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INTELLIGENT FACIALRECOGNITION SYSTEM USING MACHINE LEARNING ALGORITHM

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Abstract

Over recent years, Researchers have displayed a keen interest in dynamic research domains, including the realm of Face Recognition Systems. This study aimed to develop a facial recognition system using a machine learning algorithm, specifically Feedforward Neural Network.Utilizing an effective and efficient facial recognition system enhances itseconomic importance to optimize processes, improve security, enhance customer experience, and reduce costs across a wide range of industries. The study presents a comprehensive methodology for developing an efficient facial recognition system using machine learning techniques. The workflow involves literature review, data collection from the database, image processing with Gaussian and Median filters, robust feature extraction via PCA, and training using a Feedforward Neural Network (FNN) algorithm. The resulting FNN-based model achieved a commendable TPR of 95.58%, FNR of 3.98%, and overall accuracy of 98.78% which showcases the effectiveness, reliability, and versatility of the model across various scenarios.The performance of the FFN-based model demonstrates a balanced trade-off between accuracy, efficiency, and robustness. The innovative approach and consideration of diverse performance metrics of this study contributed significantly to the field of facial recognition technology. The model's potential for real-world scenarios and its unique insights emphasizes the importance of holistic system evaluation. This work enriches the understanding of facial recognition technology and provides a promising direction for future research and advancements in the field.

Keywords: Face, Image Processing, Machine Learning, Neural Network, Median Filters, PCA

1. INTRODUCTION

Recently, there has been a surge of interest in face recognition research due to heightened security demands and the rapid advancement of mobile devices. Numerous potential applications exist for face recognition technology, including access control, identity verification, security, and surveillance systems, as well as integration into social media networks. Face recognition is also becoming important in other fields like image processing, animation, security, human-computer interface, medicine, etc. Although face recognition is not yet the prevailing method for granting entry, but with advancing in computer technologies and increasingly sophisticated algorithms are leading to its emergence as a viable replacement for passwords and fingerprint scanners(Alvappllai and Barrina, 2016).The events of 9/11 have driven a greater focus on enhancing security systems to safeguard innocent citizens, particularly in locations like airports and border crossings where identification verification is necessary, Face recognition systems have the potential to play a crucial role in mitigating risks and ultimately prevent future attacks from occurring. Surveillance systems can also benefit from facial recognition capabilities. By employing surveillance cameras with face recognition, law enforcement can improve their ability to locate and apprehend criminals. These systems could also aid in identifying missing persons, contingent upon the availability of robust facial recognition algorithms and a comprehensive facial database. Furthermore, facial recognition has surfaced in social media application platforms such as Facebook which suggeststaggingfriends who have been identified in photos, highlighting the versatile applications of this technology.

