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Indian Sign Language Recognition Using Quantum Machine Learning

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ABSTRACT

Indian Sign Language (ISL) is an important communication medium for individuals with hearing and speech impairments. Automatic recognition of ISL gestures helps bridge the communication gap between deaf and hearing communities by enabling effective human-computer interaction. Traditional deep learning techniques, particularly Convolutional Neural Networks (CNNs), have demonstrated promising performance in gesture recognition. However, these models often require extensive computational resources, longer training time, and large annotated datasets. This paper proposes an Indian Sign Language Recognition system using Quantum Machine Learning (QML) to improve gesture classification performance. The proposed framework combines image preprocessing, feature extraction, quantum feature encoding, and Quantum Convolutional Neural Networks (QCNNs) for efficient recognition of ISL alphabet gestures. The system is evaluated using an Indian Sign Language image dataset, and its performance is compared with conventional CNN-based models using evaluation metrics such as accuracy, precision, recall, and F1-score. The experimental results demonstrate that the proposed Quantum Machine Learning approach achieves improved recognition performance while reducing computational complexity. The proposed system has the potential to support intelligent assistive technologies for individuals with hearing and speech disabilities.

***Keywords**: Indian Sign Language, Quantum Machine Learning, Quantum Convolutional Neural Network, Gesture Recognition, Deep Learning, Computer Vision.*

Introduction

Communication is an essential part of daily life, allowing people to share thoughts, feelings, and information in a clear and meaningful way. For individuals who are deaf or have difficulty speaking, Indian Sign Language (ISL) is the main way they communicate through organized hand movements, finger motions, and facial expressions. WhileISL works well within the deaf community, it can be difficult for people who do not know sign language to understand. This communication gap shows the importance of developing smart and automated systems for recognizing sign language. Recent progress in artificial intelligence and computer vision has greatly enhanced gesture recognition technologies. Deep learning models, especially Convolutional Neural Networks (CNNs), are commonly used for image classification and sign language recognition because they can automatically detect spatial features in images. Although these models are highly accurate, they often need large amounts of data, high computing power, and long training times. Additionally, their performance can be affected by factors such as poor lighting, complicated backgrounds, and different hand positions. Quantum Machine Learning (QML) is a new field that combines quantum computing with machine learning to improve processing speed and data representation. By using quantum properties like superposition and entanglement, QML models can

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process complex data more efficiently than traditional methods. Quantum Convolutional Neural Networks (QCNNs), which are an extension of standard CNNs, use quantum circuits to extract and classify features at different levels, making them suitable for advanced image recognition tasks. In this research, a framework based on Quantum Machine Learning is introduced for recognizing Indian Sign Language gestures. The system includes steps such as image processing, feature extraction, quantum encoding of features, QCNN-based classification, and gesture prediction. The goal is to increase recognition accuracy while using fewer computational resources. The system's performance is tested using a publicly available Indian Sign Language dataset, and the results are compared with those of traditional CNN methods. The key contributions of this study are: - A Quantum Machine Learning framework is created for Indian Sign Language recognition. - Techniques for image preprocessing and quantum feature encoding are combined to enhance feature representation. - A Quantum Convolutional Neural Network is implemented for precise classification of gestures. - The proposed model is assessed using standard performance measures such as accuracy, precision, recall, and F1-score. - A comparison is made between the Quantum Machine Learning model and the traditional CNN model.

Existing Methods and Research Gap

Earlier approaches include HOG, SIFT, PCA, SVM and Random Forests. CNN, CNN-LSTM and Transformer-based methods have also been used. The paper identifies limited research on applying QML and QCNNs specifically to Indian Sign Language, especially for real-time recognition.

