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Title **FACE RECOGNITION SYSTEM RELATED CHALLENGES, ALGORITHMS, TECHNOLOGIES, DATASETS AND FUTURE DIRECTIONS: A CRITICAL STUDY**

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Face Recognition System Related Challenges, Algorithms, Technologies, Datasets and Future Directions: A Critical Study

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ABSTRACT - Since the last two decades, there have been numerous advancements made in the fields of object recognition, form matching, and pattern recognition. A computerized method called face recognition employs an algorithm to find and identify faces in images. It is a widely utilized method of biometric identification that is applied to both online and offline applications. When circumstances are uncooperative, they present difficulties and might result in a variety of facial expressions or appearances. The conditions in real-world settings are unrestricted and include things like lighting, position, occlusion, expressions, low resolution, ageing, identical twins in people, moving pictures, etc. There are still a lot of obstacles and chances to overcome. Consequently, the main goal of this study is to explore the major difficulties associated in adapting existing.

Key Terms - Computer vision, Face recognition, Unconstrained.

I. INTRODUCTION

Digital Image Processing (DIP) technology is the use of computer technology to remove the image noise, segmentation and recovery. Digital image manipulation with a computer is the focus of DIP. Its main objective is to create a computer system that can process images. The input to such a system is a digital image [1] and the system processes that image using efficient algorithms, and produces an image as an output. It has wide applications and almost all the technical fields are impacted by DIP. Image sharpening and restoration, biometrics, medical, remote sensing, transmission and encoding, color processing, pattern recognition, video processing, microscopic imaging, and other important sectors [2] are just a few of the key ones where DIP is heavily utilized.

Biometrics refers to a science involving the statistical analysis of biological characteristics. Biometric security applications analyze human characteristics for identity verification or identification. Biometric recognition offers [3] a promising approach for security applications, with some advantages over the classical methods, which depend on something you have (key, card, face image, etc.) or something you know (password, PIN, etc.,).

Fingerprints, images, iris patterns, and voices may all be verified for uniqueness using biometrics-based verification [4], which helps to solve the issue of difficulty remembering keywords and ID numbers. Like other biometric technologies, facial recognition technology measures and compares the distinguishing characteristics for the purpose of identification or authentication. Facial recognition software can identify faces in photos, measure their traits, and then compare them to pre-stored templates in a database. It frequently uses a digital or networked camera for this.

Face recognition has received tremendous significance in current scenario due to its wide range of applications such as social media, surveillance, security etc. As the range of applications is expanding day by day, the complexity of system is increasing as well. This in fact affects the efficiency of the system. Different challenges [5] of face recognition systems that are present today, including illumination, pose, occlusion, expression, ageing, motion image (CCTV footage video), iris, thermal image etc., are discussed. The algorithms vary from application to application.

There are seven sections in this essay. Section II presents background of face recognition system. Face recognition in different challenging situations is presented in section III. Section IV presents representative algorithms for face recognition. Section V covers Face Recognition System (FRS) technologies and datasets. Section VI provides a summary of related works. The conclusion and directions for the future are provided in section VII.

II. FACE RECOGNITION SYSTEM

Face Recognition (FR) is a technique for recognizing or verifying a person's identification using their face. People can be recognized with FR systems in real-time, in videos, or in images. A type of biometric security is called FR. It can be applied in a variety of situations, such as those involving ATMs, healthcare systems, driving license systems, railway reservations, surveillance operations, and passport verification. The process of identifying a face that has already been recognized is called face recognition [6]. It can be described as identifying the individual from a database of enrolled users; therefore, it might be known or unknown.

Figure 1 displays the functions of a face recognition system (FRS). Figure 1(a) [7] depicts the face acquisition stage of the enrolment process, which is when the FRS first takes a picture of a person's face. Within the face detection and normalization procedure, the obtained face is localized, and its appearance is modified. Finally, a feature set is received by the FRS, which it stores in the database along with an identification and used as a face template during feature extraction.

