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# A SURVEY ON QUANTUM MACHINE LEARNING

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**ABSTRACT**

*Machine learning is the study of computer algorithms that can enhance impulsively through experience and by the use of input data. It builds a model based on specimen data, known as training data, in order to forecast without being programmed. In this data world, Machine Learning algorithms are used in a wide variety of applications such as email filtering, speech recognition and computer vision.In recent years, new method named quantum machine learning plays high level parallel performance based on quantum mechanics. This new method focus the performance enhancement of classical machine learning algorithms through quantum computation and rambling the possibility of combining machine learning with quantum mechanics and providing new algorithms. This survey paper provides information about quantum machine learning and alsosummarizes the current research works to cover the way for researchers in quantum machine learning.*

***Key Words:****Machine Learning, Quantum Computing, Quantum Machine Learning*

## I. INTRODUCTION

Quantum computing is a type of computing used to perform calculations in a faster manner. For that purpose, it has many properties like interference, entanglement and superposition. Quantum computers solve certain problems that could not be easily solved by the classical computer within reasonable amount of time. Quantum computing used in many applications such as cryptography, simulation of quantum systems, search problems, quantum annealing and adiabatic optimization, computational biology, machine learning, quantum supremacy, computer-aided drug design and generative chemistry.Quantum algorithm is a step a step by procedure to solve the problems in a more quickly than the classical algorithms. Quantum algorithm executes calculations depending on the probability of the objects state. Several quantum algorithms are available which are grouped by the technique used by the algorithm. Quantum algorithms based on quantum Fourier transform, amplitude amplification and quantum walks.

### 1.1 Machine Learning

Nowadays machine learning plays a major role in different fields. Machine learning algorithms used for find the new patterns from the unknown patterns. Machine learning algorithms with artificial intelligence has been used for analyzing large amount of data such as speech recognition, pattern identification and image processing. Machine learning algorithms used in all places wherever the computer used to process the data. These algorithms also deal big data. In the past few decades, physicists already discussed about the processing power of quantum computing for information processing.

### 1.2 Quantum Machine Learning

In recent years new method named quantum machine learning plays high level parallel performance based on quantum mechanics. This new method focus the performance enhancement of classical machine learning algorithms through quantum computation and rambling the possibility of combining machine learning with quantum mechanics and providing new algorithms. In this technique superposition of states speed up the processing when compared to classical technique by placing two states at the same time till it is observed. The frame work contains three steps

1) Load and encode the input data
2) Process must follow unitary characteristics.
3) Read and output the learning result.

The standard outputs are derived by some measurements. By using Quantum Machine Learning researcher can explore quantum world from another perspective. It processesthe classical data mining and data analysis problems from other dimensions.

## II. REVIEW OF LITERATURE

SchuldMaria*et al*. [1] has been discussed various approaches and ideas of quantum machine learning and also discussed unsupervised and supervised algorithms for clustering tasks and pattern classification. This paper is divided into different sections. Each section discussed machine learning methods such as k-means, support vector machine, decision trees, neural networks, hidden markov models and Bayesian theory and the different approaches to relate machine leaning methods to quantum physics. Quantum algorithms used instead of classical machine learning algorithms to solve the problem and also show an enhancement in terms of the complexity can be obtained. The distance calculation methods in the clustering and classification algorithms can be speed up with the quantum computation.

The support vector machine, k-nearest neighbor and k-means clustering methods use quantum approach for efficient calculation of classical distance on a quantum computer. Decision trees and neural networks use quantum approach to find first explorations of quantum models. Hidden Markov model and Bayesian theory use quantum approach for reformulation in the language of open quantum systems. This paper also discussed the necessitate for future works on quantum machine learning that concentrate on how the concrete learning part of machine learning methods can be enhanced using the influence of quantum information processing.

AbohashimaZainab*et al*.[2] has been analyzed various quantum machine learning methods and summarizes the complete survey of the advances in the quantum machine learning. This paper also proposes the coding methods for mapping classical data to quantum data and also provides quantum computing and quantum subroutines for improving the performance of machine learning algorithms. This survey paper organizes and summarizes the current research works to cover the way for researchers in quantum machine learning.