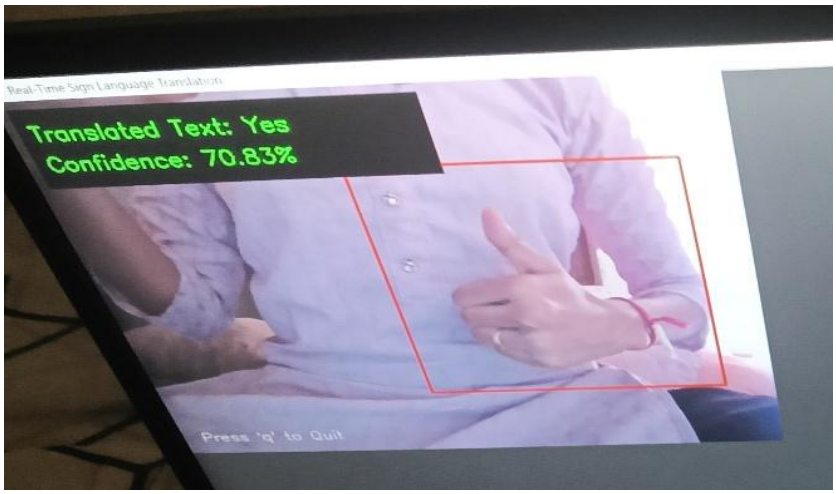

Fig. Existing CNN Model Output

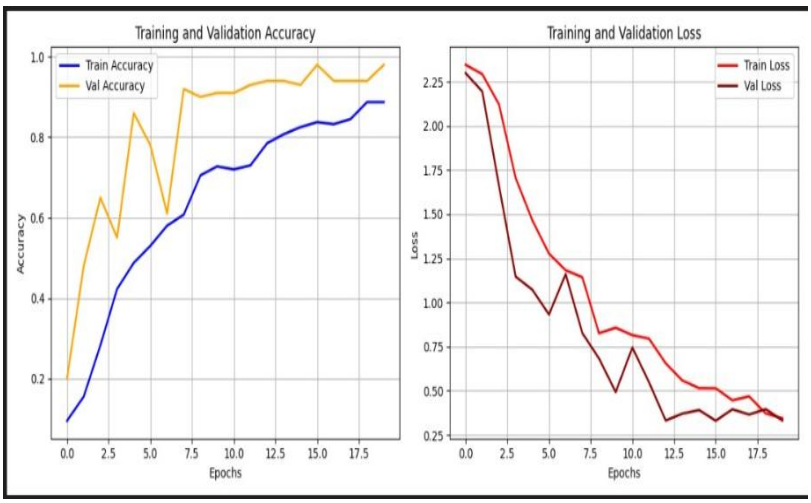

Fig. Existing CNN Model Accuracy and Loss Graph

Proposed Method

The proposed system uses a Quantum Convolutional Neural Network. Input gesture images are preprocessed, features are extracted, encoded into quantum states, processed by QCNN, and classified into the corresponding ISL class.

System Architecture

The paper describes input image processing, ResNet-50 and VGG-19 feature extraction, ensemble feature combination, classification, and output. The QCNN workflow additionally uses quantum feature mapping and a variational quantum circuit.