According to Dilu and Yan (2021),submitted that, the gradual diversification of technology, face detection, and recognition have become a technology closely related to our lives. Face detection and recognition technology has not only made life easier and faster but also added a touch of technology fun. Through the face of a series of operations such as unlocking the phone, facial payment, and intelligent identification using high-tech methods to ensure the security of property, and identity and to realize the combination of technology and life is very vital and effective in everyday life. Okokpujie and John (2021), pointedout that the accuracy of face recognition systems can be compromised by factors such as lighting, facial expression, pose, obstruction, and aging. These elements can lead to diminished recognition performance. To address this, a face recognition system has been devised, employing a four-layer neural network (CNN) to maintain consistent illumination conditions. This system has demonstrated the capability to effectively identify facial images across varying levels of illumination, ensuring a uniform model illumination.Cheng (2017), explores the effect of face recognition in an uncontrolled lighting environment based on the influence of different illumination effects. The MSR algorithm can directly extract the illumination invariant of objects, and GF and INPS algorithms can indirectly extract illumination. The algorithm characteristics of invariants are tested. From the perspective of feature-level fusion and classifier decision-level fusion, the linear discriminant analysis of illumination robustness is used to design a method to overcome illumination invariant bands in face recognition.According to Peng et al (2017), a study reveals that,to solve the problem of detection complexity caused by face, rotation, expression,etc., a new improved version of the AdaBoost algorithm is needed to achieve comprehensive skin color preproduction. The function of processing and using geometric features for filtering, and the highly robust nature of the Haar algorithm, also extract complex scenes. In addition, experiments proved that the method has an excellent detection rate and latitude for side face and rotation which provides a good implementation effect on the embedded platform.Naji and Hamd (2021), posited in this study that different databases and methods should be used to identify people and proposed to use of the local binary mode and ternary mode in the texture analysis method for comparative analysis. At the same time, three distance measurement methods, namely, Manhattan distance (MD), Euclidean distance (ED), and cosine distance (CD), were taken into account. After comparative analysis, Ren Lina's recognition rate of Manhattan distance was higher.Experimental results show that the system has strong face detection performance.Haizhouetal., (2018), used the face template method to effectivelylocate the face edge to break through the face detection which can only identify the binding under the condition of no background and pass the two eyes and different aspect ratios. The face template in the study is used for face detection, and finally, the face detection success rate of the experiment is more than 90%, which brings an effective solution for detecting and recognizingthe face in a single positive environment.Liang and Huarong (2017), introduced a novel approach that integrated deep learning technology with convolutional neural network techniques. This fusion aimed to manage and mitigate the incidence of unusual events within monitoring systems. By extracting image features and leveraging a cyclic neural framework, the study effectively processed sequences, yielding accurate determination of detection window position and size. The outcome was the development of an operational monitoring system capable of delivering real-time alerts for anomalies.To address these challenges, Image processing techniques (Gaussian and Median), with robust feature extraction using Principal Component Analysis (PCA), and the utilization of machine learning algorithm such as Feedforward Neural Network (FNN) is required to train the data to generate an efficient and effective facial recognition model.By leveraging these technologies, the research aims to enhancethe reliability and accuracy of facial recognitionsystems.

2. REVIEW OF RELATED LITERATURE

Zhang et al., (2017), developed an effective and robust real-time algorithm for detecting and recognizing faces in complex backgrounds. The approach employed a range of image processing techniques, including Ada Boost, Local Binary Pattern (LBP), and Principal Component Analysis (PCA). The Facial Recognition Technology Database, comprising 3682 face samples from 526 subjects across varied viewing conditions, was utilized for training and validating the facial recognition algorithm. The Ada Boost algorithm usedhaar features anda cascade classifier to train face and eye detectors with reliable detection accuracy. The LBP descriptor was utilized to extract facial features for swift face detection. The eye detection algorithm reduces the false face detection rate. Moreover, the PCA algorithm is used to recognize faces efficiently. The results demonstrated an overall true-positive rate of 98.8% for face detection and 99.2% for accurate facial recognition. Ullah et al., (2022), developed a machine learning and deep learning-based real-time framework for detecting and recognizing human faces in Close-Circuit Television (CCTV). The study presented different implemented algorithms which include image acquisition, image preprocessing, face detection,and recognition. The authors used two feature extraction algorithms, which include, Principal Component Analysis (PCA) and Convolutional Neural Network (CNN).The algorithms were further trained usinga Decision Tree (DT), Random Forest (RF), and K-nearest neighbor (KNN). The results recordedan accuracy of 90% for DT, 93% for RF, 93.4% for KNN, and 95.67% for CNN; hence, CNN was reported to be much more reliable than PCA. Lazarini and Hirama (2022), conducted a comprehensive review of the literature focusing on the accuracy of facial recognition algorithms. The study classifies facial recognition into three distinct phases: detection, feature extraction, and facial recognition. The facial recognition phase exhibited a notable prevalence of Artificial Neural Networks (ANNs), particularly emphasizing the utilization of Convolutional Neural Networks (CNN).However,the ANN stages were characterized by well-defined algorithms and the detection phase prominently featured the Viola-Jones algorithm, while the feature extraction phase showcased the prominent usage of Eigenface and Fisher face algorithms, both grounded in Principal Component Analysis (PCA). Finally, the identified solutions displayed significant accuracy levels in the selected articles, ranging from a remarkable maximum of 98%, in three distinct casesand a minimum accuracy of 50% as the minimum accurate value. A mean accuracy of 93% was observed across the results.

