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Research Paper on Face Recognition using Artificial Intelligence

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Abstract:

The review paper traces the development of face recognition from initial approaches to current deep learning techniques (Hasan et al., 2021; Sáez-Trigueros et al., 2018). The earliest methods employed distinct features using SIFT and LBP (Balaban, 2015), but they lacked adequate solutions for complex situations. Statistical subspace methods improved the representation of faces when implemented. Deep Face systems initiated a transformative change in the field by achieving human-level performance through the extensive use of diverse datasets (Taigman et al., 2014). Research continues to develop robust face recognition systems that address ethical concerns regarding bias and privacy, as well as fairness, to create more acceptable solutions.

Keywords: Face recognition; Illumination; partial occlusion; pose invariance.

Introduction:

The smart computer vision method known as face detection identifies people through their facial characteristics. The system detects human faces as its primary method of recognition. The system uses facial characteristic pattern matching to create its outputs. The analysis examines various approaches employed in facial recognition. First, we have geometry-based techniques. Then, there are appearance-based techniques. - 'The final methods using deep learning emerge in this game.' The main objective is to evaluate the performance of the algorithm. The analysis explores how these algorithms are used for facial identification across different regions in the real world. Our modern society depends on mutual associations, so we analyze security-redefining innovative layers to understand the extensive effects of facial recognition on identity verification systems. The human face will function as the main key to access digital identities that cannot be penetrated while offering exclusive security in authentication processes. The extreme risk and need for strict security in finance, healthcare, and government sectors make facial attention the definitive protector of touch data. Healthcare facilities benefit from non-parasitic locations and location-privatization, as well as fact protection, while facial recognition offers an effective solution for effective identity verification. Healthcare structures become more effective, and effective scientific identity theft risks decrease, thanks to facial awareness technology that delivers precise results. The system enhances its capabilities and efficiency with each use, establishing a self-improvement system for identity verification. The innovative approach to identity verification exists in the form of facial identification systems.

1. Types of face recognition:

A human being can be identified using various methods, such as facial features, fingerprints, iris detection, birthmarks, or other means. Face recognition plays a crucial role in identifying humans and helps us recognize them accurately. Resolution or image quality plays a vital role in facial identification, particularly when identifying a face in CCTV or other surveillance footage. In this belief, facial detection in the image is the first step. A human face has become primarily decomposed into four characteristics such as the face, nose, lips, and mouth to identify. Facials

mainly have different textures and facial expressions in 2D and 3D.

1.1Two-Dimensional (2D) Face Recognition:

We have discussed 2D face recognition from images using the first four stages: The first step involved detecting the face, the second step was face alignment, the third step focused on feature extraction, and the fourth or final stage matched the face to the database of nominated users where the details were stored. A matrix has been calculated based on pixel values at the corners of the face under different lighting conditions for 2D face detection. Generally, a face image can be represented by a high-dimensional vector that contains pixel values. The feature matching from the available database is used to match the face image from the video, where that information is associated with a unique facial identification. Various techniques were adopted for detecting faces, such as lighting, intensity, and color. Identifying a face in 2D poses a challenging question: Who is this? Or whose face is this? Researchers face many challenges, such as expression, posture, lighting, and facial identity.

1.22D and 3D face recognition:

One of the most popular researchers, Andrea F. Abate et al., proposed reliable techniques for collective 2D visual image and 3D model face recognition based on different parameters, such as the size of input, the number of addressed tasks, and the recognition rate. A comparison of different techniques provides future perspective to the researcher for enabling new techniques for face detections. Eigenface and Stereovision techniques are used to enhance the performance of 2D face recognition systems with 3D information, specifically the disparity of faces. All we detect in a face is that we use a neural network that helps us to recognize the face from 2D and 3D images. Principal Component analysis (PCA) for features extraction and recognition were effectively used.

Face Identification is shown in Figure 1.