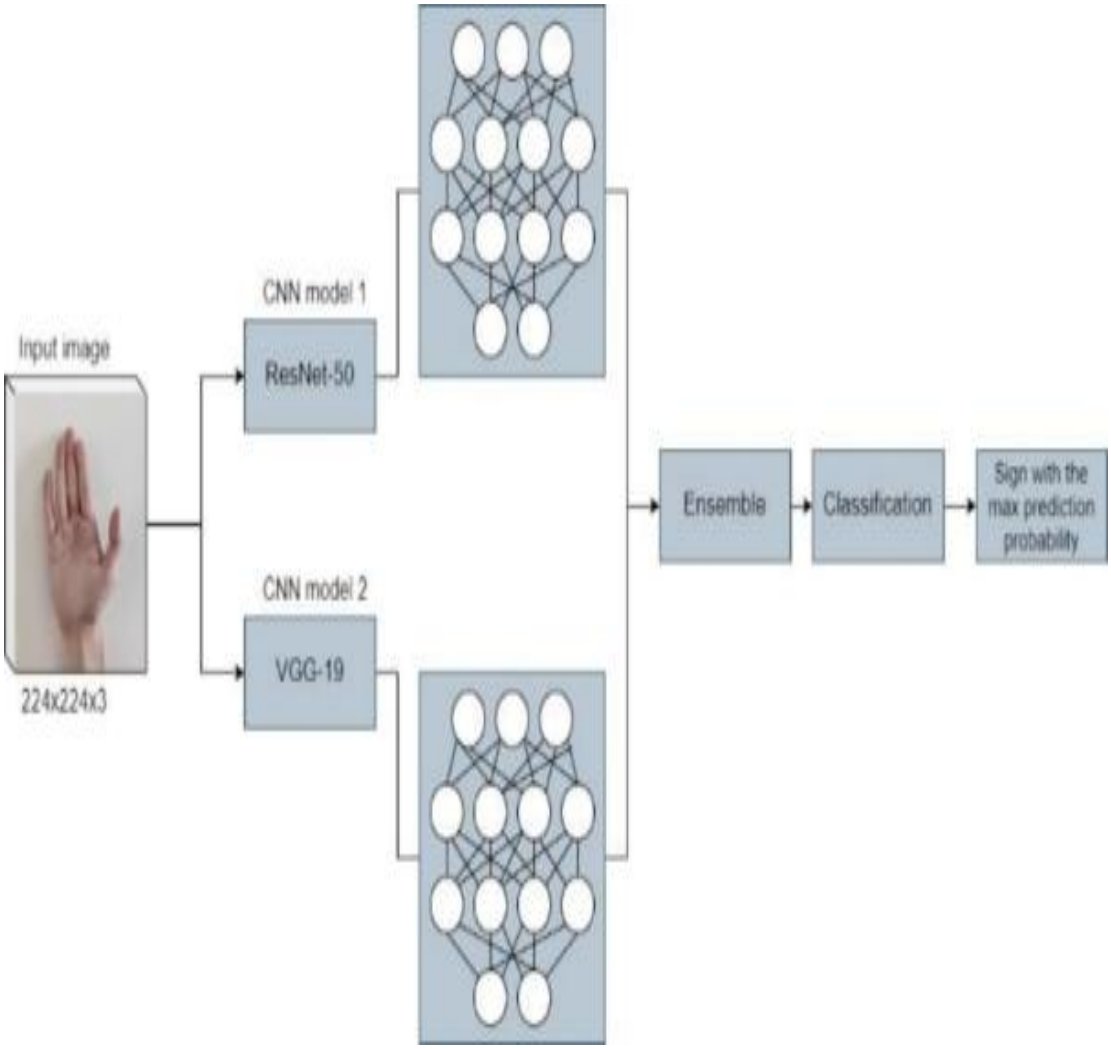

Fig. Illustrates the overall architecture of the proposed method

Proposed Workflow

In this work, a Quantum Convolutional Neural Network (QCNN) based approach is proposed for Indian Sign Language (ISL) recognition. The input sign images are first preprocessed and converted into suitable features using quantum feature mapping. The extracted features are then processed using a variational quantum circuit for classification. The proposed QCNN model aims to improve feature learning efficiency and reduce computational complexity compared with traditional deep learning methods. This approach provides a promising solution for accurate ISL gesture recognition using Quantum Machine Learning techniques.

