

Review on Quantum Computers in Machine Learning

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Abstract

The product development, process optimisation and chemical discovery are also among the actual manufacturing areas for witnessing the major innovations for quantum computing. The quantum simulations can also be capable of replacing the laboratory experiments that reduces the research cost and also even minimise the requirement of animal and human testing. Apart from that, quantum computers can bring the huge potential advantages within the financial sectors that are from deeper analytics to the latest and faster trading possibilities. In the current scenario, the existing computers struggle in calculating big data and are unable to solve several complex problems. Therefore, these problems are much more expected to be resolved within a few seconds by the help and power of the quantum computers. Apart from that, it is also predicted that the AI applications within the particular ML can also benefit from the advanced technology of quantum computing.

Keywords

Artificial Intelligence, Cyber security, Machine learning, Quantum computing,

INTRODUCTION

The quantum computer uses qubits by harnessing the entanglement and superposition. These computers can also perform the quantum operations which are much more difficult in emulating within the scale with several classical computers. Algorithms of machine learning (ML) are fully used for computing the immense qualities regarding the data. It generally utilises the quantum and qubits operations or the system of specialised operation for improving the data storage and computational speed that is done by several programs within the program. This report includes the applications of quantum computers in machine learning. It also includes the benefits and advantages of quantum computers with its results and discussion.

Quantum Machine Learning and its applications

Quantum computing is the actual process for performing several calculations by using the quantum mechanics and this

field regarding the quantum behaviour is only for certain subatomic particles. It is subsequently used for performing the calculations in a larger scale of information processing [5]. On the other hand, these capabilities can also give the advantage to the quantum computers regarding the cost and the computational time that is over the classical computers. The automated tools methods and improvement is for assisting the design and simulation regarding the corresponding applications that are required along the development of the device. Apart from that, the scientific progress within the materials creation, disciplines such as complication and error correction, hardware fabrication and many more. In addition, these have also enabled people in creating the large scale and also increasingly fault-tolerant within the quantum computers [8]. One of the most important applications of quantum computers is machine learning and other applications include Artificial Intelligence, Cyber security, financial modelling, weather forecasting, logistics optimisation and many more.

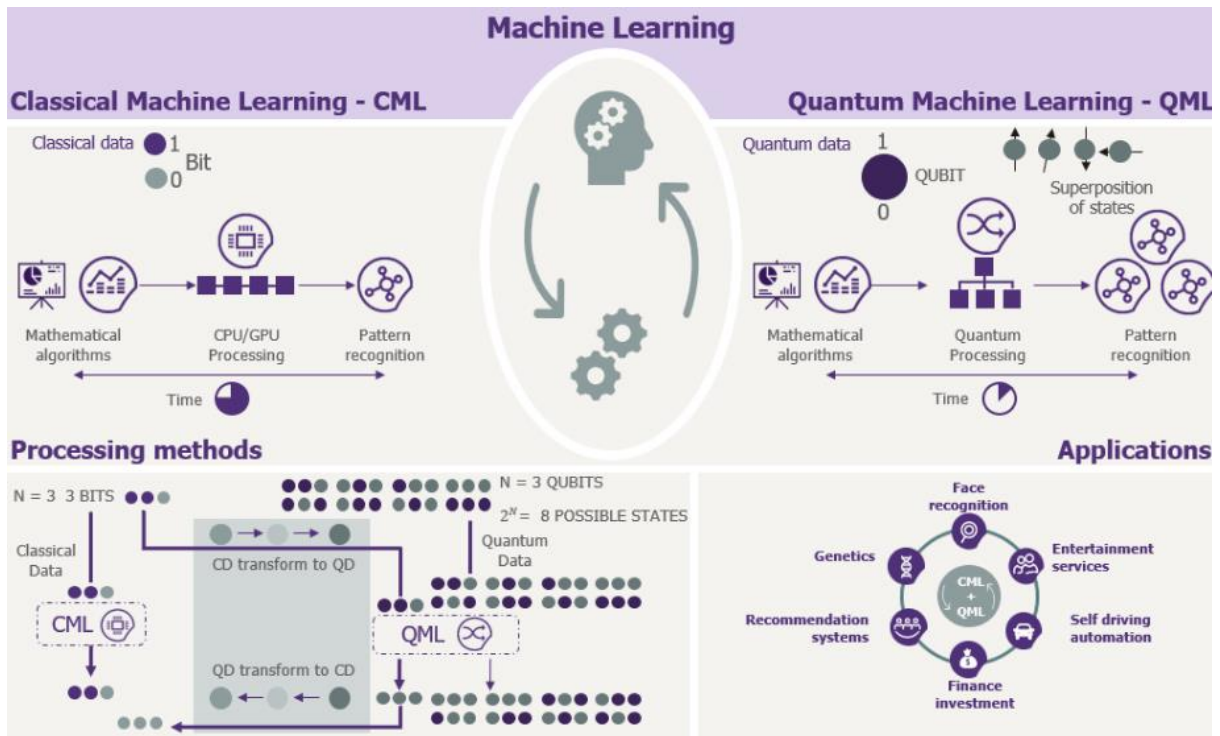


Figure 1: Applications of Quantum machine Learning [4]