Ravinder and Kaur (2015) researched on Evaluation of the Performance of Face Detection Using a Skin Color Model and Face Recognition Using an Artificial Neural Network (ANN). The study presented a new and robust algorithm for face detection and recognition using a skin color model with Feed Forward Neural Network. The skin color model is used to detect the face of the region from a given input testing image. After detection, Features are extracted from detected face regions using Zernike moment and correlation. Also, Extract features from the training database. The next step was applied to a fuzzy set for the pre-processing of extracted features of the training image. The fuzzy set has shortlisted more matchable images (greater than the threshold value of the matching feature). The system has been tested on a face pix database in which 6600 images of 90 persons of 74 different images of angle variation. On evaluatingthe performance of the new algorithm based onfactors such as accuracy, time, etc.The New System was found to have an overall accuracy of 94.64% at a distance of 60 to 80 cm of images. The result shows that the new system of Face Detection and Recognition provides better accuracy (96.25%) as compared to other existing systems such as the Viola-Jones algorithm for face detection and ANN for face recognition (87.5%).

Janarthanan et al., (2022), researchedan efficient face detection and recognition system using RVJA and SCNN. The study presented an approach combining the Reconstruction-oriented Viola–Viola-Jones algorithm (RVJA) and the Shallowest sketch-centered Convolutional Neural Network (SCNN) introduced to create an effective Face Detection and Recognition (FDR) system. The proposed FDR system operates in a multi-step manner. The proposed methodology's performance is assessed using metrics such as Area Under the Curve (AUC), Recognition Accuracy (RA), and average precision (AP), and its outcomes are compared with existing methodologies. The experimental results reveal that the proposed model achieves higher accuracy in facial image recognition compared to conventional methods. The combination of RVJA and SCNN results in a robust FDR system, adept at detecting faces under varying conditions and recognizing complex facial features. Evaluation against existing methods demonstrates a notable recognition accuracy of 97.14%, showcasing the effectiveness of the proposed framework. Narayan and Deshpande (2017), present an efficient approach for face detection and recognition using Viola-Jones, a fusion of Principal Component Analysis (PCA) and Artificial Neural Network (ANN) techniques. The performance of the proposed method is compared with other existing face recognition methods and it is observed that better recognition accuracy is achieved with the proposed method. The first stage detects the human face in an image using the Viola-Jones algorithm. In the next stage, the detected face in the image is recognized using a fusion of Principle Component Analysis and Feed Forward Neural Network. Better recognition accuracy is realized with the proposed method. The proposed methodology uses Bio ID-Face-Database as a standard image database. The accuracy of face detection and recognition of the proposed method is compared with the existing methods. With the PCA algorithm, an image identification of 72% is realized and with the ANN algorithm, an image identification of 92% is achieved. Sunardi et al., (2022), propose a face image classification using a machine learning algorithm Support Vector Machine (SVM), with Principal Component Analysis (PCA) feature extraction which is implemented on a room security device with all processing using raspberry pi 4b. The dataset used is facial images collected from 15 employee respondents with 2100 training data and 525 test data. Image data is taken from the face with various pose variants with both eyes, nose, and ears visible. Training using Raspberry Pi 4b resulted in a model with the best score of 99% accuracy in 0.10 seconds while testing 525 data resulted in a model with a 99% precision score, 99% recall, and 99% f1 score. The test results show that SVM can be applied properly to facial recognition devices as long as the facial features are still clearly visible. Bharadi et al., (2022), propose a real-time face recognition system that was implemented using the VGG16 architecture of Convolutional Neural Networks (CNN). Convolutional Neural Networks are mainly used for image classification. OpenCV open-source library is used for image pre-processing. The implementation process includes a collection of face samples, image preprocessing, model training, and face recognition tasks. The proposed system is analyzed based of no. of speakers, the effect of light, the effect of facial expressions, occlusion, the effect of low-resolution images, light, shadow, noise, etc. After experimenting, the results show that the system gives better face recognition accuracy to up to 20 users. The experimental results indicate that an average accuracy of 97- 99% is achieved and hence this is one of the best methods for face recognition. Kaplan et al., (2022) researched human face recognition using deep neural networks. A Convolutional Neural Network (CNN) model was presented for face recognition. Theproposed CNN model was used to classify the data set containing 20 different image samples of each individual taken from different 125 people. Model training was completed with a part of the dataset and tested with the resting part of the dataset. In addition, to see the CNN model efficiency, convolutional features of the CNN model are taken as a feature matrix. Then, they are classified with the Adaboost classifier. When the models are compared to CNN,the model achieves more promising results than the Adaboost classifier. The results prove that, while the Adaboost classifier achieves a 97.33% accuracy rate, the CNN model obtained a higher success rate than the Adaboost classifier 99.29% for this face recognition application. Zhijie and Khan (2022), develop an intelligent face recognition system based on the universal design concept. First, the universal design concept is briefly described, and the calculation process of the face detection algorithm and face detection algorithm based on the optical flow method is introduced in detail. The study noted that the algorithm is used to build a complete system framework when designing a face recognition system. The main functional modules in this system are the face detection module, face recognition module, and face training module. The functions of each module were explained in detail. The study further proceeds to validate the efficacy of the face feature extraction results obtained from the optical flow-based face detection algorithm. This validation is performed using the Yale face database and the Illumination, and Expression Face Database(PIE) face database. The results show that the algorithm has the highest detection and recognition rate. At the same time, the Olivetti Research Laboratory(ORL) face database is used to compare and analyze the system performance. The face image recognition rate of this algorithm is 92%, which is the highest compared with other algorithms.