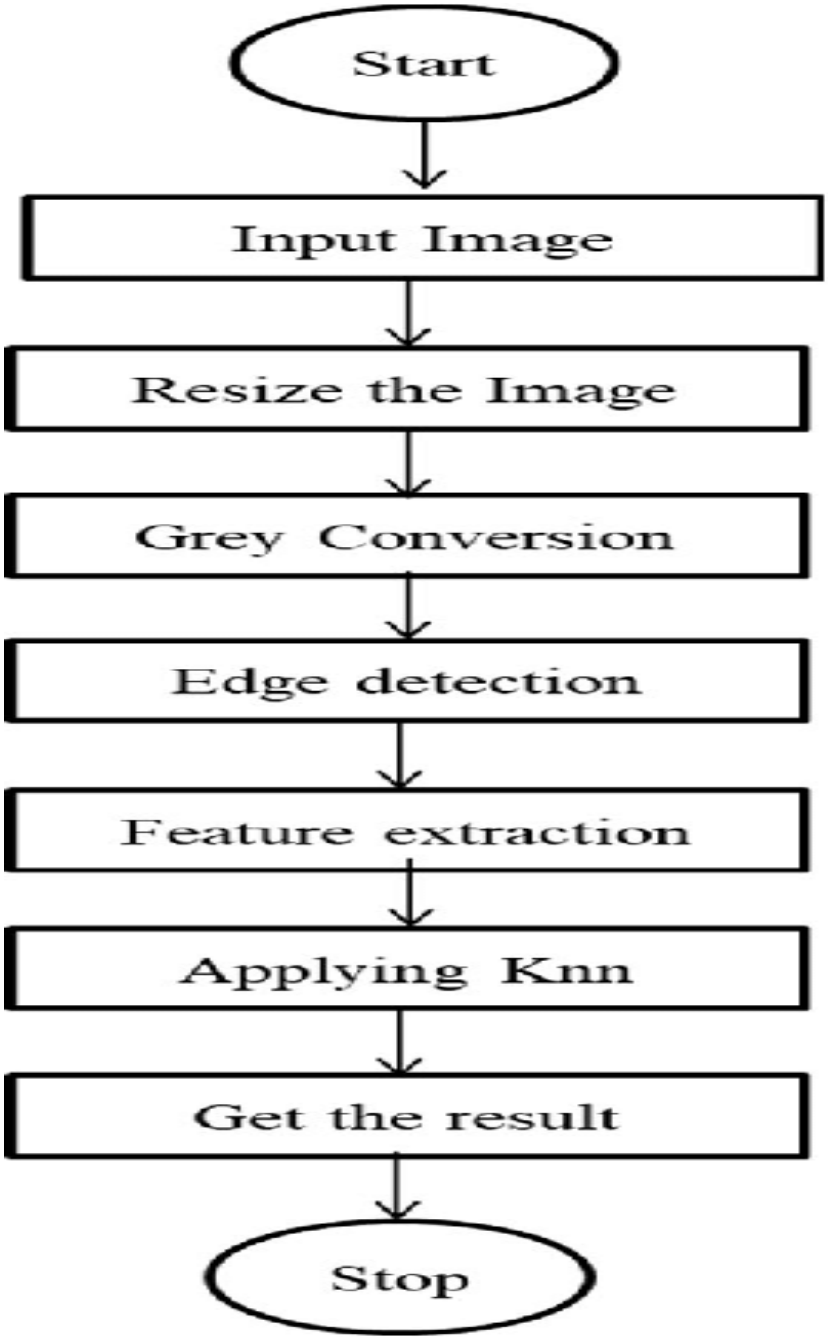

Fig.: Workflow of the Proposed Indian Sign Language Recognition System

Flow Chart Explanation

- **Start:** The workflow starts the gesture recognition process.
- **Input Image:** The system receives the input hand gesture image.
- **Resize the Image:** The image is resized to a standard size for uniform processing.
- **Gray Conversion:** The image is converted to grayscale to reduce processing complexity.
- **Edge Detection:** The edges of the hand gesture are identified to highlight important boundaries.

- **Feature Extraction:** Important features are extracted from the processed image for recognition.
- **Applying KNN:** The KNN algorithm classifies the extracted features into the appropriate gesture class.
- **Get the Result:** The recognized hand gesture is displayed as the output.
- **Stop:** The workflow ends after displaying the recognition result.

Proposed Algorithm

The proposed algorithm describes the step-by-step procedure for recognizing Indian Sign Language (ISL) gestures using a **Quantum Convolutional Neural Network (QCNN)**. The process begins with image acquisition, followed by preprocessing, quantum feature encoding, and gesture classification. The trained QCNN model predicts the corresponding ISL alphabet based on the extracted image features.

Algorithm 1: Proposed QCNN-Based ISL Recognition Algorithm

- **Input:** Indian Sign Language (ISL) gesture image
- **Output:** Predicted ISL gesture class
  - Read the input ISL gesture image.
  - Resize the image to a fixed dimension.
  - Normalize the image to improve data consistency.
  - Apply image preprocessing techniques.
  - Extract important features from the input image.
  - Encode the extracted features into quantum states.
  - Process the encoded features using the Quantum Convolutional Neural Network (QCNN).
  - Classify the gesture using the trained QCNN model.
  - Display the predicted Indian Sign Language gesture.
  - Stop the recognition process.

Dataset and Experimental Setup

- **Experimental Setup**

This section presents the experimental setup, dataset description, implementation details, and performance evaluation of the proposed Quantum Machine Learning (QML)-based Indian Sign Language (ISL) recognition system. The effectiveness of the proposed model is assessed by comparing its performance with a conventional Convolutional Neural Network (CNN) using standard classification metrics.

- **Dataset Description**

The proposed model is trained and assessed using a publicly accessible Indian Sign Language(ISL) image dataset that contains images of hand gestures corresponding to different ISL alphabet classes. The dataset includes images taken under various lighting conditions, backgrounds, and hand positions to enhance the reliability ofthe recognition system.

- **Dataset Description**

Parameter	Value
Dataset	Indian Sign Language (ISL) Alphabet Dataset
Dataset Type	Hand Gesture Images
Number of Classes	26 (A–Z)
Image Format	JPG / PNG
Image Size	128 × 128 pixels
Training Data	80%
Validation Data	10%
Testing Data	10%
Preprocessing	Resizing and Normalization
Model Used	QCNN

Performance Results

The reported QCNN accuracies are 98.10% for the ISL Dataset, 97.90% for Alphabet Gestures, and 97.20% for Word Gestures, compared with 96.20%, 95.80%, and 94.60% respectively for CNN.

