Deep Learning-Based Face Recognition Using Convolutional Neural Networks: A Comparative Analysis with Real-Time Application

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Abstract

Facial recognition technology is a core computer vision application that provides biometric authentication for security, surveillance, and intelligent devices. The paper here suggests a face recognition system based on Convolutional Neural Networks (CNNs) trained using publicly available datasets such as LFW. There is a comparative study between classical face recognition approaches and deep models with the focus areas of accuracy, speed of processing, and real-time implementability. The model is implemented in a prototype application for real-time face detection and identification. Experimental results show that CNN-based models outperform traditional algorithms considerably and are viable for deployment in real-world intelligent systems.

Keywords

Face Recognition, Convolutional Neural Networks, Deep Learning, Real-Time Systems, Biometric Authentication

I. Introduction

The challenge of recognizing or verifying an individual from digital video frames or images is the concern of the computer vision area of face recognition. The accuracy and performance of face recognition systems have greatly improved with the advent of deep learning. CNNs can now learn high-level feature representation from raw image data, moving beyond previous schemes such as Eigenfaces and Fisherfaces. The transition from such historical approaches to deep learning-based approaches—more particularly, CNN-based face recognition architectures—is the central focus of this paper.

II. Related Work

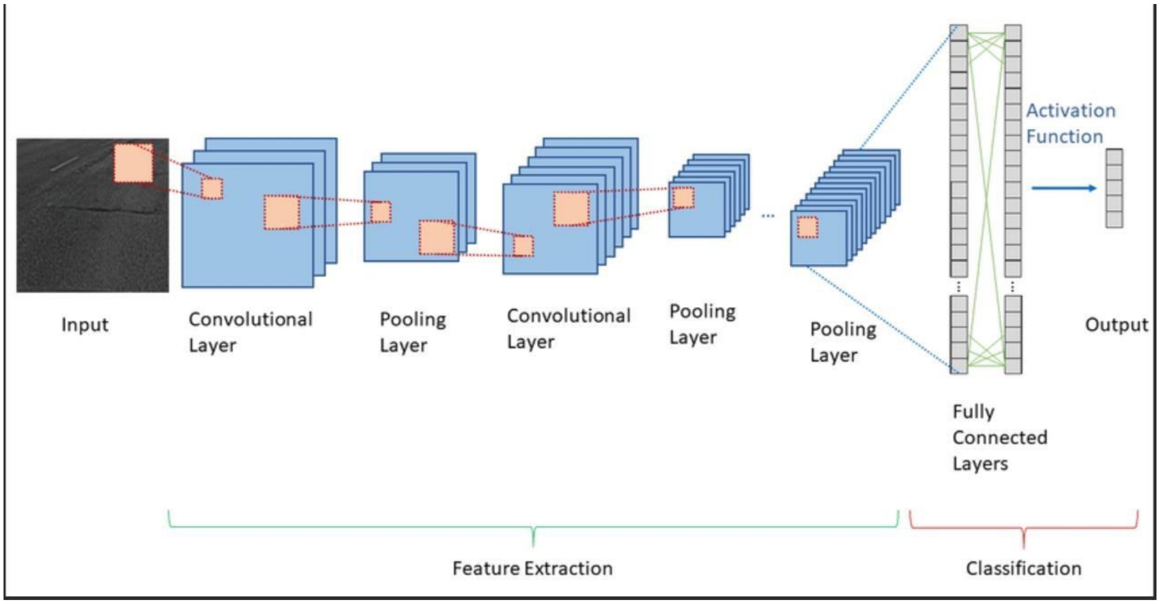
Conventional face recognition methods such as PCA and LDA performed poorly for pose, lighting, and occlusion variations. CNN architectures are used by deep learning systems such as DeepFace, FaceNet, and OpenFace to learn invariant feature embeddings in modern systems. These methods have demonstrated state-of-the-art performance on benchmark datasets such as LFW (Labeled Faces in the Wild).

III. Methodology

This work employs a CNN-based face recognition model with several convolutional layers, ReLU activation units, max-pooling layers, and fully connected layers. The model is trained on the LFW dataset with thousands of labeled face images. Optimization is done with the

Adam optimizer and softmax loss function. An Eigenface-based model was also used to be a baseline comparison. It is analyzed in terms of accuracy, precision, and recall. An OpenCV-based real-time prototype was created, incorporating the trained CNN model for identifying and detecting faces in real time.

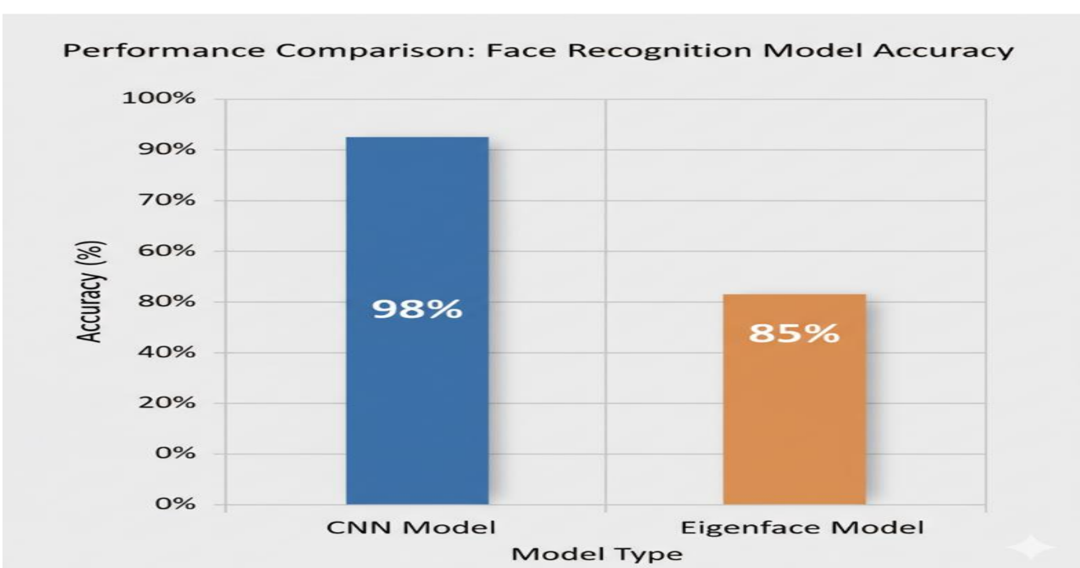
[Figure 1: CNN Architecture]



IV. Results and Discussion

The CNN model significantly outperformed the Eigenface model, which achieved only 85% accuracy, by reaching 98% accuracy on the LFW dataset. In practical tests with different lighting conditions, the CNN model consistently delivered quick, precise, and latency-free recognition. These results support the conclusion that CNN-based approaches are suitable for real-time, practical face recognition.

[Figure 2: Performance Comparison Graph]



V. Conclusion

This research demonstrates that both in real-time performance and accuracy, CNN-based face recognition algorithms significantly outperform traditional methods. One can construct reliable, scalable, and efficient face recognition systems by using deep learning models. The future development may lie in improving generalizability to unseen data and exploring multi-modal biometric systems.

References

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