iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** VI **Month of publication:** June 2024

DOI: https://doi.org/10.22214/ijraset.2024.63339

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

Advancements and Innovations in Face Recognition Technology: A Review of Methodologies, Challenges, and Emerging Approaches

Niharika Upadhyay[1], Mrs Swati Tiwari[2], Mrs Ashwini Arjun Gawande[3]
Computer Science Department, Columbia Institute of Engineering and Technology

Abstract: ***The study summarizes the key findings and contributions of the reviewed papers on face recognition technology. These papers explore various methodologies and innovations aimed at enhancing the accuracy, efficiency, and robustness of face recognition systems. From novel clustering techniques and adaptive classifiers to innovative distance metrics and robust recognition systems, the research presented in these papers demonstrates a diverse array of approaches to address the complexities of face recognition. Additionally, the exploration of emerging methodologies such as Independent Component Analysis (ICA) and novel distance metrics showcases ongoing efforts to push the boundaries of face recognition technology. By addressing challenges related to dimensionality, computational complexity, and robustness, researchers aim to develop more effective and versatile face recognition systems with applications across diverse domains including security, human-computer interaction, behavioural science, and more.***
Keywords: Face recognition, SVM

I. INTRODUCTION

In the past few decades, face recognition has emerged as a prominent application of biometrics-based authentication systems. Face recognition is a biometric technology that utilizes algorithms to analyze and compare facial features of an individual with pre-existing facial data stored in a database. The purpose is to determine the familiarity or unfamiliarity of the face being analyzed. Face recognition is a complex task due to the inherent variations in information caused by random variation among individuals and systematic variations caused by factors like illumination conditions and posture [1]. Various computational face recognition algorithms need to tackle numerous challenges. The aforementioned issues arise due to the need to represent faces in a way that optimizes the utilization of the facial data at hand, enabling the distinction of a particular face from all other faces in the database. The determination of face position poses a significant challenge due to the high degree of similarity in facial features, such as the presence of a mouth, two eyes, and a nose [1].

The user's text is "[2]." The human visage is characterized by a complex and dynamic structure that can undergo rapid and significant changes in its characteristics over time. Facial recognition technology involves a wide range of activities that are relevant to various aspects of human life. While it can be difficult to remember a vast number of images, there are ongoing developments in machine learning to automate this process for individuals. Researchers strive to understand the anatomical structure of the human face during the development or enhancement of facial recognition systems. By directing their attention towards and showcasing a keen interest in the methodology of the human face recognition system, researchers can acquire a foundational comprehension of the system. A human facial recognition system utilizes data acquired from one or more sensory modalities, such as auditory, visual, and tactile inputs. To enhance the process of gathering and storing facial data, these factors are utilized either separately or in conjunction. During the analysis of an individual, a human face recognition system often takes into account the surrounding environment in which the individual is located. The management and integration of large volumes of data present a significant challenge for a machine recognition system. However, the process of committing a substantial amount of features to memory can be equally difficult. The memory capacity of a machine system is its primary advantage. Continuing research is currently being conducted on human characteristics that possess the potential to be employed for the purpose of face recognition. Additionally, an ongoing debate persists regarding this subject. The utilization of both broad and precise attributes is necessary for the process of face recognition [3] [4].

II. LITERATURE REVIEW

Kadam et. al. [11] The recognition of a visage requires the use of sophisticated computer methods due to its complex multidimensional structure. Our solution approaches face recognition as a two-dimensional recognition problem. For the purpose of facial recognition, the thesis employs the Discrete Cosine Transform (DCT) and Principal Component Analysis (PCA). Face images are projected into a face space for encoding in order to capture the most optimal variation among known face photographs. The eigenvectors of the set of faces are the eigenfaces, which define the face space. The Discrete Cosine Transform (DCT) approach can be employed by converting the image to the frequency domain and extracting the characteristic. There are two methods employed for feature extraction. The initial method utilizes the Discrete Cosine Transform (DCT) of the entire image to determine the characteristic. The second method involves the division of the image into smaller images, the retrieval of the feature vector from each image, and the application of a Discrete Cosine Transform (DCT) to the image.

