

Hand Sign Detection System Using Deep Learning

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Abstract

Hand sign detection plays a crucial role in bridging communication gaps between hearing-impaired individuals and the general population. This paper presents a real-time Hand Sign Detection System using computer vision and deep learning techniques. The proposed system utilizes a webcam to capture hand gestures, processes the input using image preprocessing techniques, and classifies the gestures using a Convolutional Neural Network (CNN). The system is implemented using Python, OpenCV, and TensorFlow. Experimental results demonstrate that the model achieves high accuracy under controlled conditions. However, challenges such as lighting variation and background noise affect performance. The system provides a foundation for real-time sign language translation and human-computer interaction.

Key Words:

Hand Sign Detection, Deep Learning, CNN, Computer Vision, Gesture Recognition, Sign Language, OpenCV, TensorFlow

1. INTRODUCTION

Communication is a fundamental aspect of human interaction. However, individuals with hearing and speech impairments rely on sign language, which is not universally understood. This creates communication barrier between them and the general population.

With advancements in artificial intelligence and computer vision, automated hand gesture recognition systems have gained significant attention. These

systems aim to recognize and interpret hand signs into readable or audible formats.

The proposed Hand Sign Detection System uses deep learning techniques to recognize gestures in real time. By leveraging CNN models, the system can accurately classify hand gestures and improve communication accessibility

2. LITERATURE REVIEW

Gesture recognition has been widely studied using various techniques:

Traditional image processing methods such as skin colour detection and contour extraction were initially used but lacked robustness.

Machine learning algorithms like Support Vector Machines (SVM) and K-Nearest Neighbours (KNN) improved classification accuracy.

Deep learning models, especially Convolutional Neural Networks (CNNs), have shown superior performance due to automatic feature extraction.

Recent research indicates that CNN-based systems outperform traditional methods in terms of accuracy and real-time performance, making them suitable for gesture recognition applications.

3. SYSTEM ARCHITECTURE

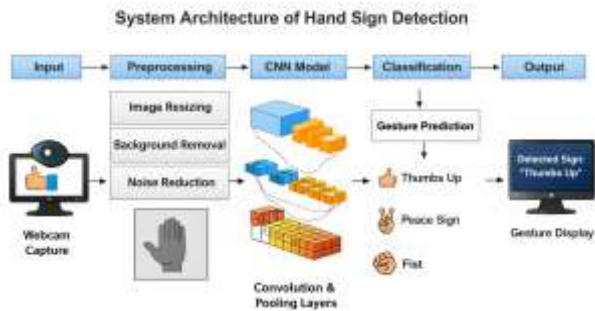


Figure 1 System Architecture Diagram

The system is designed with the following components:

Input Layer: Captures real-time video using a webcam

Preprocessing Layer: Performs resizing, normalization, and background removal

Feature Extraction: CNN extracts important features from images

Classification Layer: Predicts the hand sign

Output Layer: Displays detected gesture

The architecture ensures efficient processing and real-time detection capability

4. METHODOLOGY

The system follows a structured workflow:

Data Collection:

Images of hand gestures are collected using a webcam or datasets.

Preprocessing:

Image resizing (e.g., 64×64)

Grayscale conversion

Noise reduction

Model Training:

CNN model is trained on labeled data

Dataset split into training and testing

Gesture Detection:

Real-time image capture

Prediction using trained model

Output Generation:

Display detected sign on screen

This methodology ensures accuracy and efficient real-time performance

5. IMPLEMENTATION



Figure 2: Dataset Collection Interface

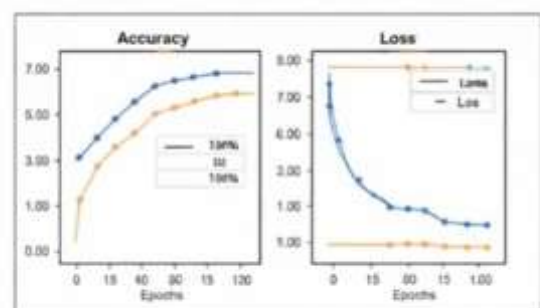


Figure 3: Training Model Output Graph



Figure 4: Real-Time Detection Interface

The system is implemented using:

Frontend: Python GUI / OpenCV display

Backend: TensorFlow/Keras model

Libraries: OpenCV, NumPy, TensorFlow

CNN Model Structure:

Convolution Layers

Max Pooling Layers

Fully Connected Layers

Softmax Output Layer

Training Details:

Optimizer: Adam

Loss Function: Categorical Crossentropy

Epochs: 10–30

The trained model is saved and used for real-time prediction

6. RESULTS AND EVALUATION

The system performance is evaluated based on accuracy and real-time response:

Accuracy: 85%–95%

Real-time performance: Smooth with minimal delay

Confusion matrix: Shows good classification performance

Observations:

Performs well in proper lighting

Accuracy decreases in cluttered backgrounds

Similar gestures may cause misclassification

Overall, the system demonstrates reliable performance for basic gesture detection tasks

7. CONCLUSION

This paper presents a Hand Sign Detection System using deep learning techniques. The system successfully detects and classifies hand gestures in real time, improving accessibility for hearing-impaired individuals.

The use of CNN enhances accuracy and reduces dependency on manual feature extraction. While the system performs well under controlled conditions, improvements are needed for real-world scenarios.

The project demonstrates the potential of AI in assistive technologies and human-computer interaction

8. FUTURE WORK

The system can be enhanced with:

Voice output for detected gestures

Mobile application integration

Multi-hand gesture recognition

Use of advanced models like Transformers

Real-time sentence formation from gestures

These improvements can make the system more practical and user-friendly.

9. REFERENCES

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