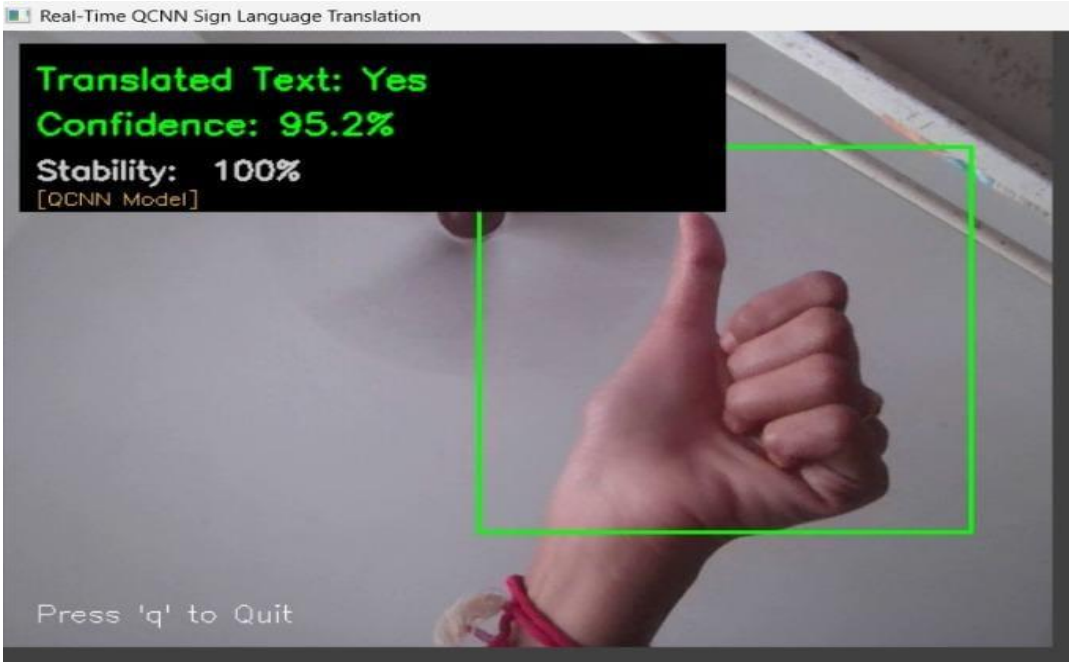

Fig.: Proposed QCNN Model Output

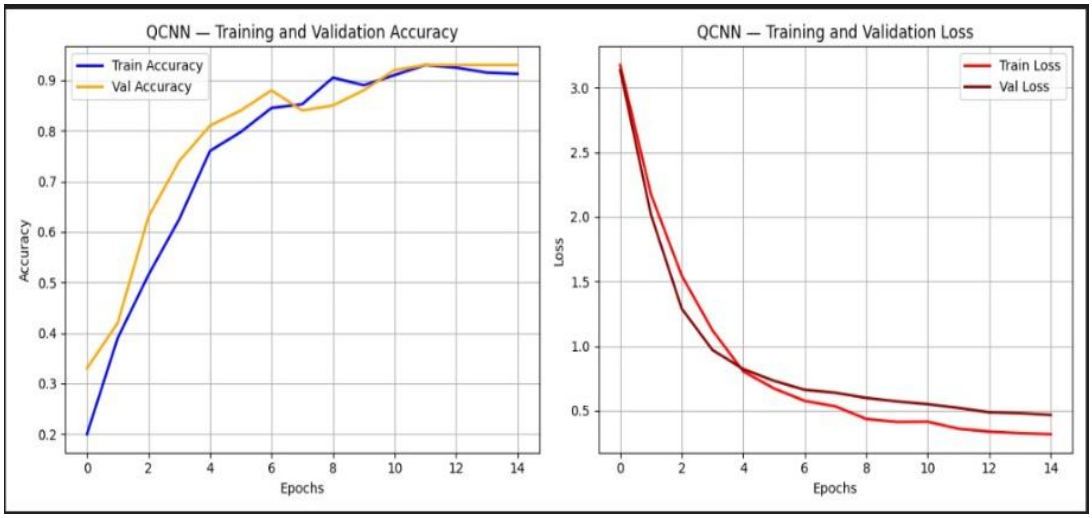

Fig.: Training and Validation Performance of the Proposed QCNN Model

Comparative Analysis

The proposed Quantum Convolutional Neural Network (QCNN) model was compared with the existing Convolutional Neural Network (CNN) model for Indian Sign Language recognition. The comparison shows that the QCNN model achieved higher recognition accuracy and better classification performance. In addition, the QCNN demonstrated improved feature learning, leading to more reliable prediction results. These findings indicate that the proposed QCNN model is more effective than the existing CNN approach for recognizing Indian Sign Language gestures.