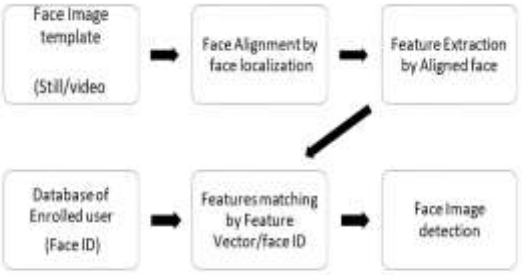


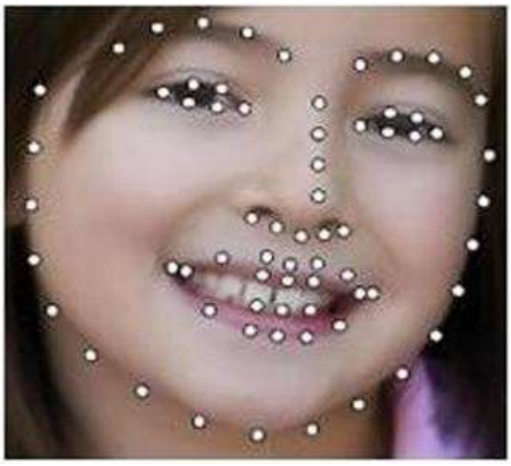
Fig 1: Face Identification Process

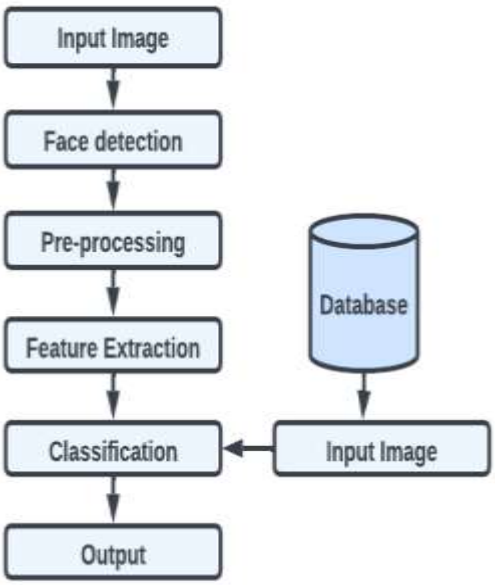
1.33D Face Recognition:

The 3D face recognition system processes real images through three-dimensional models and diverse textures while using multi-dimensional frameworks. The precise identification of face images solves the issues created by variations, partial blocking, and different lighting situations. Sima Soltanpura et al., together with other researchers, developed a survey for 3D face recognition that relied on local features. The research team split the local description into three sections, which include curves, key points, and surfaces. Ge Wen et al.. developed face recognition systems that integrated domain improvements. The improvement demonstrated a single CNN model without face alignment to achieve 99.33% accuracy. The researchers agree on several points, but they maintain distinct approaches regarding 3D face recognition.

1.4 Face Recognition Measure:

Experts consider face detection as a top-notch method for threat recognition. The face elements contain various distinct face marks along with unique peaks and valleys that define the facial structure. Every human face contains eighty distinct nodal features. The points needed for face recognition detection include eyes with varying distances and nostrils together with cheekbone shapes and jawline measurements. The face recognition dimension can be measured in Figure 2.





1.5Face Recognition Process:

The face recognition model first captures an image/video as the input and then detects a face from the image. After that, the main important step is pre-proclamation, in which the shape, compression, and normalization on the image are applied, to remove the facilities such as the eyes, nose, and lips from the face to extract the facilities such as the eyes, nose, and lips and classify an image with the test database image to match whether that image has been certified or not. Therefore, there are three stages of the facial recognition process: the facial detection is detected by the image or video. To know the exact location/coordinates of the facial, apply preprosying and remove the face for further processing, then harvest the extraction-by-crop with image and features to extract features from it. Embedding based on recognition-recognition-perception about every face in the data is saved in a file and classifies whether a person's face coincides or not.

1.6Methodology:

Through pattern recognition methods, face detection identifies people present in visual content. The detection system finds human faces before comparing them against existing facial information databases. The system begins another detection procedure when it fails to identify or authenticate faces. The decision-making process operates within five seconds. Digital cameras serve as the first step to initiate the procedure. The system proceeds to crop the detected face before extracting essential features from it. The system analyses face features against stored facial data to establish a match or not. The system verifies or recognizes the face whenever it detects a match. The system allows us to both identify faces and authenticate people through its functionality.

2. Challenges of Face Recognition:

To recognize a face or verify a human face, we face some challenges that are given below:

I. Aging:

Here, face in terms of numerous textures involves typical value changes over some time and indicates aging. Aging is a natural, inevitable process

throughout the life of an individual compared to other facial variations. The effect of aging can be seen under three primary unique features:

A) The Aging is uncontrollable: It cannot be accelerated or even postponed, and it is slow and irreversible.
B) Personalized Aging Signs: Each human goes through various aging patterns. Aging is based on his face genes and numerous other conditions, like health, food, region, and many more.
C) The Aging signs depend on time: The face of a person at a particular age will be influenced by aging marks as he is aging face, but not influenced in young age.

II. Thermal Image:

Thermal images display temperature distributions found in bodies or scenes through visual representation. The infrared camera functions by detecting the infrared radiation that bodies emit according to their temperature levels. The temperature variations across object surfaces become visible through different color representations in thermal images. The main drawback of thermal imaging for face recognition techniques is its reduced image clarity when compared to visible light images. Traditional images produce clearer details of facial features and texture than thermal images do, which hinders face detection algorithms from precise individual human face recognition. The reliability of thermal imaging for face recognition or detection gets impacted by environmental temperature changes and variations in thermal signatures resulting from different conditions.

III. IRIS:

IRIS represents the most essential facial component because it exists within eyes, and its feature extraction serves as a critical element in face detection systems. The available IRIS recognition systems operate through bio-hashing techniques. The IRIS mapping and robustness improvement process will be conducted on six databases, followed by result tabulation for IRIS recognition. The recognized system demonstrates robust performance in detecting faces through its effective operation.