Ming (2021), introduces a novel approach centered on data dimensionality reduction algorithms for face image digital processing and recognition. Through a comprehensive examination of prevailing data dimensionality reduction and face recognition techniques, the study formulates a face recognition and processing technology workflow. This workflow takes into account face image input, feature composition, and external environmental factors. The findings distinctly indicate that the method presented in the paper surpasses existing approaches in terms of correct recognition rates, particularly demonstrating notable efficacy within the extended Multi-modal Multi-Lin gual Varication for Telecommunications Security (XM2VTS) face database. Compared with Linear Regression Embedding(LRE), Least Squares Discriminant Projection(LSDP), Truncated Nuclear Norm Regularization (TNNL), Low-Rank and Sparse Representation(LPRR), and Truncated-LRE, the new method is better. Specifically, in the XM2VTS database, the results using LRE, LSDP, TNNL, LPRR, and Truncated-LRE methods are 92.43%, 92.59%, 92.17%, 91.35%, and 92.68%, respectively, and the highest recognition rate of the method proposed in this paper is 94.75%.Xianwei (2022), designed a recognition method for face local features based on the fuzzy algorithm and intelligent data analysis. Firstly, the wavelet denoising method was used to reduce the noise of face images, and adaptive template matching was performed on the obtained images. Then, the face information was encoded, and the face features were identified to locate the face features. On this basis, the principal components of the face were analyzed to obtain the global features of the face. Finally, through the candidate set of facial local feature recognition, the extraction of face local features, and the fusion of face local features, the recognition of local face features was realized. The experimental results show that the average recognition rate of this method is 88.84% in a noise environment and 97.3% in a noise-free environment. It can accurately recognize the face local features, can meet the needs of recognition of the face local features, and has certain practical application significance.Sakshi (2023), a study presented a novel method for implementing a facial recognition-based smart voting system using machine learning. The method involves the use of a facial recognition algorithm that is trained using deep learning techniques to recognize the faces of registered voters. The proposed method was evaluated using a dataset of pre-registered voters, achieving an accuracy rate of 98% in recognizing the faces of registered voters. The use of the Face Net algorithm in this system provides accurate facial recognition, and it is a widely accepted algorithm in the field of computer vision and machine learning. The outcome proved that; the proposed system is an effective solution to the challenges of traditional voting systems. It is reliable, and efficient, and ensures a fair and transparent voting process. In addition, the system can be used in various settings, such as government elections, organizational elections, and other voting-related processes.

