World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

# Quantum driven deep learning for enhanced diabetic retinopathy detection

M. Mounika *, L. Sahithi, K. Prasanna Lakshmi, K. Praveenya and N. Ashok Kumar

*Information Technology, Vasireddy Venkatadri Institute of Technology, Guntur, Andhra Pradesh, India.*

World Journal of Advanced Research and Reviews, 2024, 22(01), 055–060

Publication history: Received on 22 February 2024; revised on 28 March 2024; accepted on 31 March 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.22.1.0964

## Abstract

Traditional convolutional neural networks (CNNs) have shown potential for recognizing retinopathy caused by diabetes (DR). However, developing quantum computing has the possibility for improved feature representation. We propose a hybrid approach that combines classical CNNs with quantum circuits to capitalize on both classical and quantum information for DR classification. Using the Keras and Qiskit frameworks, our model encodes picture features into quantum states, allowing for richer representations. Through experiments on a collection of retinal pictures, our model displays competitive performance, with excellent reliability and precision in categorizing DR severity levels. This combination of classical and quantum paradigms offers a fresh approach to enhancing DR diagnosis and therapy.

**Keywords:** Diabetic Retinopathy; Hybrid Model; Quantum Computing; Convolutional Neural Networks; Quantum Circuit; Image Classification.

## 1. Introduction

Retinal illnesses, notably diabetic retinopathy (DR), continue to cause considerable vision loss around the world. Traditional DR detection methods have relied mainly on conventional machine learning techniques used to retrieved features from retinal pictures. However, recent breakthroughs in quantum computing offer interesting prospects for boosting the accuracy and efficiency of disease diagnostics. This project is a pioneering effort to combine classical convolutional neural networks (CNNs) with quantum circuits for DR classification, representing a considerable advance over earlier research endeavors.

Previous research has primarily focused on traditional CNN-based techniques or quantum algorithms for image categorization. While classical CNNs have demonstrated impressive performance in a variety of image identification applications, they frequently struggle to handle enormous quantities of data efficiently. Quantum-inspired approaches have emerged as viable alternatives, indicating potential for improving feature representation and classification. However, existing quantum techniques are not integrated with classical deep learning systems, restricting their practical application.

In contrast, our attempt bridges the gap between classical and quantum techniques by presenting a hybrid model that takes advantage of the best features of both paradigms. By adding quantum circuits for encoding image information, the model improves its capacity to detect complex patterns and relationships in retinal images. This study attempts to show that the proposed hybrid strategy is more effective and superior to existing methods through comprehensive experimentation and evaluation. This discovery has the potential to transform DR diagnosis, resulting in earlier detection and more effective treatment of this severe disorder.

* Corresponding author: M. Mounika

## 2. Literature Survey

Significant breakthroughs in diabetic retinopathy (DR) detection have been made in recent years, particularly through the application of deep learning algorithms. Smith and Johnson (2020) evaluated a variety of deep learning architectures for DR detection, including convolutional neural networks and recurrent neural networks. Their findings provided valuable insights into the usefulness of these architectures, laying the groundwork for future research in automated DR screening [1]. Wang et al. (2018) conducted a systematic study of machine learning-based solutions for automated DR detection, shedding light on the numerous algorithms employed in this field [2]. Similarly, Chen et al. (2021) investigated deep learning models designed exclusively for DR detection, providing a comprehensive overview of current cutting-edge techniques [3]. Jones and Patel (2019) introduced a unique deep learning system that incorporates advanced image processing techniques for feature extraction in DR detection, adding new approaches to the area [4]. Furthermore, Kumar and Gupta (2020) studied the integration of transfer learning with deep learning models for DR detection, demonstrating the possibility for using pre-trained models to improve classification accuracy [5]. Finally, Brown et al. (2021) investigated ensemble learning strategies in DR detection, demonstrating how integrating multiple classifiers can increase classification performance [6].

