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Face Recognition in the Modern Era: A Survey of Techniques, Challenges, and Innovations

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Abstract:

This review paper talks about the development of face recognition, ranging from traditional methods to the latest methods of deep learning (Hasan et al., 2021; Sáez-Trigueros et al., 2018). The early methods were based on separate characteristics like SIFT and LBP (Balaban, 2015) that could not handle complex scenarios. The use of statistical subspace methods helped to improve face representation. Deep learning, however, has transformed the domain, where systems like DeepFace attain nearly human-like performance by taking advantage of vast and various datasets (Taigman et al., 2014). Nonetheless, the bias, fairness, and privacy issues that remain unsolved have led to the ongoing research to make the face recognition systems more robust and ethically acceptable.

Keywords--- Face recognition; Illuminations; partial occlusion; pose invariance

Introduction:

Face detection is a smart computer vision technology. It recognizes people by their faces. This happens by spotting & matching patterns in facial features. This overview dives into different face recognition methods. First, we have geometry-based techniques. Then, there are appearance-based techniques. Lastly, deep learning methods come into play. The focus here is on algorithms and how well they perform. It also considers real-world uses of these algorithms for face recognition in various fields.

By dissecting the layers of innovation that promise to redefine the very nature of security in our interconnected society, we hope to gain a deeper understanding of the tremendous impact that facial recognition has on the identity verification landscape. The human face, with its wonderful points and patterns, will become the key to unlocking an impervious digital identity, imparting a stage of comfort that is unparalleled in the realm of authentication. In sectors such as finance, healthcare, and government, the place where the stakes are excessive and the want for stringent safety paramount, facial attention emerges as a bold guardian of touchy information. In the realm of healthcare, the place-affected person's privateness and facts protection are non-negotiable, facial consciousness presents a sturdy answer for identification verification. The effectiveness of healthcare structures is augmented, and the threat of scientific identification theft is mitigated through the precision of facial awareness technology. The greater it is utilized, the smarter and greater adept it becomes, making it a self-improving mechanism in the realm of identification verification. In conclusion, facial recognition stands as a beacon of innovation in the panorama of identification verification. As we navigate the evolving terrain of biometric technology, it is necessary to tread with mindfulness, addressing moral worries and making sure that the empowerment bestowed via facial attention is a pressure for a wonderful change.

1. Types of face recognition

A human being can be identified with the help of many ways like face features, fingerprints, eyes/IRIS detections, birth marks, or many other ways. Face identification plays the most important role in recognizing humans and help us to identify them. Resolution or Image quality plays an important role in face recognition while identifying face in CCTV or in other surveillance. In this recognition it's first step is to detect a face in image. Face have decomposed mainly in four features like eyes, nose, lips and mouth for identifying a human face. Faces are mainly having dimensions in 2D and 3D with different texture and facial expressions

1.1. 2D face recognition

We have discuss previously for 2D face recognition from image by following four steps was used:
In it the first step was to detect face, second step was face alignment, third step was feature extraction and fourth or last step was feature matching from database of enrolled users to recognize face where the details of that was stored. Matrix has been computed on the basis of pixel values at corner of face under different illumination condition for 2D face detection. Normally, face image can be represented by a high dimensional vector which contain pixel values. Feature matching is done to match the image face or face from videos from available database where that information is enrolled with unique face identity. Various technique were adopted to detect a face like illumination, intensity and colour. It is the challenging task to recognize a face in 2D that who it is? or whose face is it? And researcher faces have many challenges like expression, pose, illumination, occlusion in face recognition.

1.2. 2D – 3D face recognition

One of the most popular researcher "Andrea F .Abate et al. proposed a reliable techniques for collective 2D visual image and 3D model face recognition based on different parameters such as size of input, number of addressed tasks and recognition rate. In comparison of different techniques provides futures perspective to the researcher for enabling new techniques for face detections. Eigen face and Stereovision techniques used to improve the performance of 2D face recognition system with 3D information known as disparity of face. All we detect a face we use neural network which help us to recognize the face from 2D and 3D images. Principal Component analysis (PCA) for features extraction and recognition were effectively used. Face identification process is shown in figure 1.

