DEEP LEARNING BASED PREDICTIVE FACE RECOGNITION: ADAPTING TO AGING AND FACIAL VARIABILITY

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Abstract

Artificial intelligence-based face recognition systems have become essential in areas such as attendance tracking, government authentication, and fraud detection. However, their accuracies are hindered by physical changes in individuals, such as aging and cosmetic alterations, leading to mismatched identifications. The proposed research addresses these challenges by employing deep convolutional neural networks (CNNs), to enhance the robustness of face recognition systems. It begins with a comprehensive auto analysis to create an image dataset. When a face is detected with an 80% match, the system activates to analyze changes and generates a new dataset, that integrates with the pre-trained dataset. This approach enables accurate recognition of images from five years ago to current ones, and projects future images five years ahead. Various noise conditions are introduced to enhance realism, and lighting conditions are linearized for precise calibration, resulting in accurately recognized images. The findings demonstrate that CNN effectively adapts to the variations in facial features, significantly improving the reliability of identification processes.
Keywords: Facial recognition systems, Deep CNNs, Image analysis, Identification processes, Face detection.

1. INTRODUCTION

In neoteric years, the advancement of deep neural network technology has significantly enhanced the capabilities of real- time object detection in mobile applications [1]. However, the practical demands of these applications necessitate optimizations in speed, energy consumption, and accuracy. In various real-world scenarios, particularly in face recognition and face attribute recognition. While multi-model strategy allows for specialized performance, it has a downside, as it demands considerable computational resources for context switching [2]. In recent years, AI-based face recognition systems have emerged as vital tools within the global community. Face recognition systems have made significant advancements; however, their accuracy remains a concern. These systems often struggle to perform reliably, especially when individuals undergo changes in physical appearance, such as aging, style changes, or cosmetic surgery [2]. As a result, trained models may fail to recognize faces correctly, leading to mismatches and incorrect identification outcomes. The limitations of current technologies highlight the need for ongoing research and development to enhance the robustness of face recognition systems.

There is literature showing effectiveness of deep convolutional neural networks (CNNs) [4] for image identifications. The findings suggest that implementing CNNs can effectively address the shortcomings of traditional face recognition models, facilitating better identification processes [7], [5]. The proposed research focuses on developing a deep learning based predictive face recognition capable of recognizing faces [9] despite variations in facial conditions such as scars, aging, masks, and facial hair. Moreover, the proposed model is designed to maintain performance under diverse lighting conditions and noise levels. Through rigorous training and adaptation, the classifier's resilience and accuracy are enhanced, ultimately contributing to advancements in facial recognition technology across various applications.

2. LITERATURE REVIEW

AI face recognition technology has experienced remarkable advancements, particularly through the utilization of GPU computing with TensorRT, which accelerates reasoning processes. This innovation significantly enhances the speed and performance of face recognition systems. An approach using single-model method that efficiently performs face detection recognition, and attribute analysis simultaneously is presented. Exploration of multimodal machine learning approaches that explore intrinsic nature of diverse data modalities such as vision, audio, text, and motion are analyzed. Through a thorough review of these advancements, a comprehensive idea that could further enhance our understanding and application of AI in face recognition contexts are developed Continued investigation into these mechanisms will be crucial in advancing face recognition technologies and their applications [1],[2],[3], [6] [7].

The authors in [8] investigate a face recognition system that leverages deep learning techniques to accurately identify facial images. By employing various CNN models [4], the study focuses on both face detection and categorization. While previous research has primarily concentrated on ResNet or DenseNet models individually, this study innovates by integrating both to establish a hybrid model. Moreover, existing research has failed to address key challenges such as predictive face recognition which adapts to aging, facial variability and availability. The proposed research employs deep CNNs to enhance recognition by dynamically updating datasets when an 80% match is detected, enabling accurate identification across a five-year range. Noise conditions and lighting normalization improve model robustness, ensuring reliable recognition under varying conditions.

3. METHODOLOGY

The proposed research focuses on recognizing faces despite various facial conditions such as scars, aging, masks, and facial hair. A unique feature of the proposed model is its ability to predict how an individual's facial appearance will change both five years into the past and five years into the future, with automatic data updates. Additionally, the classifier is designed to maintain high performance under diverse lighting conditions and varying noise levels. To accomplish these objectives, a deep convolutional neural network methodology is employed that stabilizes the recognition process effectively. This approach is depicted in Fig. 1, with each block's roles and functions are elaborated.

Raw face images, collected from diverse sources like surveillance cameras, are crucial for training facial recognition and emotion detection systems. These images undergo preprocessing, including resizing, normalization, and augmentation techniques like rotation and flipping, to ensure dataset diversity and standardization.

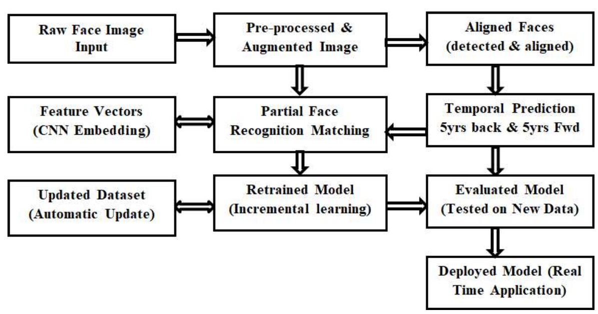

Fig. 1. Deep Learning Based Predictive Face Recognition.