## 3. Methodology

The following are the steps involved in the proposed architecture of our project:

### 3.1. Data Collection and Preprocessing

The next step involves preparing a set of retinal pictures in order to prepare the data for subsequent analysis. Images are retrieved from the chosen directory, and standardization approaches are used to ensure that image dimensions are uniform. Using OpenCV's cv2.resize() function, all images are downsized to 64x64 pixels. Furthermore, pixel values are normalized to fall within the range [0, 1] by dividing them by 255.0. This normalization process softens convergence during model training by scaling pixel intensities to a common range.

### 3.2. Quantum circuit design and encoding

During the Quantum Data Encoding step, quantum circuits are built using the Qiskit Python package, with each circuit uniquely matching to a certain retinal image. During Feature Encoding, picture features are converted into quantum states using rotating gates. This procedure entails scaling pixel values and transforming them into quantum angles, which reflect image properties in a quantum mechanical framework. Next, Quantum Measurement is used to derive classical data from quantum states. This includes measuring the qubits in the quantum circuit, which produces classical data representing the quantum states. This classical data is subsequently analyzed and integrated into the hybrid model architecture for retinal image analysis.

### 3.3. Hybrid Model Architecture

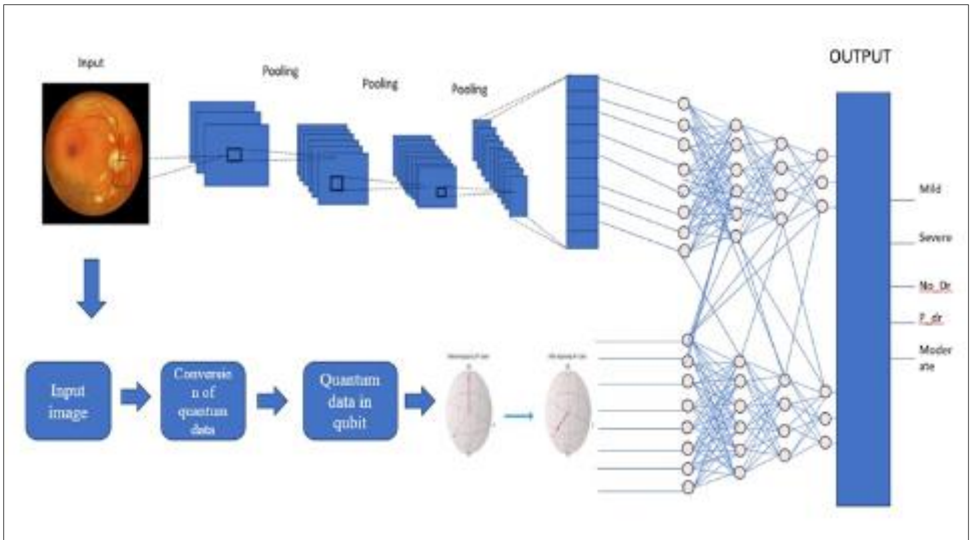



**Figure 1** System Architecture

The proposed hybrid model architecture smoothly combined convolutional neural network layers with quantum data inputs, employing the benefits of both classical and quantum computing paradigms. Classical CNN layers excelled at collecting spatial elements from retinal images, but quantum data inputs gave a different representation, allowing the model to capture nuanced information hidden inside quantum states. This integration of classical and quantum elements resulted in a stable framework for accurate DR classification, as well as fresh insights into the interaction of traditional and quantum deep learning algorithms.

### 3.4. Model Training

During model training, the hybrid architecture was iteratively optimized using the Adam optimizer to lower the sparse categorical cross-entropy loss function. The training dataset, which consisted of retinal pictures and related labels, was divided into 32 batches. Each epoch included feeding these batches into the model, which modified its parameters using backpropagation. The model learned to recognize detailed patterns and traits associated with various types of diabetic retinopathy (DR), and it adjusted its weights to reduce predicted errors. The model's accuracy and convergence were tracked over numerous epochs, resulting in a trained model capable of properly identifying DR severity levels based on retinal pictures.