Slavković et. al. [12] This paper investigates a face recognition method that is predicated on Eigen features. The primary goal of the investigation is to employ Eigen features to recognize individuals in a collection of photographs. Initially, a collection of images was regarded as a training set. The images were ultimately determined by calculating the Euclidean distance between the newly computed image and the image in the training set, following the completion of calculations on the training set. The proposed method's efficacy is corroborated by test results for varying quantities of facial features, and we also addressed other image metrics. In conclusion, we conducted a thorough security analysis that encompassed an analysis of temporal complexity. The Eigen face approach is touted as a highly effective method for facial recognition. The recommended secure system is capable of identifying users. From an exhaustive database, a total of 2888 photographs were evaluated. Based on the simulation results, the Eigen faces technique was implemented to the database, which yielded a 95% success rate. Additionally, picture metrics have been assessed. The temporal complexity of the proposed approach was determined to be O(n3/2). Future investigations will prioritize the improvement of the success rate for datasets that are exceedingly big.

Sharma et. al. [13] Face recognition is a critical component of the face processing algorithms employed in sophisticated computer-human interaction systems that are based on intelligent vision. The neurons of the Self-Organized Map (SOM) neural network were grouped using an agglomerative hierarchical clustering method in this study. These neurons were subsequently employed to cluster the face dataset, as opposed to explicitly clustering the facial data using the neurons of the SOM network. Previously, Principal Component Analysis (PCA) was employed to determine the initial state of SOM neurons and to reduce the dimensionality of the facial data. The clustered-SOM identification engine is equipped with post-training procedures that generate a supervised SOM network by designating labels to the clustered SOM neurons. The proposed approach's efficacy is illustrated through the utilization of the ORL database, which is extensively utilized. When five images are utilized per individual for self-organizing map (SOM) training, the proposed recognizer achieves a recognition rate of 94.7%. Nevertheless, the recognition rate reaches 99.33% when nine images are utilized. The facial recognition system has demonstrated exceptional robustness and reliability in the presence of additive white Gaussian noise. Just 8% of the identification rate was lost when the noise variance level was raised from 0 to 0.09. Additionally, an assessment of time expenditure is conducted. The time required to conduct a test on a new set of 200 images is less than 0.013 seconds, which is comparable to the time required for several AI and machine learning-based methods. The instruction procedure can be concluded in approximately four seconds when 200 images are utilized.

Murtaza et. al. [14] The selection of a feature subspace with reduced dimensions from a large dataset is a critical element of optimal classification. Linear discriminant analysis (LDA) is a widely used and popular supervised classifier for classification. Nevertheless, two issues arise within the class during discriminant analysis. If the number of intraclass samples is less than the number of sample dimensions, LDA experiences instability during training. Another contributing factor is the substantial processing expense that is generated by data elements that are irrelevant and unrelated within the same class. An Adaptive Margin The limitations imposed by intraclass issues are addressed by Fisher's Criterion Linear Discriminant Analysis (AMFC-LDA). In order to address the issue of Small Sample Size (SSS), a revised version of the Maximum Margin Criterion (MMC) is implemented, which includes a convex hull and a customized Linear Discriminant Analysis (LDA). The inter-class variation is determined using LDA, whereas the intra-class variation is established using rapid hull. In the same vein, the within-class scatter matrix can be reformulated using the minimum Redundancy Maximum Relevance (mRMR) approach, which preserves discriminant information and reduces computational expenditures. The algorithm that has been suggested yields favorable results. Lastly, a comparison is made with the current methodologies.

Sahu et. al. [15] Face recognition technology is a critical tool in our everyday lives. The main objectives of this technology are to enhance security in various domains and to authenticate individuals. The task of quantifying the optimal facial recognition rate across diverse settings and criteria poses significant challenges for researchers.

An accurate and reliable technique is necessary for the recognition of a human face, as it is complex and has multiple aspects. The precision of face recognition relies on two essential procedures: human face identification and feature extraction. Face recognition utilizes a range of methodologies to extract facial characteristics; nevertheless, further enhancements are necessary to attain optimal outcomes. The main objective of this study is to conduct a comparative evaluation of two face identification feature extraction methods: Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). The comparison will be conducted using various parameters, including the presence or absence of spectacles in frontal face photographs, illumination fluctuation, and facial expression. The methodology utilized in the proposed study is deemed suitable and adheres to the required criteria with accuracy [16].

