

Novel Approach based Skin Disease Detection using Deep Learning

Surbhi Atul Purwat, Prof. Nandkishor G. Dharashive, Prof. Rohini B. Late

Department of Computer Science & Engineering, M.S.Bidve Engineering College, Latur, India

ABSTRACT: In this paper, a 4-qubit Quantum Machine Learning (QML) model is used to propose a hybrid quantum–classical framework for multi-class skin disease categorization. The system combines a Variational Quantum Classifier (VQC) for prediction with a Quantum Convolutional Neural Network (QCNN) for feature extraction. In order to reduce dimensionality to four features that are compatible with quantum encoding, a dataset of 770 dermatological images representing chickenpox, measles, monkeypox, and normal skin is preprocessed using PCA. SPSA optimization and a class-weighted loss function are used to solve extreme class imbalance. The model greatly outperforms biased baselines, achieving 70.13% accuracy on 154 test photos and 70.83% on unseen multi-image samples. This paper shows the viability of QML for medical imaging within NISQ limitations, emphasizing portability, reusability, and applicability for resource-constrained diagnostic contexts, even though classical CNNs yield higher accuracy.

KEYWORDS-NISQ Healthcare Applications, QCNN, Variational Quantum Classifier, Quantum Machine Learning, and Skin Disease Classification

I. INTRODUCTION

Combining the flexibility of conventional machine learning with the computational principles of quantum computing, quantum machine learning (QML) has become a promising paradigm. Large fault-tolerant algorithms cannot be executed on quantum devices in the current Noisy Intermediate-Scale Quantum (NISQ) era due to qubit count, coherence time, and noise limitations. Because they enable useful applications with minimum quantum resources, hybrid quantum-classical techniques have drawn attention. Even with current hardware restrictions, these models are appropriate for real-world issues since they use quantum circuits for feature learning and classification and classical preprocessing. The intricacy and high dimensionality of picture data make healthcare, especially medical imaging, an attractive field for QML research.

Because the symptoms of various dermatological problems are visually identical, classifying skin diseases is a difficult diagnostic procedure. Manual diagnosis is challenging since diseases including chickenpox, measles, and monkeypox frequently share rashes, lesions, and discolouration patterns. Additionally, publically accessible medical datasets are sometimes quite unbalanced, with some classes predominating, which causes biased predictions in traditional deep learning models. To achieve balanced performance across all classes, conventional Convolutional Neural Networks (CNNs) need huge datasets, a lot of processing power, and careful tuning. These difficulties spur the investigation of alternate learning paradigms that can effectively handle high-dimensional, unbalanced medical data.

This work suggests a hybrid QCNN-VQC architecture running on a 4-qubit device as a solution to these problems. Compatibility with quantum circuits is made possible by Principal Component Analysis (PCA), which reduces image features from 4096 dimensions to four. While the VQC uses variational parameters tuned with SPSA for classification, the QCNN extracts hierarchical quantum features. To address dataset imbalance and enhance minority class recall, a class-weighted loss function is presented. This method lays the groundwork for quantum-assisted diagnostics in settings with limited resources by showing that effective medical image classification may be accomplished with few qubits.

Motivation

The goal of this work is to create a dependable and effective skin disease classification system that can handle the difficulties of unbalanced medical datasets while operating with constrained computational resources. Large datasets, strong GPUs, and a lot of training time are needed for traditional deep learning models. Additionally, these models

frequently exhibit bias toward majority classes, which lowers their accuracy for rare diseases. Quantum Machine Learning (QML), on the other hand, presents the possibility of processing intricate patterns with the least amount of quantum resources. In order to accomplish balanced, resource-efficient, and useful skin disease detection within the limitations of the NISQ era, this work intends to investigate a hybrid quantum–classical technique employing a 4-qubit system.

Gap Analysis

The majority of skin disease classification systems now in use rely on traditional deep learning models like CNNs and Vision Transformers, which attain excellent accuracy but necessitate sizable datasets, potent GPUs, and substantial processing resources. These models frequently have trouble with highly unbalanced medical datasets, which results in decreased recall for minority disorders and biased predictions toward majority classes. Furthermore, given NISQ restrictions, the majority of Quantum Machine Learning (QML) research is unsuitable for actual medical applications because it usually uses higher qubit counts and concentrates on balanced benchmark datasets like MNIST. The development of a lightweight, minimal-qubit hybrid quantum–classical framework with realistic reusability and deployment capabilities for imbalanced medical picture categorization is clearly lacking.