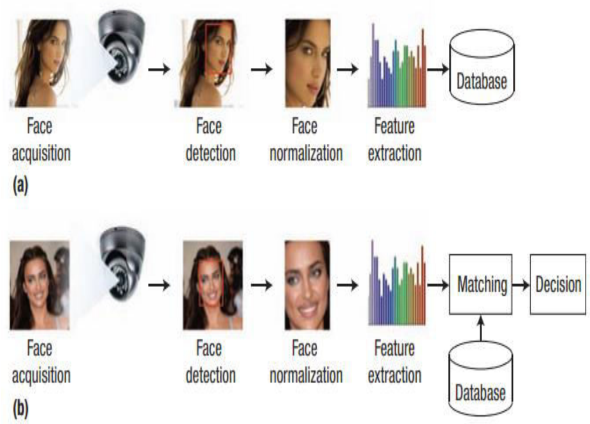

Figure 1: Tasks in a Face Recognition System (FRS) [7]

Figure 1(b) shows the recognition stage [7]. The FRS repeats the image acquisition, detection, normalization, and extraction steps; however, this time, it performs matching instead of storing the feature set, comparing the face to the previously stored templates and attempting to determine whether the new feature set matches one of them or not.

III. FR IN DIFFERENT CHALLENGING SITUATIONS

Face identification has always been a very challenging subject in the world of image processing and computer vision. It can be applied to many different fields. On the other hand, because of the various contexts where a human face might be found, it has always been exceedingly challenging to execute. The initial stage of automatic face recognition is face detection. However, due to the numerous variations [8] of picture appearance, including changes in illumination, position, occlusion, emotion, ageing, motion images, etc., face detection is not an easy task. Similar to this, videos are frequently captured from moving cameras or in unpredictable circumstances in visual surveillance scenarios. Actually, there are a variety of challenges and significant factors

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that can significantly affect both the accuracy of face recognition and the matching results [9].

Following are the few of the challenges in face recognition system.

A. ILLUMINATION VARIATION

Illumination fluctuation is one of the many bottlenecks in a face recognition system that reduces the system's capacity to match faces since it can dramatically affect the appearance of a face image. Extreme lighting circumstances, such as underexposed and overexposed areas, are likely to be present in security and surveillance photos taken in open, uncontrolled situations, which reduces the number of relevant details in the gathered face images. When creating a trustworthy and efficient face recognition system, lighting/illumination variance must be taken into consideration [9]. This is seen in Figure 2. A person's face might appear in a variety of ways.

Figure 2: Example of illumination variation in a human face [9]

A face recognition approach employing SPCA-KNN is proposed by Patrik Kamencay et al., (Scalable Principal Component Analysis on Special data-K-Nearest Neighbor). In this paper, the face region is segmented using graph-based segmentation algorithm and features are extracted from the segmented face region using Scale Invariant Feature Transform. The samples are classified using hybrid SPCA-KNN and the accuracy attained was 95.3% [10]. A quick and effective algorithm was created by Mithila Sompura et al., with a higher rate of face recognition under various circumstances, including lighting, head attitude, and expression. They used (LBP) Local Binary Pattern to divide the entire face into sub-blocks, then (PCA) Principal Component Analysis [11] to extract the global features taking into account the entire face and the local features. The stated accuracy of LBP is 93%.

B. POSE VARIATION

Photographs of a face can vary due to the relative camera face attitude, as shown in Figure 3 [12], and key facial features, like the eyes or nose, may be partially or totally hidden [13]. Pose changing face recognition is the challenge of recognizing or approving people using facial photos taken in arbitrary poses. Pose alterations actually affect the recognition process because they introduce self-occlusion and projective deformations. Pose-tolerance [14] is considerably more important for facial recognition systems that rely on a single view of an object.

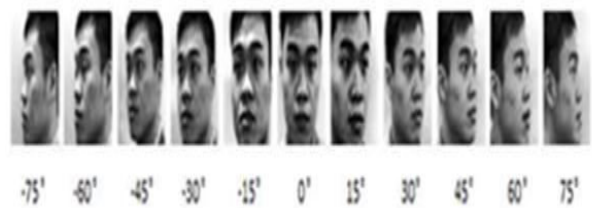

Figure 3: All view of the face poses [15]

In order to address the issue of pose variation, frontal face and profile face detectors are both used to record all angles of facial postures. However, the profile face detector only picks up the left profile face. To obtain the right profile face, we flip the image horizontally and perform face detection using the left profile face detector. Therefore, the detecting system will be able to distinguish between all variations of facial positions. To identify faces in images, a decision tree is utilized. For the purpose of recognizing frontal faces, Liton Chandra Paul et al., propose Principal Component Analysis (PCA) [15]. It uses Euclidean distance for similarity measurement. The method has been put to the test using MATLAB and the picture databases ETE-07 series and RUET. Although it has restrictions due to the

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different image sizes, this technique provides a superior classification accuracy for faces.