3. METHODOLOGY

The methods that were applied for the facial recognition system using machine learning were encompassed in the respective workflow which begins with a literature review to identify the different models used in identifying various problems associated with FR and the efficient algorithm used in solving those problems. In the review also, the study aims to find out the gaps in the review mentioned above, with the respective solution that was applied to mitigate some of the identified gaps from the review. Secondly, the image dataset was collected and processed using image processing techniques (Gaussian and filtering techniques) with robust feature extraction using PCA. Finally, by implementing suitable Machine Learning algorithms and training the data using the Feedforward Neural Network (FNN) algorithm developed to generate an efficient and effective FR model.

3.1 Data Collection

The dataset utilized in this study was sourced from the labeled images in the wild dataset, which was collected from Kaggle directories. The dataset compresses 1680 individual directories, each corresponding to a celebrity, and within each directory, there are 25 images representing that particular celebrity. However, the dataset encompasses 42,000 images, making it a substantial and diverse collection for training and evaluating the facial recognition model.

3.2 Image Processing Techniques

To achieve meaningful accuracy in the image data collected for processing, noise filtering techniques were employed to enhance the quality and accuracy of facial feature extraction. The Image processing techniques involve a diverse array of methods to manipulate and analyze digital images for this application.It also aims to enhance the visual quality and improve the interpretability of the images by suppressing noise while preserving important details and structures.In this work, image noise filtering was used to reduceunwanted variations in pixel values caused by interference or imperfections. Various filtering techniques, such as Gaussian and median filters, were applied to mitigate noise while retaining essential details. Gaussian filtering enhances image quality by reducing noise and smoothing fine details, making images visually more pleasing and emphasizing larger structures. On the other hand, Median filtering, enhances image interpretability by effectively removing noise while preserving edges and fine details, making the underlying information in the image clearer and more distinguishable (Kenneth and Castleman 2003). These filtering methods play a crucial role in enhancing image clarity, making images more suitable for analysis and interpretation.

3.3 Feature Extraction

This section represents the feature extraction process used to extract features from the collected data. It is a very popular concept used to extract the features from images in face detection and recognition. It has been widely used in different approaches, such as Digital Image processing, Pattern Classification, Computer Vision, and Deep Learning. It has transformed the input materials or images intopixels. This pixel value has transformed a combination of features in the database. Because these selected features containthe most appropriate information in the original data. It is very useful in biometrics applications and Machine Learning. Feature extraction is crucial because it helps reduce the dimensionality of the data, removing noise and irrelevant information, while retaining the most important characteristics.

In this study, Principal Component Analysis (PCA) was adopted Among other image processing techniques to extract the features of the image data collected. PCA is a widely used dimensionality reduction and data analysis technique in the field of machine learning and statistics. It aims to transform high-dimensional data into a lower-dimensional representation while preserving the original data's variance. Reducing the number of variables of a data set naturally comes at the expense of accuracy, but the trick in dimensionality reduction is to trade a little accuracy for simplicity. Because smaller data sets are easier to explore and visualize and make analyzing data points much easier and faster for machine learning algorithms without extraneous variables to process.

3.4 The machine learning algorithm

Following the successful extraction of the features, Feedforward Neural Network (FNN) was employed as a machine learning algorithm to facilitate the training of image features extracted to generate the facial recognition model.FNN was utilized to automatically learn and extract relevant features from the facial images for accurate identification. The process begins by inputting images of the faces into the FNN where the neurons in the input layer correspond to the image's pixels. As the data flows through the concealed layers, the network progressively acquires the ability to recognize intricate patterns and attributes within the images. The initial layers detect fundamental elements like edges, corners, and texture, while the deep layers combine these features to recognize more complex attributes such as facial expressions and unique identity-related traits. This process optimizes the network's ability to accurately distinguish between different individuals. The output layer of the FNN produces predictions about the identity of the provided faces. This prediction was then compared to the actual identity label to compute loss, which quantifies the difference between the prediction and the true identity.