II. LITERATURE SURVEY

Kuldeep Vayadande [1], By shedding light on the field's emerging advancements in dermatology, hopes to advance a wider understanding of machine learning's potential to revolutionize the diagnosis and treatment of skin disorders, ultimately improving patient outcomes and boosting the provision of healthcare services.

Shuchismita Anwar [2] investigates the problem of enhancing multiclass picture categorization using quantum machine-learning methods. It investigates how a classical classifier can be used in conjunction with the discarded qubit states of Noisy Intermediate-Scale Quantum (NISQ) quantum convolutional neural networks (QCNNs) to enhance classification performance. After pooling, current QCNNs lose qubit states; however, in contrast to classical pooling, these qubits frequently stay entangled with the retained ones, resulting in the loss of important correlated information.

Mohamed Badr [3], In order to diagnose skin diseases with high precision, this work presents a unique deep-learning multi-model architecture. To categorize skin lesions into five classes—Atopic Dermatitis, Acne and Rosacea, Skin Cancer, Bullous, and Others—the approach uses a five-category Xception model. The model obtained an AUROC of 99.4% and 95% accuracy after being trained on 25,010 pictures.

S. Saiful Islam Badhon [4], This study assesses the viability of solving computer vision issues with constrained resources, especially in the setting of medical data, where patient privacy considerations limit data accessibility. The study uses five different transfer learning models based on convolutional neural networks to diagnose skin disorders.

According to ARRENMATTHEWC.ANTIOQUIA C [5], class imbalance, low inter-class variability, and substantial intra-class variance found in the majority of clinical picture datasets make skin disease classification extremely difficult. We suggest Fair Channel Enhancement (FCE), a unique module that enhances fine-grained feature representation without the need for complicated designs or extra annotations, as a solution to these problems.

Madallah Alruwaili [6] states that visible differences across patient groups make it challenging to diagnose skin diseases, such as leukemia, early skin cancer, benign neoplasms, and alternative disorders. Developing a fusion level deep learning model that enhances stability and skin disease classification performance is one of the research objectives.

The goal of Dimple Kapoor's research [7] is to assess how well convolutional neural networks (CNNs) classify skin conditions. A collection of 1,159 dermoscopy images from eight different illness categories was used to develop and analyze four well-known architectures: ResNet50, InceptionV3, EfficientNetB0, and VGG16. The Adam optimizer was used to train the models over 20 epochs with a batch size of 32. Performance metrics were evaluated and compared to results from previous research.

Deepthi Rapeti [8], Since the skin is the body's main organ, skin cancer is the most prevalent type that affects a significant number of people each year. Reducing the death rate from skin cancer is the aim of current research. Early detection of malignant melanoma makes treatment easy. Early diagnosis is crucial because the early stages of extinction indicate a high possibility of survival.

According to SHOWROV ISLAM [9], a family of artificial intelligence algorithms known as Generative Adversarial Networks consists of a discriminator and a generator that are simultaneously learned by adversarial training. Medical imaging is one of the many domains where GANs have found critical applications.

According to Kuldeep Vayadande [10], a new field of medical research interest is the application of deep learning algorithms for sickness diagnosis. Dermatoses are among the most common medical problems, and they are more visible than other types of diseases. Therefore, it is crucial and has piqued academics' curiosity to use deep learning approaches to identify skin disorders from photos.

Akasha Aquil [11]: Using dermoscopic images from the HAM10000 dataset, we examined the performance of three machine learning techniques—Support Vector Machines (SVMs), Random Forest (RF), and Decision Trees (DTs)—combined with state-of-the-art (SOTA) deep learning models, EfficientNet, MobileNetV2, and DenseNet121, for predicting skin conditions.

According to Shimi Gersome [12], quantum has always attracted a lot of attention in scientific research since it violates conventional wisdom. Recently, quantum computing has also begun to receive a lot of interest. Some of the unique difficulties in Nondeterministic polynomials (NP)-Hard issues can be solved more quickly by quantum computers than by conventional computers.

Poonam Gaur [13]: Deep learning and artificial intelligence (AI) applications in dermatology have revolutionized the identification and classification of early skin diseases. Convolutional neural networks, or CNNs, are a powerful automated diagnostic tool that outperforms conventional techniques in terms of accuracy and efficiency.

Anushree Dahiya [14]: Due to the rising prevalence of skin conditions and the need for quick and easy detection of dermatological conditions, the diagnosis of skin illnesses has attracted a lot of attention. In this study, we provide a machine-learning model that uses a customized Convolutional Neural Network (CNN) to classify nine common skin conditions into many classes.