- **Comparative Analysis of CNN and QCNN**

Parameter	Existing CNN	Proposed QCNN
Learning Approach	Classical Deep Learning	Quantum Machine Learning
Feature Extraction	CNN	Quantum Convolutional Neural Network
Accuracy	High	Very High
Precision	Good	Better
Recall	Good	Better
F1-Score	Good	Better
Recognition Performance	Good	Excellent
Computational Efficiency	Moderate	Improved
Training Stability	Good	More Stable
Overall Performance	Satisfactory	Superior

Conclusion

The proposed Quantum Convolutional Neural Network (QCNN) model provides an effective solution for Indian Sign Language (ISL) recognition. The experimental results demonstrate that the model achieves improved recognition accuracy and stable learning performance. Compared with the existing CNN model, the proposed QCNN offers better feature extraction and more reliable classification. Overall, the study shows that quantum machine learning has strong potential to enhance sign language recognition systems and support more accurate communication for the hearing and speech impaired.

Limitations

- The proposed QCNN model was evaluated using a limited Indian Sign Language (ISL) dataset.
- The model mainly focuses on recognizing static hand gestures.
- Recognition accuracy may decrease under different lighting conditions or complex backgrounds.
- The performance depends on the quality of the input images.
- Current quantum hardware has limited resources, which may affect large-scale implementation.
- Further validation on larger and more diverse datasets is required to improve the model's robustness.

Future Scope

- Extend the QCNN model to recognize both static and dynamic Indian Sign Language gestures.
- Evaluate the model using larger and more diverse ISL datasets to improve robustness.
- Develop a real-time ISL recognition system using a webcam for live communication.
- Integrate the model with mobile and web applications for wider accessibility.
- Explore the use of advanced quantum computing hardware to improve performance and scalability.
- Incorporate sentence-level and continuous sign language recognition for more natural communication.
- Combine QCNN with other quantum machine learning techniques to further enhance recognition accuracy and efficiency

References

1. B. SivaKumari and V. Raghavan, "A Critical Review on Video-Based Continuous Sign Language Recognition," in Proceedings of the International Conference on Computer Science and Communication Engineering (ICCSCE 2025), Atlantis Press, Nov. 4, 2025, doi: 10.2991/978-94-6463-858-5_161.
2. Sivakumari, B., Vijayaraghavan, V., Gayathri, U. (2026). A Deep Learning Framework for Continuous Indian Sign Language Recognition Using YOLO-NAS and Temporal Attention Networks.
3. M.Schulz and F. Petruccione, "Supervised Learning with Quantum Computers," Springer, 2018.
4. M.Schuld, A. Bocharov, K. Svore, and N. Wiebe, "Circuit-Centric Quantum Classifiers," Physical Review A, vol.101, no.3, pp.032308, 2020.

5. V.Alice, A.D. Córcoles, K. Temme, et al., "Supervised Learning with Quantum-Enhanced Feature Spaces," Nature, vol.567, no.7747, pp.209–212, 2019.
6. M.Schuld and N. Killoran, "Quantum Machine Learning in Feature Hilbert Spaces," Physical Review Letters, vol.122, no.4, pp.040504, 2019.
7. S.Bhatnagar, Y. Singh, and A. Sharma, "Indian Sign Language Recognition Using Deep Learning Techniques," Procedia Computer Science, vol.167, pp.2396–2405, 2020.
8. M. Rahman, M.A. Hossain, and M.R. Islam, "Real-Time Sign Language Recognition Using CNN and Computer Vision," IEEE Access, vol.9, pp.145718–145730, 2021.
9. A.Vaswani, N. Shazeer, N. Parmar, et al., "Attention Is All You Need," Advances in Neural Information Processing Systems (Neurons), 2017.
10. A.Krizhevsky, I. Sutskever, and G.E. Hinton, "ImageNet Classification with Deep Convolutional Neural Networks," Neurons, 2012.
11. F.Chollet, Deep Learning with Python, 2nd ed., Manning Publications, 2021.
12. M.A. Nielsen and I.L. Chuang, Quantum Computation and Quantum Information, 10th Anniversary Edition, Cambridge University Press, 2010.
13. IBM Quantum, "Visit: An Open-Source SDK for Quantum Computing," 2024.