III. Occlusion:

The face recognition technique works during challenging conditions where system identification of individuals becomes more difficult because someone covers their face. Occlusions develop from several sources, including face accessories such as glasses, hats, and masks, as well as facial hair components like moustaches and beards, and also from shadows that fall on the face. The face recognition system faces difficulties in matching partially visible faces to store templates or reference faces because the missing or altered facial features affect its recognition process. The system produces three potential errors: it rejects valid subjects, fails to identify them correctly or verifies them incorrectly.

Yu-Feng et al.. researched single-sample face recognition systems that handled occluded faces while being robust and sparse. The method employed learning-based PCA for building the intra-class variant dictionary while optimizing a multi-scale spare coding model. The model operated as a discriminative multi-scale system, which functioned rapidly for detecting faces with occlusions. The recognition of faces with partial obstruction in extensive databases relied on generic dictionary methods that incorporated structural sparsity.

IV. Poses:

The recognition systems encounter difficulties because of different facial poses. People adopt different poses during photography since there are no established rules for face recognition or detection image capture. The recognition of faces becomes more difficult when images contain different poses. The performance levels of facial

features decrease when faces adopt diverse poses. The quality of gallery images suffers because numerous systems need strict imaging conditions. The methods that handle pose variations exist in two distinct groups, which are multi-view face recognition and face recognition across poses.

A face recognition system with pose robustness was developed by Li-Fang Zhou along with his colleagues through the combination of LBP and Hoffman coding. The authors implemented a divide-and-conquer approach for face representation and classification to enhance face variation. RSF served as a region selection factor, which enabled the system to handle different face poses during image representation. The researchers employed a patch-based SRC fusion classification method to improve their approach rather than adopting a generalized solution.

Some of the comparisons of different face recognition techniques, applications, and accuracy rates are given in the table below:

S No.	Techniques	Applications	Face Database Applied	Accuracy Rate
1	Histogram Oriented Gradient (HOG) [9]	Globalgabor/Zernike Descriptor	ORL YALE AR	98% 97.80%
2	Feature Processing [10]	2D/3D recognition	Stereoscopic information	Higher in 3D face
3	Fusion algorithm [19]	Visible and thermal image face	UGC-JU AR	99.07% Up to 24.5%improved
4	Two-dimensional multicolour fusion	2D Slash MCF model partitioned spare sensing recognition	CURTIN FRGC Bosphorus	Up to 3.8% improved Up to 25% improved Up to 2.86% improved
5	Two-dimensional multicolour fusion	General Discriminant Analysis	Deep Belief Network	96.25%
6	Multi-scale strategy based on geometric and local descriptors	3D face recognition	GavabDB and Bosphorus	98.90%
7	LBP techniques shape model	3D face recognition	PHPID database VLC database	88.76% 44.97%

Challenges and Solution Techniques:

Technique used	Challenges	Solution
SVM, LBP	This challenge or face problem with the evaluation of age effects.	The system can be implemented with the newly born child's face.
Eigenface, Fisher face,and LBPH	Several faces were identified with a single data when using the LBPH database.	In the future, we can elaborate with ambient analysis and implementation for the recognition of faces with distinct angles and poses.
two-level CNN layer	Challenging conditions with resolution, lightning effects, and deep makeup on the OUI_images data set	A deep convolution neural network model with a lasting algorithm will be considered. We can investigate the apparent age estimation approach.
FCN faster R-CNN, Mask R-CNN, G-Mask model	The model suffered from overfitting when detected in between 70 and 80 passes, and then the model seemed to overtrain.	This model can be extended to identify a person's mood swings due to situations that come in an environment that was the reason for varying behavior and expressions.
Deep learning framework with CNN, Res Net.	The difficulty in impact measure of low-quality facial images	CNN may be used to work in measuring the effect of face and gender bias to detect and express individuality signs.
CNN classifier and CSV image format were used	The problem comes with many faces while the model detects them. This restriction shows poor results.	Try to make an adequate system that overcomes the limit of detection of faces
SRC, CNN's	Errors occurred during the recognition of gestures, and the expression of face was still a challenge.	Face recognition might be further rectified with the merging of CNN locality and SRC linearity to enhance variants. It may also investigate to overcome errors from gestures and expressions of the face.

3. Applications of Face Recognition:

There are many applications where face recognition techniques are successfully used to perform an important role. There are many applications of face recognition, such as the following:

a) Security:

The security industry relies on facial recognition to operate security systems that grant entry to restricted areas through examples like smartphone facial recognition for unlocking.

b) Law Enforcement:

Police organizations can identify wanted criminals and missing persons through facial recognition technology in existing databases.

c) Marketing and Retail:

The analysis of store customers, combined with data on shop movement, helps retailers design specific market strategies for individual stores.

d) Healthcare:

The application of the technology in healthcare settings allows medical professionals to identify patients while they monitor vital signs and detect particular medical conditions through facial analysis.

e) Automated Immigration and Customs:

Several transportation facilities employ face recognition systems that help passengers complete immigration procedures through automated passport checkpoints.

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