The quantum ML are having several objectives, and these can be achieved by improving the simulation times within the chemical compounds that leads to the substantial reductions within the times of data creation. Furthermore, the creation regarding the complex systems of cryptography will be allowing the overall creation of the secured computers, also guaranteeing the security of the internet for several users [4]. The application also designs new algorithms of AI within most of the devices used by the user that range from better recommendation systems and prediction to the support systems of new industrial ones. On the other hand, the area of application within the quantum algorithms has also expanded dramatically and it arranges efficient methods within these areas by solving several complex problems in linear equation systems. The other areas are physics simulations, machine learning, complex problems of chemistry and many more. The existing quantum algorithms and devices have improved the classical processes and the classical ML is fully used for enhancing the procedures of the quantum computer [2]. Furthermore, the techniques of the classical applications of ML are for improvement regarding the quantum world and the main detection of entanglement within quantum computers includes the partially or fully entangled structures.

Therefore, the technique of deep learning allows in reducing the noise that is produced within the quantum systems. Hence, it also determines the molecular dynamics and structural properties within the overall quantum scenario.

Advantages and Benefits of Quantum Computers

The benefits and advantages suggest that the overall learning models that are made on the quantum computers might be dramatically powerful in selecting several applications, it also potentially boasts the faster computation process. It is also indulging in a better generalisation process on the less data. The quantum computers are totally effective and faster as they can easily perform several calculations within a few seconds where the supercomputers in the current scenario require decades [7]. The leaders of several companies are trying to launch quantum computers as they are much more viable, and they can be exponentially much more powerful from the computers present in the current scenario. It also helps the industries or companies in processing all data that can be generated in solving several complex problems.

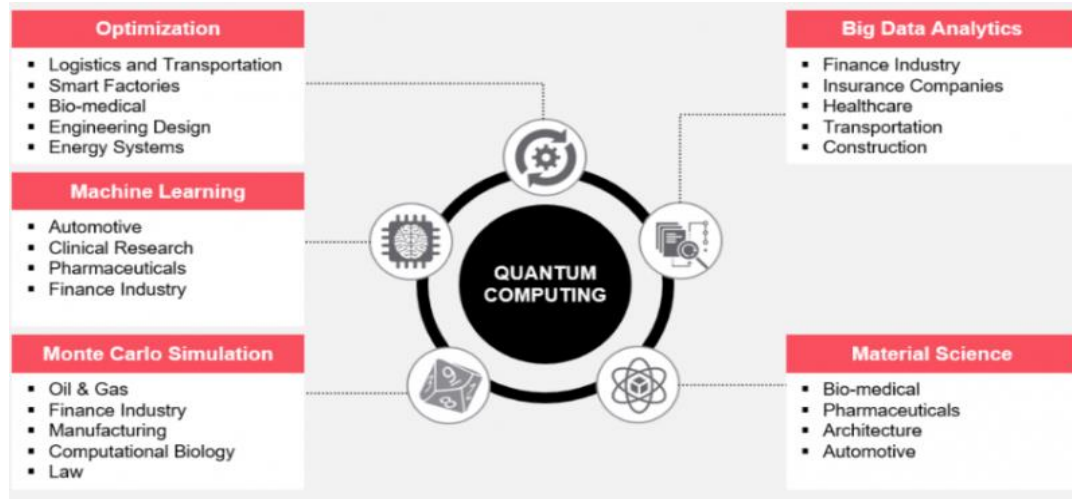


Figure 2: Future of Quantum Computing [11]

The benefits and advantages of quantum computers are,

Quantum computers help in solving several complex problems

The leaders within several companies are viable in successful production of the quantum computers and it is generally possible that these computers are capable of doing the complete calculations within a few seconds. On the other hand, the company Google is having the quantum computers as they usually claim that it is 100 million times quicker and faster from the current systems [11]. The size and the complexity regarding the data sets are having the faster growth than the computing resources and it is placed considerably with the strain on the computing fabric. Hence, the algorithms of quantum computing also allow people for enhancing the possibilities with the applications of ML.

Quantum computers will be optimising several Solutions

The process of quantum computing will be facilitating the capability in sampling the data and also optimising several problems that are encountered by the portfolio analysis within the delivery routes [6]. It also helps in determining the medicine protocol and optimal treatment for each and every individual. The quantum computers are much better equipped in solving the sequential problems and it also helps the consumers in taking better decisions for convince the companies in investing in the latest technologies.

