying this we can decrease incredible time of computing which means a few movements instead of many years. This model is not only useful for detecting fraudulent bank transactions but also useful for creating an effective spam filter.

LITERATURE SURVEY

Biamonte, J., Wittek, P., Pancotti, N., Rebentrost, P., Wiebe, N., and Lloyd, S. (2016) suggests a hybrid between machine learning and quantum information handling benefits . Customary machine learning has enhanced the benchmarking and control of test quantum computing frameworks, including versatile quantum stage estimation and outlining quantum computing doors and quantum mechanics offers enticing prospects to upgrade machine learning, running from lessened computational intricacy to enhanced speculation execution.

Aïmeur, E., Brassard, G., and Gambs, S. (2006) said that Quantum Information Processing (QIP) performs ponders in a world that complies with the laws of quantum mechanics, while Machine Learning (ML) is for the most part thought to be done in a traditional world. While examination of the experience of ML with QIP by characterizing and concentrate novel learning undertakings that relate to Machine Learning in a world in which the information is in a general sense quantum mechanical.

Dunjko, V., Taylor, J. M., and Briegel, H. J. (2016) said that the rising field of quantum machine learning can possibly considerably help in the issues and extent of computerized reasoning. This is just improved by late accomplishments in the field of established machine learning. In this work we propose an approach for the methodical treatment of machine learning, from the viewpoint of quantum information. While quantum enhancements in supervised and unsupervised learning have been accounted for, fortification learning has gotten substantially less consideration.

Wiebe, N., Kapoor, An., and Svore, K. (2014) gave the Quantum Algorithms to Nearest-Neighbor Methods for Supervised and Unsupervised Learning.

BENEFITS OF QUANTUM COMPUTING

- It is useful to solve complex discrete combinatorial optimization problems easily.
- In processing, it is very faster.
- It provides better methods of Machine learning, which is really high-quality instead of improving
- Classical methods.
- There are other artificial intelligence problems which can also easily solved by quantum computing.

DRAWBACKS OF QUANTUM COMPUTING

- It requires more memory to solve complex problem includes more summation.
- Just like we are talking, it is not easy to design or formulate quantum computing.
- The cost and other hardware related expenses are very high in the implementation of quantum computing.
- The major drawback is, quantum computing is not used in practice till date.

APPLICATION AND FUTURE USE

Among these are the utilization of quantum states to allow the protected transmission of traditional information (quantum cryptography), the utilization of quantum ensnarement to allow dependable transmission of quantum states (teleportation), the likelihood of saving quantum soundness within the sight of irreversible commotion forms (quantum mistake amendment), and the utilization of controlled quantum advancement for proficient calculation (quantum calculation). The basic subject of every one of these experiences is the utilization of quantum ensnarement as a computational asset.

CONCLUSION

Quantum computing is the technique which provides better and faster machine learning. It is a current research trend in the field of computer science and technology having some drawbacks which we have discussed above. Machine learning is a process which requires past data to predict future and it is only possible by using high demanding computational operations. These operations always require very long time which can be avoided by using quantum computing technique. There are other applications and algorithms of quantum computing apart from those discussed above. Finally, it is high time to implement quantum computing on practical basis as it is not in exercise at the present. Quantum Computing is a kind of imagination where instead of millions of desktops running side by side there is rather just one working on the same problem.

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