C. OCCLUSION

The faces of other objects could be partially hidden. When viewing pictures of groups of people, it's common for only a small section of a person's face to be visible since other faces or objects may partially conceal some faces [9, 16]. Facial occlusions are frequently linked to a number of serious security problems. Scarves and/or sunglasses are frequently worn by football thugs and ATM thieves to conceal their identities. When entering locations where they commit crimes, shoplifters and bank robbers frequently wear caps.

Anywhere on the human face can have facial occlusion (FO), and it is difficult to predict both its size and shape. As a result, it is hard to acquire background data on the blocked part in a timely and precise manner. FO is a significant barrier to face recognition (FR). Facial occlusion will occur if the target of detection is wearing accessories, as indicated in Figure 4, such as masks, hair accessories, scarves, hats, or unanticipated objects emerge in front of it. This causes the appearance of the target to change more dramatically as a result of the occlusion, which hurts the FR system. Six categories of variables, including facial accessories, external occlusion, partial face, intense illumination, artificial occlusion, and self-occlusion, can cause occlusion [17].

Figure 4: Different types of Facial Occlusions in a human face [18]

Gabor Wavelets are suggested by Rui Min et al., [18] for extracting characteristics from potentially obstructed locations. Due to the size of the recovered Gabor feature, PCA (Principal Component Analysis) is used for dimension reduction. The PCA subspace is computed using a training dataset consisting of feature vectors from both occluded and nonoccluded patches. Nonlinear Support Vector Machine (SVM) classifier [18] is adopted for occlusion detection. If face is covered with scarf the recognition rate is 92.08%, and for uncovered faces the recognition rate is 94.58%.

D. EXPRESSION

Humans can express their emotions most effectively through their faces [19]. By altering our focus, vision, and memory, they can have an impact on how we live our daily lives and aid in our ability to discern others' intentions. Face expressions serve as a vehicle for information and can faithfully convey the real feelings of a person. Different face emotions are depicted in Figure 5. Facial expressions can reveal others' inner thoughts to humans [20, 21].

Figure 5: Basic Expressions of Humans: (a) happy, (b) sad, (c) anger, (d) fear, (e) disgust, and (f) surprise [22, 23].

Based on computer technology, Facial Expression Recognition (FER) [24, 25] can assist intelligent robots better comprehend and recognize human emotions, enabling them to actively interpret those emotions, better serve humans, and establish barrier-free interaction between machines and

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humans. The FER images [22] are classified following the face detection, preprocessing, and feature extraction stages. Deep learning algorithms and conventional machine learning techniques are two categories of existing methods.

E. AGEING VARIATIONS

Due to its widespread use in both public and private systems, as well as in many real-world applications, facial age simulation research [26] has gained importance. Facial age modelling is a crucial technology that is employed in many public institutions. The search for missing children or families who have been split up, forensic montages of lengthy unsolved crimes, and FRS are just a few of the critical applications that are currently being used all around the world. Ageing may occur naturally as a result of ageing or artificially (using makeup tools). The efficiency of face recognition systems might be greatly decreased by ageing and wrinkles in both scenarios [27]. Age variation is demonstrated in Figure 6. In face recognition studies, the influence of age variation, [28], or age factor, is not typically taken into account.

Figure 6: Example of age variation for face recognition [31]

Two of the main reasons for the limited research on [29, 30] ageing recognition are the absence of representative public databases with photographs of people of different ages and the low quality of historical images. Shape information and texture information can both be extracted from a facial image. To extract the landmarks from the shape information, Active Shape Model (ASM) is recommended [32]. To analyze the landmark coordinates, we employed Principal Component Analysis (PCA).