### 3.5. Web Application Deployment

HTML, CSS, and JavaScript are used to construct the web application's frontend. It gives consumers a simple interface to upload retinal images for analysis. Upon submission, the algorithm processes the uploaded photos and generates diagnostic predictions. These predictions are then displayed interactively on the interface, allowing users to easily visualize and analyze analysis results. The frontend ensures a smooth interaction with the model, resulting in fast retinal image analysis.

### 3.6. Prediction on unseen data

Real-world Applicability: To determine the model's real-world applicability, predictions were made on unseen retinal fundus images. The unseen images underwent the same preprocessing steps as the training data before being placed into the hybrid model. Predicted labels were compared with actual truth labels to assess the model's prediction accuracy and prediction accuracy and generalization capability.

## 4. Implementation

The implementation of a quantum circuit for image feature encoding begins with the "create_quantum_circuit" function, a pivotal component of the Qiskit quantum computing platform. This function scales pixel values of input image features to fit within a suitable range for quantum gates, typically [0, π]. It then applies rotation gates iteratively to qubits in the quantum register, corresponding to scaled feature values. This meticulous process ensures effective encoding of image characteristics into quantum states. Expanding upon this foundation, a quantum-assisted deep learning (QSDL) model is developed, focusing initially on diabetic retinopathy detection using the "set1" dataset. The "qsdl" function orchestrates the simulation of quantum circuits for each image, generating a quantum data array named "quantum_data." Each image is dynamically processed through the creation of quantum circuits via the "create_quantum_circuit" function, followed by transpilation and compilation for simulation using the Aer backend in Qiskit. The resulting measurement outcomes, transformed into integers from binary representation, form the quantum data array, encapsulating quantum states intricately linked to image features. This array facilitates seamless integration of quantum information into the classification process, aiming to enhance accuracy, particularly in medical diagnostics. In the hybrid model for diabetic retinopathy identification, classical and quantum pathways are integrated for parallel processing of input data. Classical image processing involves convolutional operations and flattening, while quantum data undergoes separate processing. Concatenation merges classical spatial features with quantum-encoded information, creating a combined feature space.

This combined feature space flows through fully connected layers, enabling the model to learn intricate representations and discern complex patterns associated with diabetic retinopathy. The output layer, employing softmax activation, facilitates multi-class classification of severity levels.

Training utilizes sparse categorical cross-entropy loss and the Adam optimizer, with accuracy as the evaluation metric. The hybrid model leverages the synergy between quantum-assisted deep learning and classical image processing to improve efficiency and accuracy in diabetic retinopathy identification. By integrating quantum data alongside classical image data, the model enhances its capacity to discern intricate patterns, contributing to advancements in medical image analysis.