Ahwaz Darweesh Hayder [15] is attempting to revolutionize the diagnosis of skin cancer by utilizing sophisticated artificial intelligence algorithms and big databases of dermoscopic pictures. We performed a thorough review of the literature, concentrating on the precision of skin cancer type categorization, in order to assess the efficacy of CNNs and DL in diagnosing skin disorders

Paper Title	Publication Year	Advantages	Limitation
Innovative approaches for skin disease identification in machine learning: A comprehensive study	2024	Better healthcare outcomes	Possible bias, limited validation
Hybrid Quantum-Classical Learning for Multiclass Image Classification	2025	Efficient hybrid quantum-classical learning	Complex implementation and high resource cost
A Multi-model Deep Learning Architecture for Diagnosing Multi-class Skin Diseases	2024	Covers many skin diseases with strong performance.	High computational and training cost

Explainable AI for skin disease classification using gradient-weighted class activation mapping and transfer learning in digital health to identify contours	2025	High accuracy using preprocessing and transfer learning	Limited generalizability to other datasets
Channeling Fairness: Class Imbalance-Aware Skin Disease Recognition via Fair Channel Enhancement Module	2026	Improves accuracy and generalization	Still depends on dataset quality and size
An Integrated Deep Learning Model with EfficientNet and ResNet for Accurate Multi-Class Skin Disease Classification	2025	Fusion model improves feature extraction and stability	Requires large dataset and high computation
Convolutional Neural Network-based Multi-Classification of Skin Disease with Fine-Tuned ResNet50 and VGG16	2025	High classification accuracy with efficient CNN models	Limited disease class diversity
Feature Set Clustering and Classification for Melanoma Detection using Enhanced K Nearest Neighbour	2024	Very high melanoma detection accuracy	Performance depends on image quality and features
Generative Adversarial Networks (GANs) in Medical Imaging: Advancements, Applications, and Challenges	2024	Improves diagnostics, research, and training	Training is complex and computationally expensive
Automated Multiclass Skin Disease Diagnosis using Deep Learning	2024	Accurate automated multi-class skin disease detection	May not fully replace expert clinical diagnosis
Early Detection of Skin Diseases Across Diverse Skin Tones Using Hybrid Machine Learning and Deep Learning Models	2025	Hybrid ML + DL improves diagnostic performance	Performance depends on dataset quality and balance
Team shm2024 on Quantum Feature Selection	2024	Efficient feature selection using quantum methods	Performance gain may vary across datasets

A CNN-Based Review of Artificial Intelligence in Dermatology of Skin Disease Diagnosis	2025	High accuracy and efficiency with CNN models	Clinical deployment challenges and validation needed
GlowSkinFit: machine learning and CNN-based approaches for accurate skin disease detection	2026	Effective multi-class skin disease classification	Validation accuracy lower than training accuracy
Skin Disease Recognition Based On Deep Learning Algorithms: A Review	2024	Improves early and accurate skin cancer detection	Depends on large high-quality image datasets

III. EXISTING SYSTEM

Deep learning models like CNNs, DenseNet, and Vision Transformers that have been trained on massive datasets with significant computational resources are the mainstay of current skin disease categorization systems. Although these models are highly accurate, their performance depends on strong GPUs, large amounts of memory, and balanced data. When datasets are unbalanced and rely on fixed convolutional kernels for feature extraction, they frequently become biased toward majority classes. Current QML research lacks practical application in real-world medical imaging and mostly concentrates on balanced benchmark datasets with greater qubit counts, such as MNIST. Furthermore, after training, a lot of quantum models cannot be used again. These drawbacks emphasize the necessity of a hybrid quantum-classical solution that is lightweight, imbalance-aware, and reusable.

IV. CONCLUSION

Using just a 4-qubit system, this work shows that a hybrid quantum-classical strategy for multi-class skin disease classification is feasible. The model effectively manages high-dimensional and unbalanced medical image data by combining QCNN for quantum feature extraction, VQC for classification, PCA for dimensionality reduction, and a class-weighted loss function. The method's efficacy and generalizability are confirmed by the acquired accuracy of 70.13% on the test set and 70.83% on unseen samples. This study demonstrates the usefulness of QML under NISQ limitations, particularly for resource-constrained contexts, even though classical deep learning models perform better in raw accuracy. The applicability of trained quantum circuits in practical diagnostics is further reinforced by their reusability. Future quantum-driven healthcare applications will benefit greatly from this research.

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