F. MOTION IMAGES (CCTV SURVEILLANCE)

In many countries, Closed-Circuit Television (CCTV) surveillance is pervasive in public spaces. The judicial and policing systems have been greatly impacted by the availability of CCTV recordings. Maintaining public safety can depend greatly on locating a person of interest, but doing so requires sustained attention, excellent identification, detection, and recognition skills, as well as other cognitive resources. The difficulty of finding a target person in real CCTV recordings [33] at a busy rail stop is now shown in Figure 7. The CCTV viewers were previously unaware that the searchers had access to the kinds of photos given to police and security institutions, such as passports, driver's licenses, and custody images. There was a wide range in the density of the crowd, erratic ambient illumination, and inconsistently good CCTV. Due to all of these factors, this search task is incredibly difficult.

CCTV monitoring is appealing because it can be used as a substitute for eyewitness testimony, which has been the focus of extensive forensic and applied study [34]. It is well known that eyewitness accuracy is quite prone to inaccuracy. However, as CCTV footage [35] keeps a permanent record of all occurrences and all parties involved, it can help to solve some of these issues. Due to this apparent advantage, CCTV cameras have been widely installed, which has increased their use and influence in courts across numerous jurisdictions.

However, there is strong evidence [36] that determining whether two photographs are of the same identity or not involves unfamiliar face matching. G. Sreenu et al., [37] propose a deep-rooted survey, beginning with object recognition, activity recognition, crowd analysis, and concluding with violence

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detection in a crowd environment. For scene-independent crowd analysis, deep learning is applied.

Figure 7: Closed Circuit Television (CCTV) Footage [33]

G. IRIS RECOGNITION

Biometric identification is a trustworthy method for confirming a person's identity. For biometric authentication, a number of physically stable qualities are used, such as voice recognition, hand geometry, handwriting, the retina, and iris identification [38]. Most of the features call for the sensing equipment to take specific, physical actions. Automated recognition technology [39] is a less intrusive alternative to circumvent barriers like physical encounters. One of them is the iris recognition technology. The iris is a significant component of the eye, and iris feature extraction is crucial to biometrics analysis. We can obtain the iris pattern from human eyes, which is dependable and identical for use in human identification.

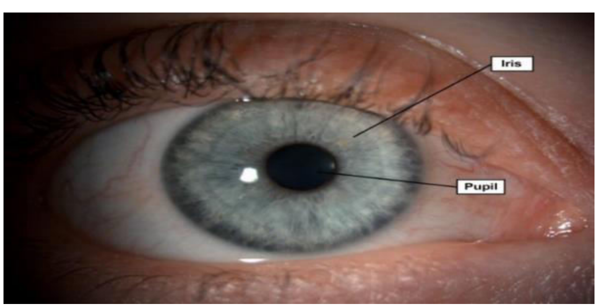

Figure 8: The iris and Pupil [40]

The iris, pupil, and component of the eye that controls eye color are shown in Figure 8. The pupil is the opening in the middle of the iris [40]. The iris regulates the pupil's size, which affects how much light enters the eye. J. Daugman [41] proposed the Canny Edge Detection Technique, a multi-stage algorithm, to recognize the various edges in the image. Humayan Kabir Rana et al., [42] recommend the Daugman model for normalizing segmented iris regions. The resolution of each normalized image must be the same. The Gaussian radial kernel function of the SVM (Support Vector Machine-Single Class) is used for recognition [45, 46]. The iris and pupil are present in human eyes [43, 44].

H. THERMAL IMAGES

Infrared light is used by thermal imaging cameras [47] to take pictures. They were initially employed in a military setting. Typical civilian applications of thermal imaging include measuring the temperature of industrial component parts, inspecting buildings, monitoring for security and law enforcement, and robotic vision.

Thermal pictures are used by wildlife ecologists [48] to distinguish between various animal types. Different facets of animal physiology, such as thermoregulation, are studied using infrared pictures. Finding and tracking thermal anomalies in various animal anatomical regions can reveal underlying circulation that could be connected to physiology, behavior, or disease.

(a) (b)

Figure 9: (a) Visible image under Normal Illumination (b) thermal image under Normal Illumination. [49]

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Figure 9 shows the visible image and thermal image in normal illumination. Thermal facial images contain information about blood vessels network. For face detection on infrared thermal pictures, Ricardo F.R. et al. [47] suggest a number of techniques. (i) The binary image is subjected to an edge detection technique, and the face detection is based on the contours. (ii) A template matching method is utilized to search for and locate a binary image template with the shape of a human head. A matching algorithm is utilized in (iii). This technique reduces false detection by incorporating edge orientation information.