Carlo Cilibertoet al. [3] clarified the limitations of quantum algorithms, how they compared with their best classical counter parts. This paper also discussed why quantum resources are needed in this data world and also clarifies the practical problems like how to upload classical data into quantum form.

Van Dam *et al.* [4] have been demonstrated three examples of unknown shift problems that can be solved efficiently on a quantum computer using the quantum Fourier transform. This paper also defines the hidden cosset problem, which generalize the hidden shift problem and hidden sub group problem. The framework provides the viewing ability of Fourier transform to capture subgroup and shift structure.

Adcock Jeremy *et al.* [5] discussedthe advances in the field of quantum machine learning. The following document offers a hybrid discussion; both reviewing the field as it is currently, and suggesting directions for further research. We include both algorithms and experimental implementations in the discussion. The field's outlook is generally positive, showing significant promise. However, we believe there are appreciable hurdles to overcome before one can claim that it is a primary application of quantum computation.

Biamonte*etal*. [6] investigate how to devise and implement quantum software that could enable machine learning that is faster than that of classical computers.

MontanaroAshley [7] briefly summarized the some known quantum algorithms, with an emphasis on a broad overview of their applications rather than their technical details.

## III. METHODOLOGY

The different stages of process in Quantum Machine Learning are shown in the Figure 3.1.


Fig. 3.1. Stages in Quantum Machine Learning

The steps are as follows,

Step1: Load the input states, Quantum speed up the processing by superposition states.

Step2: Create a quantum circuit to define the qubits

Step3: Perform the gate operations

Step4: Apply machine learning algorithms and quantum processing

Step5: Finally predict the states

Quantum computing system has tens of qubits. The information's are encoded as qubit in quantum computing. The two level qubit system is expressed as |0> and |1>. It can be in a state |1> or |0> or in a linear arrangement of both states that is superposition [8]. Superposition is an important principle of quantum mechanics. In superposition, quantum state is defined as a linear combination of additional different quantum states. The resultant states form valid quantum states. If n-qubits in a quantum system can form $2^n$ states, then the quantum state superposition is exponential. Another important term in quantum system is entanglement. In quantum physics, when the quantum state of each particle cannot be described independently of the quantum state of other particles, a pair or group of particle is entangled. The result of measurement of the individual qubits can be 0 or 1. The result of the measurement on one qubit will always be associated to the measurement on the other qubit. The reality that the entangled property of qubits makes the quantum computer more powerful than classical computer. Problems solved exponentially faster with the information stored in superposition.

Quantum computing refers to the changing the quantum systems with the purpose of process information. In quantum computing, the operations can be carried out in a faster manner by performing operations on many states. Quantum algorithms are used to solve the distinctive problems of machine learning using the effectiveness of quantum computing.

Quantum circuit describes the quantum algorithms. It has quantum gates which are performed on one or more qubits to solve the problem. The quantum gates are categorized by single qubit gates and two qubit gates. When compared to classical algorithm, quantum algorithm solves the problems exponentially faster.

Quantum machine learning algorithm is the amalgamation of quantum algorithms within machine learning algorithms. Quantum enhanced machine learning used to analyze the large amount of data on quantum computer. Quantum machine learning uses qubits and quantum operations to improve the data storage and computational speed.

## IV. CONCLUSION

Quantum-enhanced machine learning refers to quantum algorithms that solve tasks in machine learning, thereby improving and often expediting classical machine learning techniques. Such algorithms typically require one to encode the given classical data set into a quantum computer to make it accessible for quantum information processing. Subsequently, quantum information processing routines are applied and the result of the quantum computation is read out by measuring the quantum system. For example, the outcome of the measurement of a qubit reveals the result of a binary classification task. While many proposals of quantum machine learning algorithms are still purely theoretical and require a full-scale universal quantum computer to be tested, others have been implemented on small-scale or special purpose quantum devices.

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