The Effects of the Quantum Computing on Improving the Performance of Artificial Intelligence

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Quantum computing is the field that focuses on quantum computation, information processing, and the mathematical and physical theory for which different circuits and algorithms must be integrated into hardware performance. Computational science incorporates artificial intelligence, and there is a strong engineering component attached to computational science. The basic purpose served by artificial intelligence coupled with computational science is to formalize intelligence and analyzing that knowledge. Analysis of the knowledge is performed by building software and/or hardware systems that are able to perform intelligent operations (Manin, n.d.). Machine learning and deep learning, nowadays, can be pragmatic with the help of simulating physics, generating art, voice recognition, computer vision, autonomous robotics, and through genomic data. However, these approaches take a very data-centric approach to classify and navigate complex data spaces.

Simple and small rule/units in large number, when combined, end up in the conclusion of big complex systems. Besides, for better calculations and smart intelligence operations, efforts are being made to build optimized and custom hardware via gates and arithmetic/logic units, and small memory units; a deep neural net accessible for programming via low-level capable languages like C or go the hardware description route such as VHDL.

# Problem to be Solved

Quantum computers have the ability to solve complex problems that are, to some extent, are impossible to solve using conventional computers. In addition, the quantum states, i.e. "qubits" are exceedingly unstable while interacting with interference environment because each interaction leads to a state function collapse, (Ying, 2010a). One way of combating the error-correction is through artificial neural networks. Artificial neural networks are computer programs that replicate the behaviour of interrelated neurons. So, how artificial neural networks will devise error-correction strategies? Quantum computers, unlike conventional computers, use quantum bits or qubits that superimpose the two states – zero and one – of the qubit. Besides, the processor of quantum computers superimposes multiple qubits in a single joint state. So, the entanglement of multiple qubits enhances the processing power of a quantum computer for solving complex tasks. The algorithms based on quantum bits, capable of dealing with multiple states can be interfaced with artificial intelligence to achieve more speed and to install decision-making capabilities in AI machine models.

Another problem that can be solved through quantum computing is; revealing defects in the quantum computer using auxiliary qubits. By positioning additional qubits – auxiliary qubits – that store the actual information, the defects in quantum computers are not only revealed but also ratified. Auxiliary bits will allow the controller of quantum computers not only to locate the fault but also perform operations on the qubits that carry information in such areas. The idea of using auxiliary bits is to train the quantum network so efficiently that it outstrips the correction strategies designed by human minds. These trained networks can be interfaced with artificial intelligence to train deep learning models to obtain greater computational power. The main area of focus in QC is optimization, and optimization problems are undoubtedly a real challenge to artificial intelligence. In optimization problems, the aim is to make the best decision out of a very large number of possibilities. QC will allow for much faster and better answers. More often than not DSMC (Direct Simulation Monte Carlo) methods are used for the sampling of the research space in conventional computers. It has been witnessed that search space is huge most of the times thus, for the initiation of the process initial guesses of the starting points are used. Quantum computing gives you the choice of running all possible choices and all possible permutations of decisions simultaneously (Aaronson & Ambainis, 2018). Even choices of models are often simplified to make the problem tractable in a given time. If this is less of an issue, more robust models can be run; however, there is a need to caution against new over-promising techniques.

# Literature Review

Quantum computing’s applications in AI extend from learning algorithms to decision problems and quantum research. Besides, AI researchers can design algorithms of quantum computing to solve complex problems efficiently (Ying, 2010b). Quantum computing will allow AI researchers to borrow ideas from quantum computing and devise methods of formalizing problems in AI. AI and QC researchers can develop new AI techniques to solve the problems in the quantum world. Quantum computers are able to solve the problems that are impossible for classical computers to solve. However, there is a limitation to QC, i.e. it is highly sensitive to interference from the environment. One of the first-order tasks for AI researchers is to analyze visual information, however, owing to the complex algorithms it is high time that AI and QC researchers develop better ways to store, retrieve, and process image processing (Miakisz, Piotrowski, & Sładkowski, 2006).

While working with these states, the responsibility of the operating system is not only limited to process them simultaneously but also to store and leave the information intact. The other issue which is also central when it comes to dealing with quantum computers is their high sensitivity to the environment. Special arrangements are to be made to preserve the system and its premises as a slight violation can result in an alteration of results. The optimization problems that interfacing neural networks with artificial intelligence are also a big concern. Quantum computers can be harnessed in some specific ways to solve sequential problems. The ability to optimize different samples and data using quantum algorithms will go handy as far as the compatibility issues are concerned.

# Algorithms and Applications

The word "algorithm" is used the same in quantum computing as anywhere else. It is just that many quantum algorithms have a probabilistic step in them. The final act of instrument cannot be performed by the classical deterministic computers because they are only capable of determining final distributions while quantum computers handle probabilities of the qubits to get random output (Ying, 2010a). The randomness is an input resource for a lot of algorithms, simulations and cryptography so quantum technologies have their own methods of generating randomness. Also, there aren't an infinite number of solutions; quantum computers have a finite number of qubits which, when read out produce finite-length bit-strings.

Quantum search algorithm is used to avoid quantum parallelism using quantum entanglement. It is a representation of the power of quantum. Let suppose we have a function ‘f’. We know that there is a unique input ‘x’ which satisfies the function such as f(x) = 1. To find the function ‘f’, we put this into the quantum circuit to make it reversible. This search process inserts value 1 to the function at point ‘x’, what we want to compute. The big O analysis of quantum search suggests that it finds the list of black-box containing functions (like f) in O(√N) (in comparatively very less time) instead of O(N) (number of inputs) in classical search because of no information of function ‘f’.

Shor’s algorithm has a probabilistic approach having two distinguished sources of randomness. One observes quantum memory and generate random results while other works by reducing the factors to find the function’s period.

Forrelation is one technique which extensively distinguishes quantum computing with that of classical. It is actually an algorithm that is used to test the properties while comparing Boolean functions and Fourier transform of the second function. To analyze the time required to perform a function ‘f’, we have a query model to determine how much time an algorithm takes. So instead of time complexity, a query complexity is measured and this query is called t-query. As in forrelation “This problem can be solved using 1 quantum query, yet we show that any randomized algorithm needs Ω (√ N / log N) queries (improving a Ω (N1/4 ) lower bound of Aaronson). Conversely, we show that this 1 versus Ω( e √ N) separation is optimal: indeed, any t-query quantum algorithm whatsoever can be simulated by an O N1−1/2 t-query randomize.” (Aaronson & Ambainis, 2018). Where N is the number of input elements. It reveals that any quantum query having constant complexity does not possess partial Boolean function provided linear randomized query complexity. This work is very useful and gives an empirical basis for the maximum power of quantum computation. (Aaronson & Ambainis, 2018)

# Implementation

Games are one major display of modern technology as they have become a part of life, especially for youth. Online or video games with multiplayer where players are divided into teams. Quantum information can be incorporated in such types of games to acquire a certain level of equilibrium strategy which is not present in other games. Researchers are working on the quantum mediated framework in order to enable multiplayer with each player having more than two strategic choices. Quantization of games in artificial intelligence has now been implemented and researchers are doing extensive research and experiments in the field. The framework functions by pre-quantizing and quantizing as clear-cut modifications of classical simulation games. By quantizing, a game is redefined as a reverse operation on quantum bits to represent player’s strategies. In quantization, the number of quantum bits is reduced and resultant unitary operations preserve the features of actual classical games. A new qubit called ancillary qubits is introduced so that other quantum characteristics can be explored. Those characteristics include non-local quantum gates, entanglement, and measurements of reduced states. Quantum game theory is not very common today, but future prospects suggest that this field is one of the very crucial disciplines of the emerging information age. “Quantum game theory cannot be neglected because current technological developments suggest that sooner or later someone would take full advantage of quantum theory and may use quantum strategies to beat us at some realistic game”(Miakisz, Piotrowski, & S\ladkowski, 2006)

Quantum computation also assists AI in the field of image processing. It is out of the scope of conventional computer systems to cater for state of the art machine and deep learning algorithms and their computational complexity. Quantum computing serves the purpose by providing solutions by superposition of qubit states in the infinite number of possibilities by changing the values of A and B (the two qubits) and entanglement. Entanglement has no basis in classical computers and is a special characteristic of quantum systems. An image is stored in a qubit array having the capability to store the information in quantum systems that are multi-particle. It also provides eavesdropping and secrecy detection services. “Entanglement is seen to be at the heart of QIP unique properties, and an example of it is its role in Quantum Teleportation” (Venegas-Andraca & Bose, 2003)

# Advantages and Drawbacks

## Advantages

1. Quantum computers will solve the complex problem quickly.
2. Quantum computers will be able to optimize the solutions to challenging problems that consist of a huge number of possible answers.
3. With quantum computers, it will be easy to identify and locate patterns in large data sets.
4. The integration of data from different data sets is also one of the great advantages that quantum computing offers.
5. It makes the computation easy and fast.

## Drawbacks

1. Quantum computing is not cost-effective.
2. Only a limited class of algorithms can be run through quantum computing.
3. It is incredibly hard to program quantum computers.
4. There is no clarity in quantum programming so far.
5. Quantum computers are very sensitive to the environment and require a specially designed environmental framework which is very expensive and require a lot of maintenance.

# Summary

The function of quantum computers is more erudite as subatomic particles are employed that yield processing orders, and such processing orders are more advanced when compared to simple operations performed by circuits, binary operations, gates, so on - quantum computer uses atomic spins to produce outcomes and perform operations. Intelligent systems aid in performing exponential operations, and extrapolation of such architectures is rendered by quantum orders – quantum orders extrapolate in a more efficient manner than simple computers coupled with better performance. Quantum computing promises extreme speedups for many algorithms: prime factorization, modular logarithm, maximum lag, matching substrings, matrix inversion, group commutativity, the list goes on and is growing. When quantum computing becomes increasingly powerful and ubiquitous, this could lead to some powerful applications (such as potentially breaking RSA encryption).

# References

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