IV. SOME REPRESENTATIVE ALGORITHMS FOR FRS CHALLENGES

Facial recognition software is a subtype of biometric software that maps a person's facial characteristics and saves the data as a face print. The system uses deep learning algorithms to match a live captured image to the recorded face print in order to verify a person's identification. Image processing and machine learning are the cornerstones of this technology. Four types of face recognition methods are presented in Table 1 and different representative algorithms are given in Table 2.

Table 1: Facial Recognition Methods [7]

Face Recognition Method	Analysis	Sample Algorithms
1. Local, holistic, and hybrid model	**1. Local Method**: Local facial features are recognized using local binary patterns. **2. Holistic Method**: Uses the input of the entire image. **3. Hybrid Method**: Employs both local and holistic features.	1. Principal Component Analysis (Eigenfaces) 2. Modular Eigenfaces 3. Linear Discriminant Analysis (Eigenfaces) 4. Modular Eigenfaces 5. Linear Discriminant Analysis (Fisherfaces) 6. Independent Component Analysis (ICA) 7. Local Binary Pattern (LBP) 8.Scale-Invariant Feature Transformation (SIFT) 9. Speeded-UP Robust Features (SURF) 10. Learning-Based Descriptor (LBD)
2. Appearance and model-based method	**1. Appearance based method**: A high-dimensional vector space is thought of as containing each image as a point. There are two types: linear and nonlinear. **2. Models based Method**: Aims to model a face in to 2D or 3D.	1. 3D morphable model 2. Active Appearance Model (AAM) 3. Eigen light field 4. Associate-Predict Model (APM)
3. Geometry and template – based method	**1. Geometry based Method:** Local facial features are analyzed along with their geometric relationship using elastic bunch-graph matching. **2. Template based Method:** An algorithm is used to define a face by comparing the input image to a set of template images.	1. Dynamic Link Architecture (DLA) 2. Elastic Bunch-Graph matching (EBGM) 3. Trace Transform (TT) 4. Kernel Methods 5. Simulated annealing for 3D face recognition
4. Template-matching, statistical, and neural	**1. Template Matching method:** It uses models, pixels, curves, or textures to represent patterns. **2. Statistical approach:** Recognition is a discriminant function, and patterns are represented as features.	1. Probabilistic Decision-Based Neural Network (PDBNN) 2. Genetic Algorithm 3. Wavelet Packet Analysis (WPA) 4. Sparse Representation (SR) 5. Partial Least Squares (PLS)

network methods	**3. Pattern Representation Method:** Although there are many different pattern representations used in neural network techniques, a network function is usually included at some point.	6. Hybrid Deep Learning 7. Discriminant Face Descriptor 8. DeepFace Deep Neural Network 9. Deep Hidden Identity Features (DeepID) 10. FaceNet Embedding

Table 2: Representative Algorithms for FRS Challenges

Name of the FRS Challenge	Applied Representative Algorithms in the Papers
[60] 1. Variation in Illumination	**1. AdaBoost Algorithm**: Used for Face Recognition. **2. Nonsubsampled contourlet transform (LNSCT)**: Used to extract from a facial image invariant features of string edges, weak edges, and noise. **3. Artificial neural Network (ANN)**- Employed in the realms of image processing and pattern recognition.
[61] 2. Pose Variation	**1. Principal Component Analysis (PCA)**: It is used to create more compact representations by reducing statistical redundancy in natural face photos. **2. Karhunen - Loeve Transformation (KLT)**: The facial image's orthogonal decomposition is provided.
[17] 3. Occlusion	**1. Convolution Neural Network (CNN)**: Used to extract local area feature. **2. Subspace Regression Algorithm**: Used to separate the face into the unobscured original image and the obscured portion of the image, as well as to classify various face types into the appropriate low-dimensional subspace and construct a distinct subspace for the obscured region.
[22] 4. Expressions	**1. Spatio -Temporal Convolutional features with nested LSTM (Long Short – Term Memory) (STC-LSTM)**: Used to identify medium expressions in picture sequences. **2. RVFLNN (Random Vector Functional Link Neural Network) Broad Learning System**: It is a large network topology that is strengthened for face expression recognition by appropriately increasing the number of feature nodes and enhancement nodes.
[26] 5. Aging Variations	**Generative Adversarial Networks (GANs)**: Are applied to create photos that are more lifelike. It can detect many changes in the human face, including ageing and changes in hair color.
[62] 6. Motion Image (CCTV Footage)	**K-Nearest Neighbor (KNN)**: It is a system built on Machine Learning (ML) for finding and identifying faces in CCTV images with different backgrounds and occlusion.
[63] 7. Iris Recognition	**Canny Edge Detection Algorithm (CEDA)**: In order to eliminate incorrect edge detection responses, this technique first estimates the intensity gradients in the image.
[47] 8. Thermal Image	**Viola-Jones Algorithm**: When used to thermal imaging, the conventional methods created for visible light pictures are compared using Haar feature-based cascade classifiers.

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V. FR TECHNOLOGIES AND DATASETS

A. FR TECHNOLOGIES

Face detection software compares captured faces from videos and photos to identities already stored in a database. In essence, the technology locates a face in a picture, maps it for analytics, and recognizes or verifies a person's identity while also having a significant market share. Face recognition technology is less prone to security breaches than conventional authorization techniques because a person in physical form must be present to grant any kind of access. The software programme attempts to improve security and authentication for their mobile applications globally. Clients will then be able to log into their mobile banking application and receive access using facial recognition and authentication, which will replace passwords.

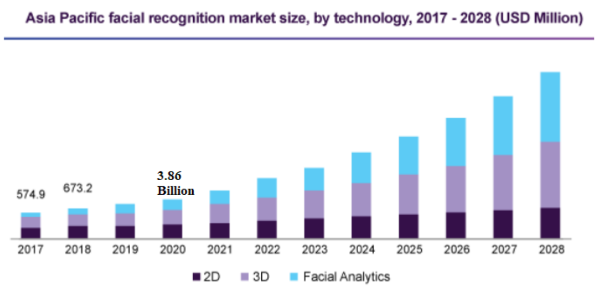

Figure10: Facial Recognition Market Research Report [64]

Grand View Research's report is depicted in Figure 10. The size of the Global Facial Recognition Market (GFRM) [64] was estimated to be USD 3.86 billion in 2020, and it is projected that it will increase at a CAGR (Compound Annual Growth Rate) of 15.4% from 2021 to 2028. The facial analytics market is estimated to experience a high CAGR of 20.8% over the anticipated period. The deployment and use of face recognition technology is rather straightforward. Additionally, it offers a rapid process for face matching and identification/verification. These elements have significantly aided in rapid adoption. As a result of this technology's relative insensitivity to changes un expression, face identification using facial analytics offers high accuracy.

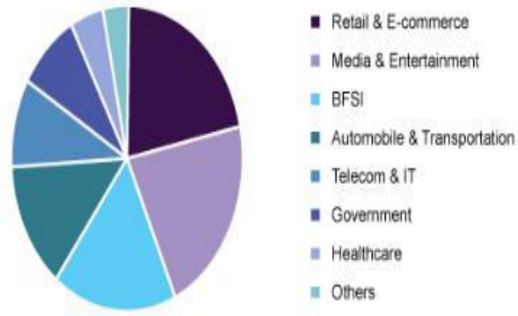

Figure 11: Global Facial Recognition Market (GFRM) share, by end-use, 2020(%) [64]

Grand View Research's GFRM pie chart is shown in Figure 11. Based on four outlooks, it has classified the global facial recognition market (2017-2028) [64].

(i) Facial Recognition (FR) technology outlook: 2D, 3D.

(ii) FR application outlook: Emotional intelligence, access control, security and surveillance, and attendance tracking and monitoring, among other things.

(iii) FR End-use outlook: Retail and e-commerce, media and entertainment, BFSI (banking, financial services, and insurance), transportation and automotive, telecom and IT, government and healthcare, and other industries.

(iv) FR regional outlook: Europe, the Middle East, South America, and North America.

B. DATASETS

Every algorithm for machine learning or deep learning uses a dataset as its input and learns from it. It gives the required algorithm with the patterns it finds in the data. Table 4 displays the outcomes of applying the FR challenges to several datasets. For instance, several things can be examined as a pattern to determine whose face is present in a particular image:

- Facial height and width (cm)
- Because the image may have been downscaled to a smaller face or grid, the height and width may not be

exact. The ratio of the face's height to its width won't change, even after rescaling, because ratios are constant in all mathematical operations.