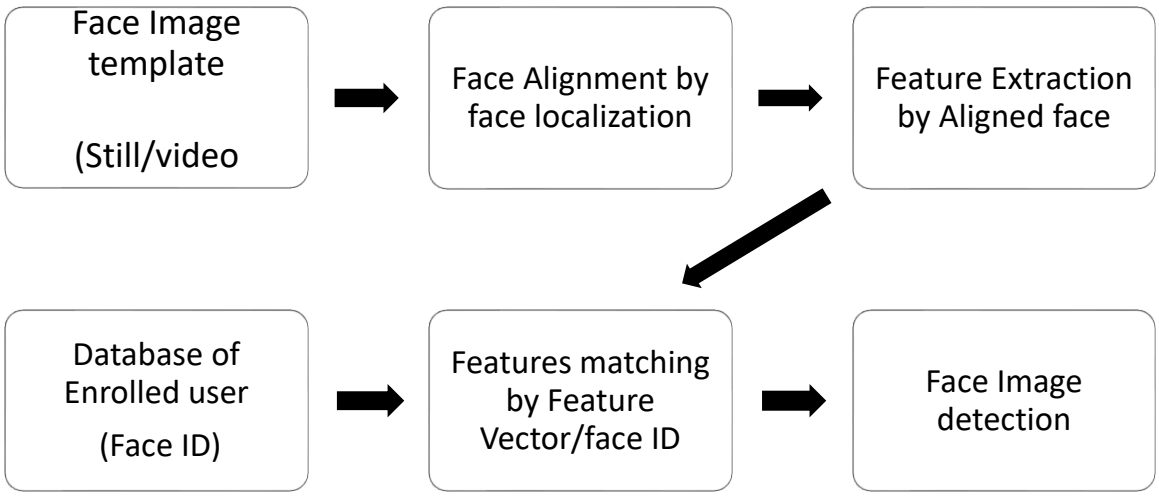

Fig 1: Face Identification Process

1.3. 3D face recognition

In 3D face recognition, Faces are in the form of real images that are in 3D model, various texture, different frameworks which convolute in three dimensions. It seems to be the precise detection of the face image and minimize the problem pose variation, occlusion and different type of illumination condition.

Many researcher such as 'Sima Soltanpura et al' proposed a survey for 3D face recognition based on local features. They divided the local description into curves, key point and surface. 'Ge Wen et al' proposed improved face recognition with domain. In improvement they achieved accuracy rate of 99.33% with single CNN model without face alignment. Both researcher having some common views and some different views on 3D face recognition.

1.4. Face Recognition measures

Face detection is often regarded as an excellent approach for recognizing threats. Face elements are made up of multiple, distinct face marks, unique peaks and valley on face. There are eighty nodal aspects to each human face. There are some points to be detect in face recognition such as eyes span a wide range of distance, nostril area, shape of cheekbone, and jawline dimensions. Face recognition dimension can be measures in figure 2.

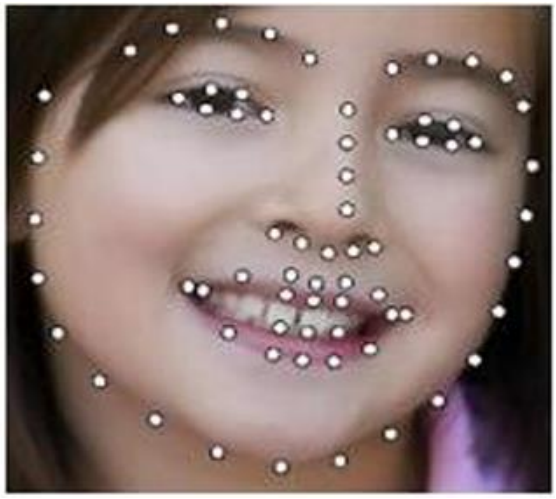

Fig 2. Face Recognition dimension measures

1.5. Methodology

Face detection aim is to identify people in image or videos using pattern recognition techniques. In this is locate the human's face and compare it to a database where face data is stored. If the detection is not successfully done or verified then the process restart. In this technique it takes less than five second to take a decision. The methodology is used that the picture is captured from digital camera and applied to pre-process and got a cropped face And extract feature then compare it from face data and classify whether a person is matched or not And extract feature then compare it from face database and classify whether a person is verified or matched or not . If matched then face is verified or recognised. Through this methodology we can recognise face and verify a person.

2. Challenges of Face Recognition

To recognise Singh a face or verifying a human face we face some challenges that are given below:

1. **Aging:**

In this, face in the form of many textures entail characteristics value changes over a period of time and reflect as aging. Aging is an inevitable natural process during the lifetime of a person as compared to other facial variations. Aging effect can be observed under main three unique characteristics:

a. The Aging is uncontrollable: It cannot be advanced or even delay and it is slow and irreversible.

b. Personalized Aging signs: Every human passes through different aging pattern. And these aging rely on his face genes and many other factors, such as health, food, region and many more conditions.

c. The Aging signs depend on time: The face of a person at a specific age will affect by aging marks as he is getting older face, but unaffected in younger age.

2. **Thermal Image**

A thermal image is a type of image that shows the distribution of temperature across a body or a scene. It's captured using infrared camera that defects infrared radiation emitted by a body based on their temperature. In thermal images different temperature are represented by different colour allowing us to save variation in temperature across the surface of an object. When it came to face recognise technique one challenge with thermal image is the lack of detail compared to visible light image. It may not capture fine facial feature or texture as clearly as traditional image which can make harder for face detection algorithm to accurately identify the human face individually. Additionally, factor like changes in ambient temperature or variant in thermal signature due to different condition can also affect reliability of thermal imaging for face recognition or detection.