Naik et. al. [17] Engineers and scientists are interested in Independent Component Analysis (ICA), a computationally efficient technique for separating sources without prior knowledge, due to its potential applications in various fields. The purpose of this article is to examine the foundational principles that form the basis of Independent Component Analysis (ICA) techniques and assess their real-world uses. The applications and ambiguity concerns associated with Independent Component Analysis (ICA) have been extensively studied.An extensive assessment has been performed on various methodologies of Independent Component Analysis (ICA) and their applications in diverse scientific and technological domains. The purpose of this page is to provide a concise and comprehensive resource for researchers who have an interest in studying this particular field. The provided resource provides a thorough analysis of Independent Component Analysis (ICA) techniques, encompassing their underlying principles and possible applications.

Wang et. al. [18] We present the Image Euclidean Distance (IMED), a new method for calculating the Euclidean distance between images. Unlike the traditional Euclidean distance, IMED takes into account the spatial relationships between pixels. Due to its low tolerance for image disturbance, it exhibits a reduced ability to handle disruptions in the image. We argue that IMED is the only Euclidean distance measure for images that has a clear conceptual interpretation. As a result, the IMED system is utilized to perform image recognition. This distance measure is compatible with the majority of image classification algorithms, such as Support Vector Machines (SVM), Linear Discriminant Analysis (LDA), and Principal Component Analysis (PCA). Its main advantage lies in its compatibility with these algorithms. The standardizing transform (ST) operation is a key factor contributing to the high efficiency of the embedding process. We provide empirical evidence that the ST (Smoothing Transformations) domain is utilized for the purpose of applying smoothing transformations. We observe a consistent improvement in the performance of the algorithms that have been integrated with the new measure compared to their original versions. The evaluation was conducted using the FERET (Face Recognition Technology) database and two advanced face identification techniques.

Taghizadegan et. al. [19] The ability of face recognition algorithms to handle variations in facial expression and rotation is a crucial measure of their robustness. This study presents a novel face recognition algorithm specifically developed to tackle the problem of manipulating facial expressions in three-dimensional (3D) images. Two-dimensional (2D) principal component analysis (PCA) is suggested as a technique for detecting and correcting local variations. The background information is first removed by applying a threshold to the depth map of the three-dimensional facial image. The nostril point is selected as the centroid of the recognized face shape after normalizing the image to a standard size of 100x100 pixels. The image depth values are normalized to a range of 0 to 255, with the snout tip assigned the maximum value of 255 for the purpose of translation and scaling-invariant identification. During the preprocessing stage, the local variation in the data is reduced by applying a refining technique to the face image. The feature vectors extracted from the individual's face are utilized to authenticate their identity in the existing face database by comparing them with the primary images generated. The obtained range data is subjected to principal component analysis (PCA), a two-dimensional (2D) method, for the purpose of feature extraction. The effectiveness of the system is assessed by utilizing the GavabDB face database. The software used to implement the facial modeling technique demonstrated in this document is Matlab version 7.7. The proposed method utilizes advanced algorithms to accurately identify individuals by analyzing the unique facial expressions present in their 3D face images, as evidenced by the experimental results.

Barnouti et. al. [20] Face recognition technology has experienced significant growth and prominence in the past few years. Moreover, it is the predominant application of image analysis in security systems. Real-time applications have exhibited their capacity to be engaging, demanding, and rapidly growing. The proposed technique is assessed using a benchmark ORL database consisting of 400 images of 40 individuals. The ORL database incorporates preprocessing procedures to enhance recognition accuracy. Using a dataset of nine training photographs and one evaluating image, the recognition rate achieved is 97.5%, which is the highest percentage recorded to date. An optimal strategy for improving the recognition rate involves augmenting the luminosity of the photo database. The rates of identification will be enhanced by utilizing a 0.3 scale for image scaling, which is equally efficient.