Quantum computers spot the patterns within larger datasets and integrate from different data sets

Quantum computing is much more expected and is capable of searching unsorted data sets, larger data for uncovering anomalies or patterns. On the other hand, the quantum computers are having the possibilities of accessing several items within the database for identifying the similarities within seconds [9]. Apart from that, the big breakthrough can be expected when the quantum computers are much more available for integrating the different kinds of data sets.

MATERIALS AND METHODS

Machine language within the quantum computers includes several methods such as the simulation of linear algebra within the quantum amplitudes; the algorithm regarding the quantum ML is based on the Grover search. It also includes several methods such as reinforcement learning methods enhanced by quantum computers, quantum annealing, sampling techniques of quantum computers, neural networks and several other models. The quantum AI is used for rubbing the algorithms of ML within quantum computing and the computational advantages is that the quantum AI might help in achieving the results that are not possible by the classical computers [3]. This report is focused on the quantum computing within ML and it is the area that develops the computer technology that is based on several principles within quantum theory. The AI applications of ML and quantum computing are both transformational technologies where AI applications require quantum computing for achieving the success in a significant process. Apart from that, the quantum computers generally open several new and latest opportunities within AI applications that usually involve the processing of combinatoric regarding the larger quantities of data. It helps in making better decisions of fraud detection and also accurate predictions. The quantum computers also allow faster integration and analysis regarding the enormous datasets, and it will be transforming and improving the capabilities of AI and ML applications [12]. Several methods of quantum computing stimulate the overall details regarding the biological molecules and this type of computers is helpful in various subjects and sectors. Therefore, quantum computers are much more important for revolutionising the overall computation process by solving different types of intractable problems.

RESULTS AND DISCUSSION

The main field of quantum computing is much more advanced and the applications of the ML in quantum computers are focused in several sectors and several

industries are trying to adopt the Quantum computers. Below figure shows the graph regarding the growth of quantum computers used by several organisations.

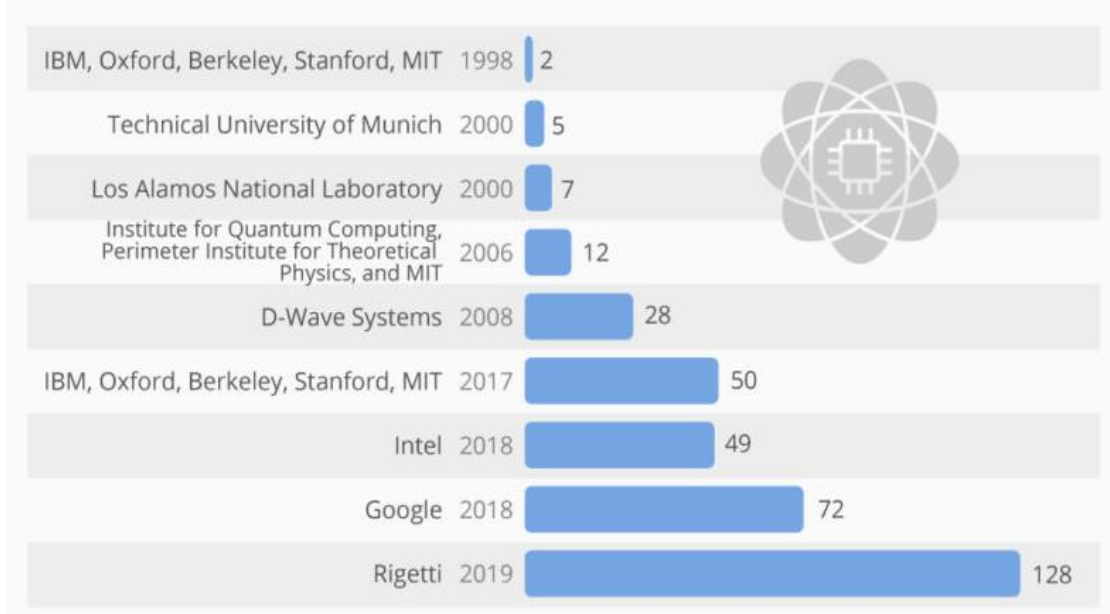


Figure 3: Increased growth of Quantum computers by Different Organisations [1]

Within the global market the quantum computing was totally valued up to USD 89 million within the year 2016 and it is projected in reaching up to USD 949 Million in the year 2025. It is claimed that the automotive industry is being the primary value that is for quantum computing, and it is having the higher impact which will be noticeable by the year 2025 [1]. Furthermore, it is also estimated that around 2 billion dollars to around 3 billion dollars of the economy will be impacted regarding the related technologies within the automotive industry by the year 2030. Therefore, it is also

estimated that there will be around 3000 to 5000 quantum computers globally by the year 2030. Apart from that, for the adaptation process several players are working in the innovation process of quantum computing. In addition, here the majority are start-ups that are about 40% and also the universities that are about 33% while the rest 27% sectors are the other sectors. The number of qubits within the quantum computers is increasing dramatically, that is from 2 qubits in the year 1998 to around 128 qubits in the year 2018.

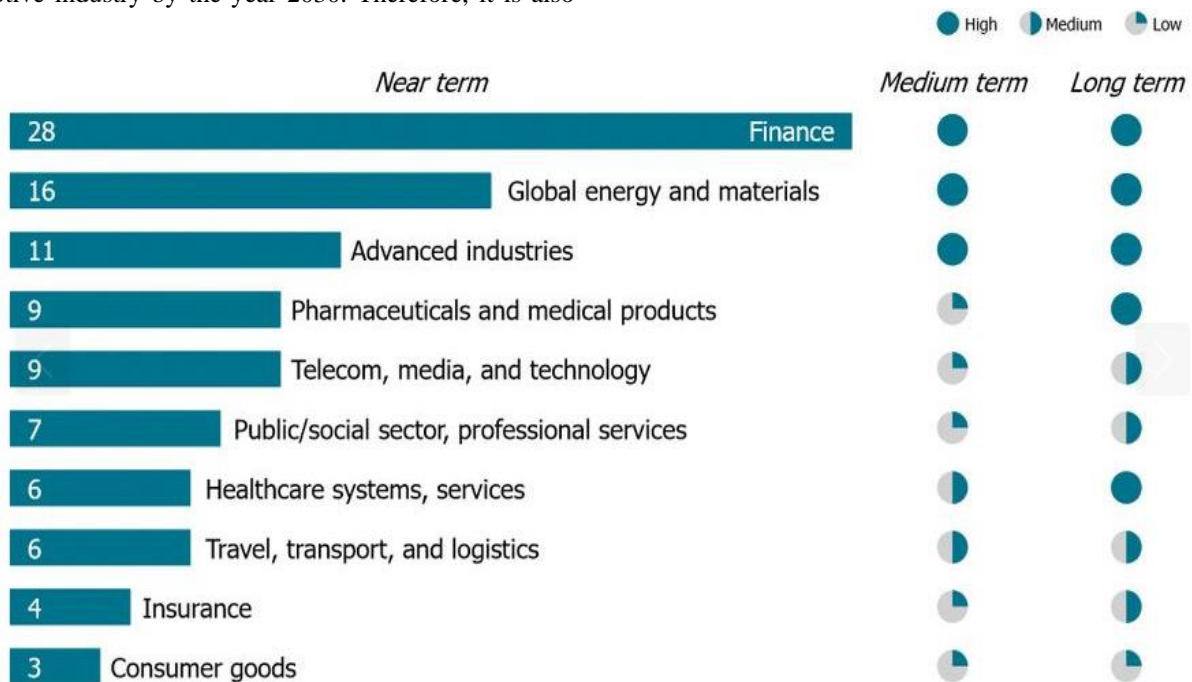


Figure 4: Applications and Used cases of Quantum Computers [10]

Around 28% of the finance sector, around 16% of the materials and global energy and around 11% of the advanced tech sectors are applicable sectors of companies for the application of quantum computing. Quantum computing is the alternative option to the classical computing, and it was conceived in the year 1982. Furthermore, quantum computing also requires the environment of cold operating where the particles are in stationary phase and the high temperature where the chips of quantum computers are operated is around -272 degree centigrade [10]).

The quantum computer is remaining within the nascent technology while it is having the potential that is already being felt around several sectors. Several companies of major technology are continuing in developing the quantum capabilities and they have launched the commercial cloud services of quantum computing. On the other hand, quantum computing is also expected in developing the breakthrough services and products while it will redefine and disrupt the manufacturing process. The results show that the quantum computer can easily solve several complex and massive problems within the quantum dynamics, quantum chemistry, sampling, material science and optimization problems. On the other hand, it is having the capability of breaking the encryption by using several algorithms and it poses the serious hurdles for building as it is much more complex. The quantum computers are the machines that use the properties regarding the quantum physics for performing computations and storing data. Therefore, it is extremely advantageous in certain tasks where the computers can easily outperform even the best supercomputers.

CONCLUSION

From the above study, it is to be concluded that the quantum computers are generally offering the possibility regarding the quantum leap in capability and performances within the range of the use cases. One of the use cases is ML and the other is definitely AI while several companies are having the goal in developing the techniques of machine language that is based on some correspondences. Furthermore those correspondences are between the tensor network that is used in the quantum physics and the neural network that is used in the process of deep learning. Hence, quantum computers are much more powerful for selecting several applications of machine learning.

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