3. **IRIS**

IRIS is the most important part of a face, it is present in an eye and feature extraction of IRIS plays a vital role in face biometric or face detection analysis. IRIS recognition method are available and mostly based on bio-hashing techniques. An IRIS mapping, robustness improve will be checked on the six databases and then results are tabulated for IRIS recognition. It has effectiveness and robustness in the recognised system for better performance in detecting a face.

4. **Occlusion**

Face recognition technique refer to the difficult phase when a part of a person face is abstracted or covered making it harder for the system to accurately identify the individual. Occlusions can be caused by various factor such as wearing accessory like glass, hat, mask, or having hair on face like moustaches and beard or even shadow falling on the face. When a face recognition system encounter occlusion, it may struggle to match the partially visible face with the store template or reference face due to the missing or alter face feature facial feature. This can lead to false rejection or incorrect identification or invalid verification.

Yu-Feng et al. discussed about single sample face recognition with occlusion, sparsity and robustness. Learning based PCA was used for intra class variant dictionary and optimization for solving multi scale spare coding model. It was discriminative multi scale model promtely used for face detection with occlusion. Partial occluded Face recognition system for large database were based on generic occlusion and structures spare dictionary approach.

5. **Poses**

Pose variance is yet another hurdle in achieving a successful face recognition system. People pose differently every time they take a picture this is not standardised rule for taking a picture for face recognition or detection. Therefore, it makes more difficult to distinguish or detect the face from image varying poses. Post variation degrade the performance of facial features. In addition many system work under inflexible imaging condition and as a result it affects the quality of gallery images. The method dealing with variation in the pose can be divided into two point that is multi view face recognition and face recognition across pose.

Li-Fang Zhou et al. Proposed pose robust face recognised with LBP and Hoffman coding. They had applied divide and wool technique on face representation and their classification to improve face variation also they had applied the region selection factor RSF for face representation of face image to consider different poses specifically, instead of journaling and applied path based SRC fusion classification strategy to improve the technique.

Some of the comparison of different face recognition technique, applications and accuracy rate as give below table:

S. No	Techniques	Application	Face Database Applied	Accuracy/Recognition rate
1	Histogram Oriented Gradient(HOG)[9]	Globalgabor/Zernike descriptor	ORL YALE AR	98% 97.80%
2	Featural Processing[10]	2D/3D Face recognition	Stereoscopic information	Higher in 3D Face
3	Fusion algorithm/RF classifiers[19	Visible and thermal image face	UGC-JU AR	99.07% Upto 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 Bosphourus	98.90%
7	LBP technique,shape model	3D face recognition	PHPID database VLC database	88.76% 44.97%
8	local geometric feature and shape matching	3D face recognition	FRGCv2 dataset	97.00%
9	face descriptor based on Gabor filter [37]	face recognition in wild animal	LFW dataset	97.29%
10	domain adaptation	face recognition in wild animal	LFW dataset	99.33%

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 face.
Eigenface, Fisherface, and LBPH	Several faces were identified with a single data when using the LBPH database.	In the future, 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 datase	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 seems 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, ResNet.	The difficulty in impact measure of low quality facial images	CNN may use 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 detected 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 recognition of gestures and, 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. 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 important role. There are many applications of face recognition as following:

I.Security

Face recognition is widely used in security system to grant access to secure area vertices for example unlocking smartphone using facial recognition.

II.Law Enforcement

It is used by law enforcement agencies to detect or identify suspect or missing person by matching their face with database of known individual.

III. Marketing and Retail

Retail store use face recognition for customer analysis track foot traffic and personalised market strategy.

IV. Healthcare

In Healthcare it can be used for patient identification monitoring patient vital sign and even diagnosing certain medical condition based on facial feature.

V. Automated Immigration and Custom

Some airport use face recognition technology for automated passport control to expedite the immigrant process.

VI. Attendance Tracking

Face recognition can be used in school, college, business organisation for automated attendance tracking.

VII. **Personalization**

Companies use face recognition to personalise user experience such as suggestion, feedback of product based on facial expression or emotion.

4. Conclusion

Face is the most important feature of living body, which plays most important role to verifying a human being. Various techniques across the world are used for face recognition application and research. In this review paper, we have tried to extent the review of face recognition techniques, types, challenges for performance comparison and many more things. We have tried to extent review on accuracy and recognition rate on different face database such as ORL, YALE, PHPID, GAVAbDB, AR, UGC-JU and many more databases. Face recognition has significantly advanced from traditional methods to learn deep learning techniques like DeepFace , which offers us near human accuracy. Despite its potential in sectors like finance and healthcare, ethical, security such as Face recognition authentication. There are main findings of this research are highlighted as under below points:

- The development trend and achievements in the real of face recognition shows that a lot of researchers have been carried out in last four decaded.
- Recently, face recognition system is implemented in many real-time application, but still it suffer from several challenges that need to be noticed in order to design a well-established face detection.
- Similarly to the face image recognition the video image recognition is more complicated and more tough to that need to be researched.

The future of face recognition and detection hinges on improving accuracy while safeguard fairness and privacy. Face recognition system that require to be filled in order to improve its accuracy and efficiency.

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