Dimension reduction and feature extraction are achieved by employing Principal Component Analysis (PCA). The matching technique utilizes the Euclidean distance for optimal performance. Face recognition is a biometric technology that utilizes algorithms to analyze and identify unique facial features. It is experiencing significant growth and finds applications in various fields. The face recognition experiment that utilizes the ORL database incorporates the implementation of Euclidean distance and PCA. Preprocessing techniques have been implemented in the ORL database in order to enhance the accuracy of recognition. Performance analysis involves the evaluation of different counts of training and testing images. The identification rates can be improved by increasing the number of training images, as the feature space will contain a more comprehensive set of information. Applying a resizing operation to the photographs, specifically scaling them down to a factor of 0.3, leads to a noticeable improvement in the recognition rate. The resulting images have dimensions of 34 by 28 pixels each. It is crucial to exercise caution when choosing the suitable scale for photograph resizing to maintain the integrity of facial features. The computational complexities and the number of features are reduced in photographs that undergo size reduction. To enhance the luminance, the recognition rate is augmented by 140 units for every pixel. An effective method that produces significant outcomes is the augmentation of an image's luminosity. The images undergo a standardized cropping process, resulting in new images with a resolution of 61 × 61 pixels. Cropping is a process that removes any unnecessary or extraneous features from an image or document. To remove the background from a photograph, it is essential to perform cropping, as the background reduces the discriminative power of the feature space. To achieve higher identification rates, it is recommended to enhance the luminance of each pixel by 140 units and then enlarge the image using a scale factor of 0.3.

Kapoor et. al. [21] Over the past few years, there has been a significant amount of research focused on enhancing the human-computer interface through the automation of facial expression interpretation and synthesis. Facial gesture detection is an essential element of human-machine interactions, playing a crucial role in various fields such as therapeutic settings, security systems, behavioral research, and other disciplines. Notwithstanding the fact that humans possess the ability to quickly and effortlessly analyze facial emotions, the accurate recognition of expressions using computers continues to be a complex task. The process of facial expression identification poses challenges due to the inherent variability in how individuals express the same emotion. This article presents a detailed analysis of the real-time gesture detection process, utilizing the Mahalanobis distance and correlation. The analysis examines the six fundamental emotional categories, namely joy, anger, fear, revulsion, sorrow, and surprise.

Gawande et. al. [22] A face recognition system is a computer program that autonomously identifies or verifies an individual's identity by analyzing a digital image or a video frame from a video source. One approach to achieve this is to perform a comparison of specific facial features extracted from the image with a pre-existing facial database. It is commonly utilized in security systems and can be compared to other biometrics, such as fingerprint or eye retinal recognition systems. The investigation primarily focuses on the 3-D and biometric face recognition systems. We conduct an assessment of facial recognition systems, with a focus on analyzing their strengths and limitations. Furthermore, this report demonstrates the scope of India's recognition system. Scientists and experts in the domains of biometrics, pattern recognition, and computer vision have shown significant enthusiasm for the study and development of face recognition technology. Facial recognition technology has the potential to enhance the security of ATM cards by verifying the identity of users. It can also be used to authenticate passports, process visas, verify criminal records in police departments, verify electoral identities, and implement security measures at airports. Principal Component Analysis (PCA) is a commonly used technique for feature extraction in face recognition systems. This study presents a face recognition system that utilizes multiple distance classifiers to enhance the process of personal identification and verification. The system utilizes Principal Component Analysis (PCA) as its underlying methodology. During the evaluation of the face recognition system's resilience and accuracy, the test outcomes obtained from the ORL face database exhibit unforeseen results. An individual's image was associated with a class (or topic) based on the training data using various classifiers.

Abdullah et. al. [23] Principle Component Analysis PCA is a classical feature extraction and data representation technique widely used in pattern recognition. It is one of the most successful techniques in face recognition. But it has drawback of high computational especially for big size database. This paper conducts a study to optimize the time complexity of PCA (eigenfaces) that does not affects the recognition performance. The authors minimize the participated eigenvectors which consequently decreases the computational time. A comparison is done to compare the differences between the recognition time in the original algorithm and in the enhanced algorithm. The performance of the original and the enhanced proposed algorithm is tested on face94 face database. Experimental results show that the recognition time is reduced by 35% by applying our proposed enhanced algorithm. DET Curves are used to illustrate the experimental results. Our research methodology is based on exercising the proposed modified PCA algorithm to decide the minimum number of images in the training set for individual that fulfill 100% of recognition, i.e., zero FAR.

