Chapter 3
A Comprehensive Review Concerning the Involvement of Artificial Intelligence Techniques in Face Recognition System

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ABSTRACT

This paper surveys the key methodologies used in the field of Face Recognition Systems, categorizing them into traditional techniques, machine learning approaches, deep learning models, and hybrid systems. Traditional methods such as Eigenfaces and Fisherfaces laid the foundation for face recognition by utilizing linear projection techniques. Machine learning methods like Support Vector Machines (SVM) and Random Forests have improved performance, particularly in scenarios with smaller datasets. The advent of deep learning has marked a significant turning point, with models like Convolutional Neural Networks (CNNs) and frameworks such as

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FaceNet and DeepFace achieving state-of-the-art accuracy and robustness across varying conditions, including illumination, occlusions, and facial expressions. Future directions discussed in this paper include advancements in explainable AI, fairness, federated learning, and scalable architectures to address these challenges while improving the robustness and scalability of face recognition systems.

INTRODUCTION

Face recognition technology has evolved significantly, transitioning from early feature extraction methods to advanced deep learning-based approaches. Initial methods such as Eigenfaces (Turk & Pentland, 1991) and Fisherfaces (Belhumeur et al., 1997) leveraged global feature extraction techniques based on Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA), respectively. These approaches were effective in controlled environments with consistent lighting and pose but struggled under real-world variations such as occlusion and diverse facial expressions. To overcome these limitations, local feature-based techniques like Local Binary Patterns (LBP) and Histogram of Oriented Gradients (HOG) were introduced (Budiman et al., 2023; Jiang, 2020). These methods emphasized extracting localized features, making them more robust to changes in illumination and pose. For instance, HOG focuses on gradient-based edge detection, while LBP captures texture features, enhancing the recognition of faces with challenging lighting conditions.

The true revolution in face recognition occurred with the advent of deep learning and Convolutional Neural Networks (CNNs). State-of-the-art models like FaceNet (Schroff et al., 2015) and DeepFace (Taigman et al., 2014) introduced hierarchical feature extraction directly from pixel data, enabling systems to map faces into high-dimensional feature spaces for superior accuracy and robustness in face verification and identification tasks. These systems addressed challenges like occlusions and diverse environmental conditions, marking a significant leap in performance. Furthermore, transfer learning methods, such as MobileNet V2, have optimized face recognition for mobile and low-resource devices, enabling efficient performance on smaller datasets while maintaining accuracy. Despite these advancements, challenges remain. Face recognition systems often exhibit biases across demographic groups, such as reduced accuracy for darker skin tones or underrepresented populations (Shukla & Tiwari, 2023). Additionally, privacy concerns arise from the potential for mass surveillance and unauthorized identification. Techniques like federated learning are being explored to mitigate these issues by training models on decentralized data, ensuring sensitive information remains private (Mulpuri et al., 2023). Looking ahead, the integration of traditional feature extraction techniques with deep

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