- Color of the image (R, G, B)
- width of other facial features, such as the lips, the nose, etc., in cm.

Table 4: FR Challenges Implementation Review on different Datasets and its Results

Face Recognition Challenges	Name of the Datasets	Outcome of the Research Papers
[50] 1. Variation in Blur, Illumination, and Expression	Yale Face Dataset	1. Used 2D Gabor Fisher Discriminant (2DGFD) obtained 70.8% recognition rate. 2. 2D Discrete Wavelet Transform (2DDWT) obtained recognition rate 82.5%. 3. Contour Transform-Weber Local Descriptor (CT-WLD) obtained recognition rate 95.23%.
[51] 2. Pose Variation	COMSATS Face Dataset	1. For 144 X 256 accuracy of image identification and resolution (in pixels) is 78.4% by using PCA algorithm. 2. For 140 X 140 recognizability and image resolution (in pixels) is 86.66% by using PAL algorithm. 3. For 70 X recognition effectiveness and image resolution (in pixels) is 62.2% by using LDA algorithm.
[52] 3. Occlusion	COFW Dataset	1. The anticipated mask and ground truth have an IOU (Intersection Over Union) of 93.7%. 2. Averaging all pixels, prediction accuracy is 98.0%. 3. The recall rate is 98.3% for the proportion of correctly predicted face pixels to ground pixels. 4. The number of photos processed per second is 257 FPS (Frames Per Second).
[53] 5. Aging Variations	FG-NET Database	Accuracy of Gender classification by using different algorithms – NeuCube - 95.00%, MLP - 76.10%, KNN - 83.00%, Naïve Bayes - 62.79%
[54] 6. Motion Image (CCTV Footage)	CheckPoint and LTFT Dataset	At eye level, a crowd was captured moving toward the camera. Face recognizes 8433 faces for a resolution of 1920 x 1080, with a density of 13.0 face detections per frame and an outside scenario.
[55] 7. Iris Recognition	CASIA-Iris-Interval V4, IITDelhi, MMU Datasets	Used CNN on CASIA dataset, recognition accuracy is 94.88%, Based on applying CNN to IITD, 96.56%; Based on applying CNN to MMU, 98.01%.
[56] 8. Thermal Image	FLIR Thermal Dataset	The biggest values of ZeroFMR are achieved using LBP descriptor as the feature descriptor and Spearman distance as the matching method. The highest recognition rate is 97%.

VI. SUMMARY OF REVIEWED PAPERS

Title of the Paper & Reference No	Outcome of the Paper	Future Directions
[65] Techniques and Challenges of Face Recognition: A	1. YALE, PHPID, VLC, GAVAbDB, AR, UGC-JU, CURTIN, FRGC, Bosphorous, and LFW datasets were used for the review in order to compare performance, accuracy, and recognition rate on 2D and 3D face images. 2. Using the Fusion approach, the maximum accuracy rate for	In future, upcoming researchers can select different popular algorithms for face recognition to increase the accuracy.

Critical Review	recognizing the faces of wild animals was 99.33% when evaluated on the LFW dataset.	
[8] A Survey on Various Problems & Challenges in Face Recognition	1. FRS was applied to systematic issues including noise, image capture, distortion from video cameras, etc 2. Age variations, lighting variations, and position variations have been verified using FERET, FRVT, and FAT techniques. 3. FRS accurately detected and recognized faces as a result of light, ageing, emotions, and facial similarities.	However, system defects used in face identification, such as camera distortion, background noise, inefficient storage, inappropriate methods, etc., continue to provide a significant problem for contemporary face recognition systems. Environmental elements might also contribute to network problems.
[66] Face Recognition challenge, Achievements and future directions	Review of recent developments, applications of FR technologies in science and daily life, obstacles, and important aspects of face recognition that have an impact on how well face recognition systems function.	The temporal evolution of the face's appearance will be used in future illumination preprocessing technologies to improve face recognition.
[67] Face detection based on open CL design and image processing technology	1. Real time face detection algorithm used open CL code units to get LBF (Local Binary Format) is used as a feature vector for face detection. 2. With 97.4% of the samples, FEID's Facial Expression Image Database is utilized to identify faces, and test findings show that 96.2% of them can be. 3. Comparing this implementation to earlier co-executions, it has shown to be faster.	In the future, provide an LBP OpenCL framework for recognizing external appearances.
[68] On Detectors and Descriptors based Techniques for Face Recognition	1. Used the Hypercomplex Fourier Transform (HFT) to perform dimensionality reduction to the images and RANSAC (Random Sample Conses) to reduce noise. 2. LGHD, PCEHD, and EHD feature descriptions were tested. employed the Harris-Stephen algorithm, Minimum Eigen Value, and SURF as feature detectors. 3. Faces94 dataset is used face recognition, accuracy is 90.67%.	A closer look reveals that, among all feature descriptor-detector combinations, Minimum Eigen Features partnered with LGHD has the highest accuracy value, along with respectable values for precision and recall.
[69] Facial detection using deep learning	Human face identification is employed in this study to recognize side and hazy faces, which are challenging to recognize using more traditional techniques.	1. The only drawback is that it fails to recognize eyes with glasses. 2. This can be expanded to in the future to using video recording to identify people, it is beneficial for obtaining identifying individuals using CCTV footage Police will quickly identify the suspect.
[70] Review Paper on Real Time Image Processing: Methods, Techniques, Applications	A summary of real-time image processing studies at this period (Applications), together with some pertinent methodologies and methods, are provided in this study.	In future, real-time image processing challenges are require grow in response time and computational power.
[60] An Efficient System for Face Recognition under Various Illumination Conditions	1. The Logarithmic Nonsubsampled Contourlet Transform (LNSCT) is used to transform a facial image in order to recover invariant properties of strong edges, weak edges, and noise. 2. Adaptive Boosting (AdaBoost) algorithm to detect the face region and enhance recognition of illumination of digital image. Artificial Neural Networks (ANN) is used for pattern recognitions.	In future, use more other algorithms to get better accuracy rate.

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[61] Face Recognition Performance in Facing Pose Variation	1. In this study, PCA was used to distinguish many facial poses based on head yaw angle movement. Frontal face recognition is already in use. 2. Then, the matching problem is resolved by combining the Eigenfaces approach with Euclidean distance. 3. The experiment is conducted with varied yaw angles and threshold levels to get the best results.	1. The primary flaw is the absence of a classification algorithm following PCA-based dimension reduction. 2. Support Vector Machines (SVM) will therefore, be used as an extra classification algorithm for the classification of various data sets.
[17] A Survey on Occluded Face recognition	This paper analyzed and summarized the three popular aspects for occluded face detection, which are- one) on surface information, two) on local surface information, and three) on deep learning.	1. The goal of future research is to advance unrestricted occlusion face recognition. 2. It will be crucial to increase research into occlusion face recognition systems based on small samples in the future in order to reduce computational costs and recognition times. 3. A promising future exists for the full use of 3D occlusion face of deep learning identification.

VII. CONCLUSION AND FUTURE DIRECTIONS

Face recognition is one of the trickiest problems in the world of computer vision research. Face recognition has many uses, including security and forensics, and it calls for greater accuracy and dependability. It is vital to develop facial recognition systems that are capable of working in restricted environments. In this study, we attempted to provide a thorough analysis of the issues associated with face identification, including variations in lighting, position, expression, occlusion, ageing, motion image, iris, and thermal image. For performance comparison, accuracy, and identification rate, face recognition technologies and algorithms for use with additional face datasets include FLIR Thermal, YALE, COMSATS, COFW, FG-NET, CheckPoint, LTFT, CASIA-Iris-Interval V4, IITDelhi, MMU, and others.

This face recognition study explores the challenges of face recognition in practical settings and provides a benchmark for a critical evaluation of the community's advancements in face recognition research. There are still many challenges and opportunities in developing sophisticated facial recognition algorithms that can work with photos often available on social media and under extremely challenging circumstances. Facial expression identification that takes into account multimodal data is helpful in realizing more in-depth emotional understanding in the future [57]. Future research will concentrate more on recognizing facial expressions in real-world situations [58], including those involving education, medicine, traffic, criminal investigation, and commerce. Contrarily, broad learning benefits from quick computation, incremental online learning, and simplicity in scaling [59]. Finally, CCTV footage video can be investigated as a research topic to enhance face recognition ability to handle novel and more difficult scenarios as well as functioning in outdoor settings.

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