This experiment aims to neutralize the factor of the number of images in the training set while as this high training set number of images is best exercise our proposed algorithm for computational time. It is also important to decide the best threshold value that fulfil the highest recognition rate, while as we use this value in the original PCA and enhanced one to compare the results. For future work we want to repeat our experiment on larger databases. We also intent to conduct the same experiment using a different face database and compare the results with our current experiment to ensure the validity of our enhanced algorithm over different types and sizes of database. Other techniques to enhance the accuracy of the face recognition and decrease the false acceptance rate need to be compared.

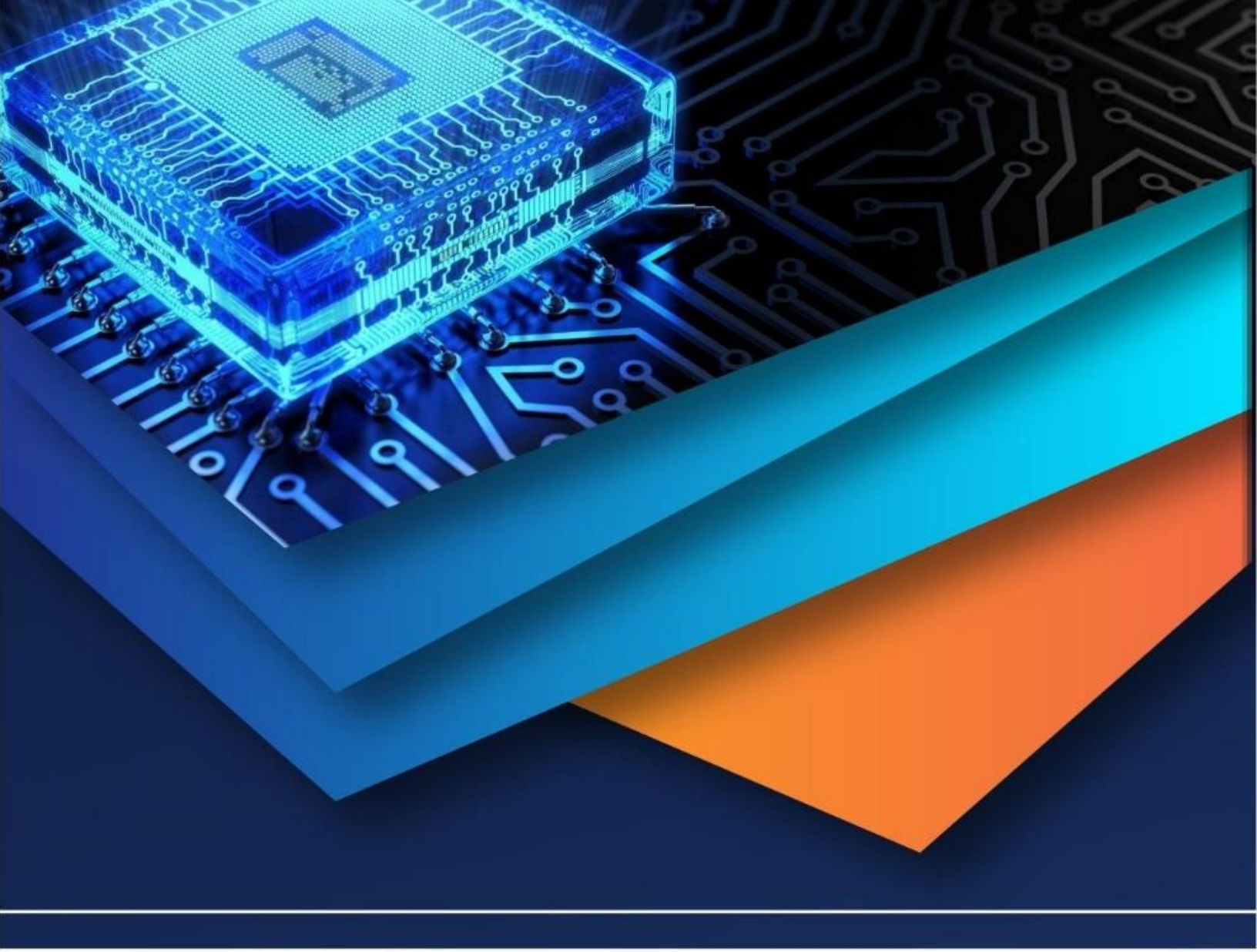
Nicholl et. al. [24] In PCA-based face recognition, there is often a trade-off between selecting the most relevant parts of a face image for recognition and not discarding information which may be useful. The work presented in this paper proposes a method to automatically determine the most discriminative coefficients in a DWT/PCA-based face recognition system, based on their inter-class and intra-class standard deviations. In addition, the eigenfaces used for recognition are generally chosen based on the value of their associated eigenvalues. However, the variance indicated by the eigenvalues may be due to factors such as variation in illumination levels between training set faces, rather than differences that are useful for identification. The work presented proposes a method to automatically determine the most discriminative eigenfaces, based on the inter-class and intra-class standard deviations of the training set eigenface weight vectors. The results obtained using the AT&T database show an improvement over existing DWT/PCA coefficient selection techniques.