Face detection and alignment, using models like MTCNN, identify key facial landmarks, while feature extraction with CNNs like ResNet generates high-level embeddings. Fine-tuning with triplet loss optimizes the model for specific datasets, enabling robust recognition even with partial face occlusion. The system dynamically updates datasets by integrating new facial data when matches are identified with high confidence, ensuring accuracy.

For temporal prediction, GAN-based models like CycleGAN predict facial changes over time while preserving identity. A Siamese network detects subtle changes, such as aging, and updates the dataset automatically. Incremental learning allows the model to adapt to new data without full retraining, using a combination of triplet and regularization loss. Model evaluation employs criterions like accuracy and F1-score to test staging on unseen data, including occlusions and aging effects. Finally, the model is deployed as a REST API or integrated into systems like surveillance, optimized for low latency using frameworks like TensorRT, ensuring real-time performance and enhanced user experience.

4. IMPLEMENTATION PERFORMANCE

Once the face is detected, alignment is applied. This step normalizes the face's orientation to make it easier to extract features. Almost 100% accuracy was received during image pre-processing and fine tuning. The image loss was below 0.5. Fig. 2 illustrates the variations in left eye distance over time, right eye distance over time, mouth width change, face height change, nose width change, and cheek width changes, showcasing predictions that reflect the face appearing slimmer or chubbier. This approach not only highlights the effectiveness of deep learning in facial analysis but also opens novel avenues for understanding personal transformations across time.

Fig. 2. Past and Future Facial Feature Changes.

In the proposed work, on partial face recognition, the evaluating scenarios where 60% of the face is obscured. The matching mechanism employed entails comparing the current feature vector derived from the obscured image with stored face embeddings. If there is an 80% match in the features, the model proceeds to update the dataset with the new data captured. To appraise the similitude betwixt feature vectors, techniques instance cosine similarity or Euclidean distance are employed. Each time a new face image is identified, the dataset is updated accordingly, which includes adding the new face and recalibrating the feature vectors. Furthermore, through incremental learning, the existing model using this enriched dataset was fine-tuned, where a gradient-based method is applied to update the model's weight effectively. This approach enhances the model's accuracy in recognizing faces under varying conditions of partial visibility.

The model's capabilities are enhanced through incremental improvements rather than starting from scratch. Following a retraining phase, the performance of the model using new data was carried out, focusing primarily on accuracy as the key metric. This criterion stipulates the segment of correct predictions, providing insight into the model's effectiveness. When analyzing the training graph that plots epochs against accuracy, we observe two crucial criterion: training accuracy and validation accuracy. Training accuracy reflects the model's staging on the data set it has already encountered, indicating how well it learns from the information provided. In contrast, validation accuracy assesses the model's propensity to postulate to unseen data, providing insights into its performance on new inputs. A disparity between these two metrics can signal potential issues in the model's learning process. For instance, achieving 100% training accuracy while having low validation accuracy advice that the model may be overfill, meaning it has memorized the training data rather than truly learning from it. Striking a balance between these metrics is crucial to ensure that the model execute well not just on familiar data but also on new, unseen datasets.

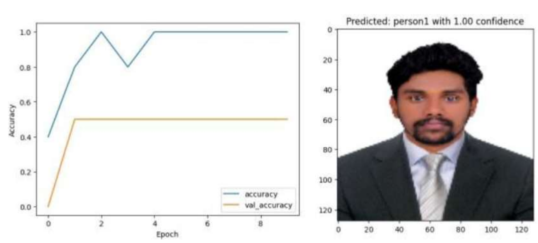

Fig. 3. Predicted Result with 1.00 Confidence

To optimize results, the scale range is compressed to 1, making it more manageable than a scale of 100. By examining 10 epochs, precise accuracy assessments, culminating in a display of 100% predicted confidence in the images processed as shown in Fig. 3

5. Result and Conclusion

The paper proposes a deep learning method to identify real-time face recognition, capable of making temporal pre- dictions and engaging in continuous learning. By utilizing CNN embeddings for feature extraction, the system excels at accurately matching faces, even when parts are occluded up to 60%. When 80% of a face is detected, the system can reconstruct missing features. Additionally, a GAN-based model is employed to visualize a person's face from five years ago and predict their appearance five years in future, effectively accounting for natural aging. This system continuously updates its dataset and retrains itself with new facial data, ensuring ongoing enhancement of accuracy and reliability. In conclusion, the proposed system presents a novel face recognition approach and offers a robust and adaptive solution, even in challenging scenarios such as partial occlusion. One of its major features is the capability to accurately predict age progression and regression over a span of five years, coupled with automatic dataset updates, which ensures that the system remains current and effective in dynamic environments. In the future enhancements in refining the temporal prediction model to achieve greater precision in age regression will be considered.

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Biographies

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