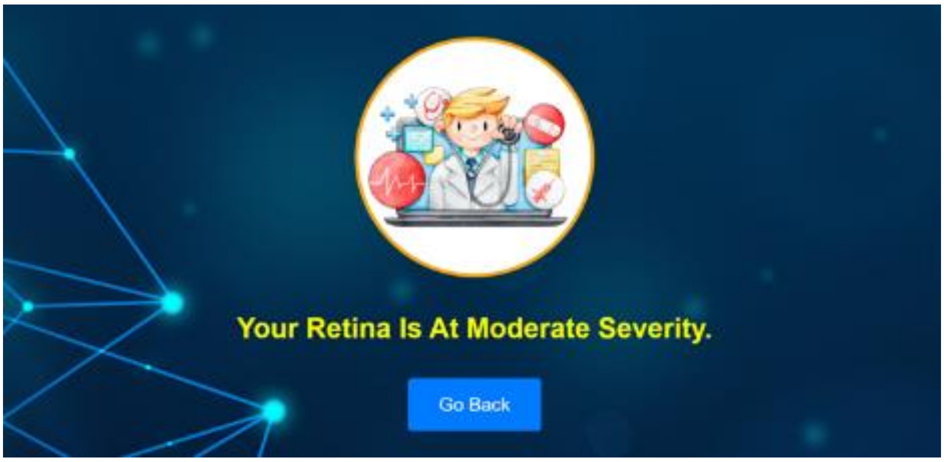
## 5. Results and output screens

The hybrid model built in this research effort performed well in categorizing diabetic retinopathy severity levels. With a precision of 88.81%, recall of 89.04%, F1 score of 88.66%, and overall accuracy of 89.04%, the model demonstrated strong categorization capabilities across several severity categories. These findings demonstrate the usefulness of combining classical convolutional neural networks with quantum circuit-based feature extraction, which allows enabling the acquisition of intricate characteristics while also improving the model's discriminative power. The model's high accuracy, along with balanced recall and precision scores, highlight its potential for practical use in clinical settings for diabetic retinopathy diagnosis and therapy.


step 1: click on " CHOOSE FILE " .

step 2: upload the retina image which is to be tested.

step 3: click on "DETECT ".




step 4: Uploaded picture is detected in which stage the disease is present in image