III.CONCLUSION

Collectively, the reviewed papers underscore ongoing efforts to advance face recognition technology, addressing challenges and pushing the boundaries of its applicability across various domains. From novel clustering techniques and adaptive classifiers to innovative distance metrics and robust recognition systems, these contributions showcase the breadth of research and innovation in this field. By tackling issues of dimensionality, computational complexity, and robustness, researchers are striving to enhance the accuracy, efficiency, and reliability of face recognition systems. Moreover, the exploration of emerging methodologies such as Independent Component Analysis (ICA) and novel distance metrics demonstrates a commitment to exploring diverse approaches to address the complexities of face recognition. As technology continues to evolve, these efforts will likely pave the way for more effective and versatile face recognition systems with applications spanning security, human-computer interaction, behavioral science, and beyond.

REFERENCES

[1] Ahonen, T., Hadid, A., & Pietikäinen, M. (2006). Face description with local binary patterns: Application to face recognition. IEEE Transactions on Pattern Analysis and Machine Intelligence, 28(12), 2037-2041.
[2] Belhumeur, P. N., Hespanha, J. P., & Kriegman, D. J. (1997). Eigenfaces vs. Fisherfaces: Recognition using class specific linear projection. IEEE Transactions on Pattern Analysis and Machine Intelligence, 19(7), 711-720.
[3] Bowyer, K. W., Chang, K., & Flynn, P. J. (2016). A survey of approaches and challenges in 3D and multi-modal 3D+ 2D face recognition. Computer Vision and Image Understanding, 101(1), 1-15.
[4] Grother, P., Ngan, M., & Hanaoka, K. (2019). Face recognition vendor test (FRVT) Part 3: Demographic effects. NIST Interagency Report, 8280.
[5] Parkhi, O. M., Vedaldi, A., & Zisserman, A. (2015). Deep face recognition. In BMVC (Vol. 1, No. 3, p. 6).
[6] Schroff, F., Kalenichenko, D., & Philbin, J. (2015). FaceNet: A unified embedding for face recognition and clustering. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 815-823).
[7] Taigman, Y., Yang, M., Ranzato, M. A., & Wolf, L. (2014). DeepFace: Closing the gap to human-level performance in face verification. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 1701-1708).
[8] Turk, M., & Pentland, A. (1991). Eigenfaces for recognition. Journal of Cognitive Neuroscience, 3(1), 71-86.
[9] Zhong, Q., Han, X., & Zhang, C. (2019). Face de-occlusion using 3D morphable model and generative adversarial network. Neurocomputing, 365, 168-178.
[10] Zhou, E., Cao, Z., Yin, Q., & Sun, J. (2017). GridFace: Face rectification via learning local homography transformations. IEEE Transactions on Image Processing, 26(5), 2402-2415.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY