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# TRAINING MULTILAYER NEURAL NETWORKS BASED ON QUANTUM COMPUTING

**Mukhamedieva Dilnoz Tulkunovna**
*Tashkent Institute of Irrigation and Agricultural Mechanization Engineers National Research University, 39, Kari Niyazov ave., Tashkent, 100000, Uzbekistan*

**Abstract**
This paper examines the application of quantum computing in the context of training multilayer neural networks. Multilayer neural networks are a powerful machine learning tool that is widely used in various fields such as pattern recognition, natural language processing, and time series forecasting. However, training and optimizing the parameters of neural networks can be a computationally expensive process, especially for networks of great depth and complexity. The paper examines the possibilities of using quantum computing to speed up the learning process of neural networks. The main emphasis is on the development of quantum optimization algorithms that can effectively train the parameters of multilayer neural networks using quantum computing. The efficiency and accuracy of these algorithms are analyzed on standard data sets to assess their applicability in practical machine learning problems. The results of the work can contribute to the development of more efficient and faster methods for training neural networks and lead to the creation of new innovative approaches in the field of machine learning.

**Keywords:** quantum computing, multilayer neural networks, training, optimization, optimization algorithms, machine learning, artificial intelligence.

**1. Introduction**. Machine learning and artificial intelligence have become an integral part of modern technologies, bringing significant changes and improvements to them. One of the most powerful tools in the field of machine learning is multilayer neural networks, which are capable of efficiently processing and analyzing large amounts of data to solve various problems such as classification, regression, natural language processing and much more. However, the training process of multilayer neural networks can be computationally expensive, especially for networks of great depth and complexity that require a significant amount of computing resources and time. In this regard, there is a need to develop new methods and approaches that could speed up the learning process of neural networks and make it more efficient. In recent years, quantum computing, a field of science and technology based on the principles of quantum mechanics, has attracted increasing attention. Quantum computing promises to revolutionize the field of information technology by providing new methods and tools for solving complex problems, including machine learning problems [1].

The purpose of this work is to study and analyze the possibilities of using quantum computing to speed up the learning process of multilayer neural networks. The work will examine several key aspects, including the development of quantum optimization algorithms that can effectively train the parameters of neural networks, as well as the study and analysis of their effectiveness on standard data sets. The results may shed light on the prospects for using quantum computing in the field of training neural networks and contribute to the development of more effective training methods in machine learning [2].

**2.Materials and methods.** The experiments are carried out using standard machine learning datasets, such as MNIST for handwritten digit image classification, CIFAR-10 for object image classification, and IMDB for text sentiment analysis. Multilayer neural networks consisting of several layers, including input, hidden and output layers, are used as models for training. Deep learning libraries such as TensorFlow, PyTorch or Keras are used to implement and train neural networks [3].

To speed up the learning process of neural networks, quantum optimization algorithms are used, such as quantum gradient descent, quantum variational algorithm and others. These algorithms are adapted to work with quantum computing resources and are used to optimize the parameters of neural networks. Quantum computing tools such as IBM Quantum Experience or Google Quantum AI are used to implement quantum algorithms and conduct experiments. These tools allow you to create and run quantum programs on real quantum devices or simulators. After training neural networks using quantum optimization algorithms, the results obtained are analyzed. The classification accuracy or other metrics of model quality are assessed on test data sets. The results are also compared with similar training methods on classical computers [4].

**3. Results.** The quantum computing-based multilayer neural network training program is a powerful tool for solving machine learning and artificial intelligence problems using the principles of quantum mechanics. Neural network initialization allows you to create multilayer neural networks with a given number of layers, the number of neurons in each layer, the network architecture and the choice of activation functions. Data loading provides the ability to load and pre-process training data for subsequent use in training a neural network. Optimizer and loss function selection allows you to select different optimizers (e.g., stochastic gradient descent, Adam, RMSprop) and loss functions (e.g., categorical cross entropy, root mean squared error). Neural Network Training provides functionality for training a neural network on the provided training data using the selected optimizer and loss function. Performance evaluation provides the ability to evaluate the performance of a trained neural network on test data using metrics for assessing the quality of the model, such as accuracy, recall, F1-measure, etc. Regularization and retraining control includes regularization functions (for example, L1, L2 regularization) and retraining control ( for example, dropout) to improve the generalization ability of the neural network. Quantum computing support enables the use of quantum methods in the neural network training process, including quantum weights and quantum operations. Parameter fine-tuning allows the user to adjust various training parameters and neural network structure to achieve optimal results.

Saving and Loading Models provides the ability to save trained neural network models to disk and load them for later use or further training. The interactive interface provides a convenient and intuitive interface for interacting with the program, including loading data, setting training parameters and analyzing results. Documentation and Support provides detailed documentation on using the program, including descriptions of methods and algorithms, as well as technical support for users. These functionalities enable the quantum computing-based multilayer neural network training program to be an effective tool for solving various machine learning and artificial intelligence problems using quantum methods. The scope of the quantum computing-based multilayer neural network training program includes various areas that require solving complex machine learning and artificial intelligence problems using the principles of quantum mechanics.

The program can be used in research and development in the field of quantum computing, including training and optimization of quantum neural networks, quantum algorithms and quantum architectures. The program can be used in the field of computer vision for object recognition, image classification, detection of objects in images and other tasks related to image analysis.

Results were obtained for the MNIST dataset for the task of classifying images of handwritten digits. The quantum circuit is shown in Figure 1. The classification results are presented in Figure 2.


Figure 1. Quantum circuit





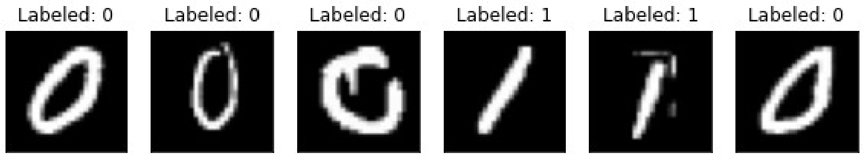


**Figure 2. Classification results**

These are just some examples of applications for training multilayer neural networks based on quantum computing. It can be useful in many other areas that require solving complex problems using quantum methods.

**4. Conclusion** The study has shown that the use of quantum computing for training multilayer neural networks is a promising approach that can lead to significant improvements in the efficiency and speed of the training process. Quantum optimization algorithms take advantage of quantum advantages such as quantum superposition and quantum parallelism to more efficiently tune the parameters of neural networks. However, it should be noted that the application of quantum computing in neural network training is still an active area of research, and many aspects of this approach require further study and development. In particular, more research is needed to determine optimal quantum optimization methods and algorithms, as well as to evaluate their effectiveness on different types of neural networks and learning problems. Despite the challenges and limitations, the application of quantum computing in neural network training has significant potential to improve the performance and accuracy of machine learning models. Further research in this direction may lead to the development of new methods and tools capable of solving complex problems of training neural networks using quantum advantages.

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