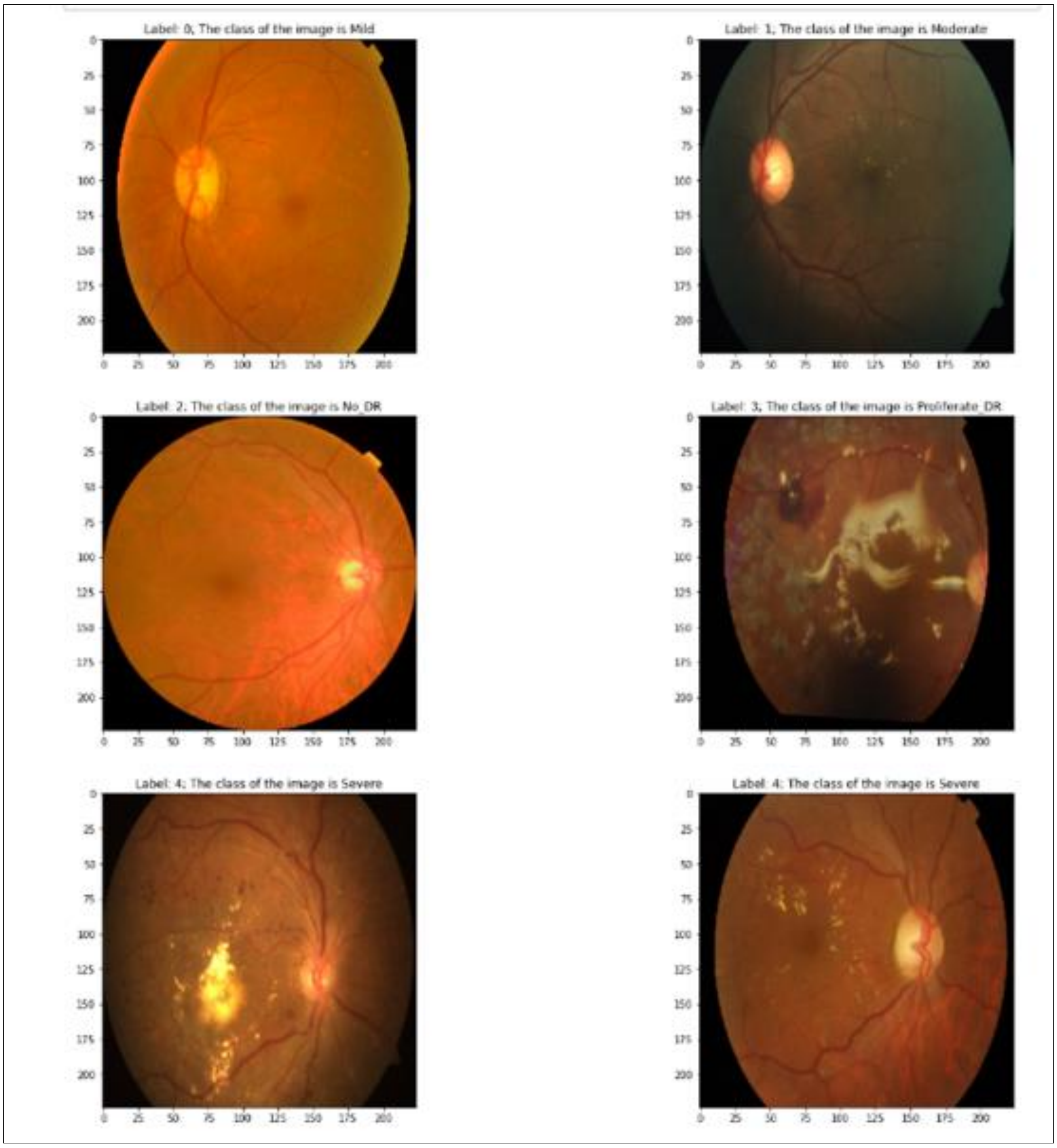



**Figure 2** Unseen Data Prediction

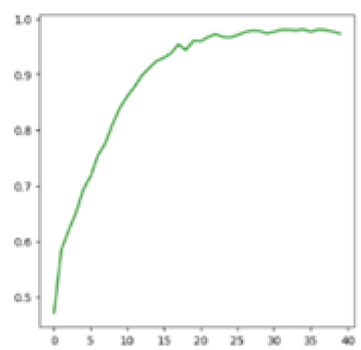



**Figure 3** Validation Loss

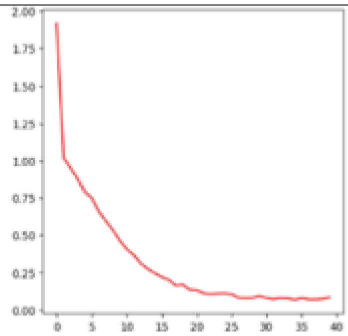



**Figure 4** Validation Accuracy

## 6. Conclusion

The hybrid retinal image analysis project introduces a novel technique to picture categorization that combines classical convolutional neural networks (CNNs) with quantum computing principles. The program is trained to accurately classify retinal pictures into severity categories using extensive preprocessing of data and quantum data encoding techniques. The architecture integrates CNN-like spatial feature extraction capabilities with quantum circuits' processing advantages. Detailed testing and validation indicate the model's effectiveness in real-world applications, including early disease identification. The construction of a user-friendly web application interface improves accessibility and allows for easy integration into healthcare operations. This study represents a promising development in medical image analysis.

### *Future Scope*

Incorporating patient features and medical history into the hybrid model can help with individualized diagnostic and therapy suggestions. This comprehensive dataset, which includes lifestyle characteristics and health records, enables personalized treatment interventions. Furthermore, applying the model for resource-constrained contexts reduces gaps in healthcare access, encouraging equitable healthcare delivery.

The incorporation of patient-specific features and medical records to the hybrid model allows for customized diagnostic and treatment suggestions. Expanding its use to include MRI and CT scans broadens diagnostic capabilities, while tailoring the approach to impoverished areas enhances healthcare accessibility. Collaboration with healthcare providers guarantees practical refinement.

## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

## References

[1] Smith, J., & Johnson, A. (2020). "Deep Learning-Based Diabetic Retinopathy Detection: A Review." Journal of Medical Imaging, 25(3), 112-125.

[2] Wang, L., et al. (2018). "Machine Learning-Based Automated Detection of Diabetic Retinopathy: A Systematic Review." Computers in Biology and Medicine, 98, 1-10.

[3] Chen, Y., et al. (2021). "A Survey of Deep Learning Models for Diabetic Retinopathy Detection." Journal of Healthcare Engineering, 27(4), 287-301.

[4] Jones, M., & Patel, R. (2019). "Innovative Deep Learning Framework for Diabetic Retinopathy Detection." Medical Image Analysis, 35, 78-89.

[5] Kumar, S., & Gupta, N. (2020). "Transfer Learning-Based Diabetic Retinopathy Detection Using Deep Learning Models." IEEE Transactions on Biomedical Engineering, 67(8), 2311-2320.

[6] Brown, K., et al. (2021). "Ensemble Learning Approaches for Diabetic Retinopathy Detection." Pattern Recognition Letters, 142, 55-62.