3.5 Development of the Facial Recognition Model

In this section, the methods provided were implemented to develop the facial recognition model. The data collected were processed using Gaussian and median filtering techniques which enhances the image for accurateinterpretability. The image features were extracted using PCA to transform the high-dimensionality of thedata, into a low-dimensional representation while the original data variance was preserved,and thenfed the data into the FNN and trained. To achieve this, the backpropagation optimization algorithm was utilized to iteratively adjust the weight and bias of the FNN during the training process and use the loss function to monitor and minimize the difference between its predicted outputs and the actual target labels.When the difference or error is tolerable, then the FNN-based face recognition model is generated. Below is the flow chart diagram, which illustrates the processes involved in the development.

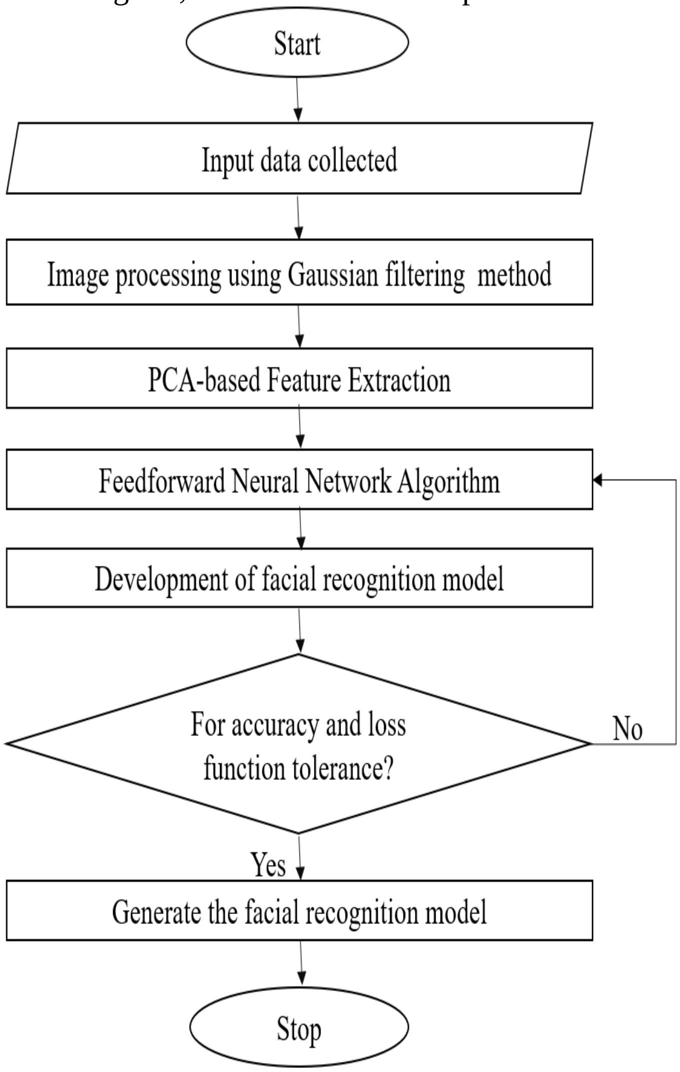

Figure 1: shows the flow chart of the facial recognition model

The diagram depicted in Figure 1above,was the flow chart of the processes and methods used in developing thefacial recognition model. The input data were collected and processed using the Gaussian filtering technique with robust PCA-based feature extraction. FNN was applied as a machine learning algorithm to facilitate the training of the feature extracted to develop the model.

4. RESULTS AND DISCUSSION

Below are some graphs that indicate the results of thedata filtration and normalization processes, withGaussian and median filtering used as image processing techniques.

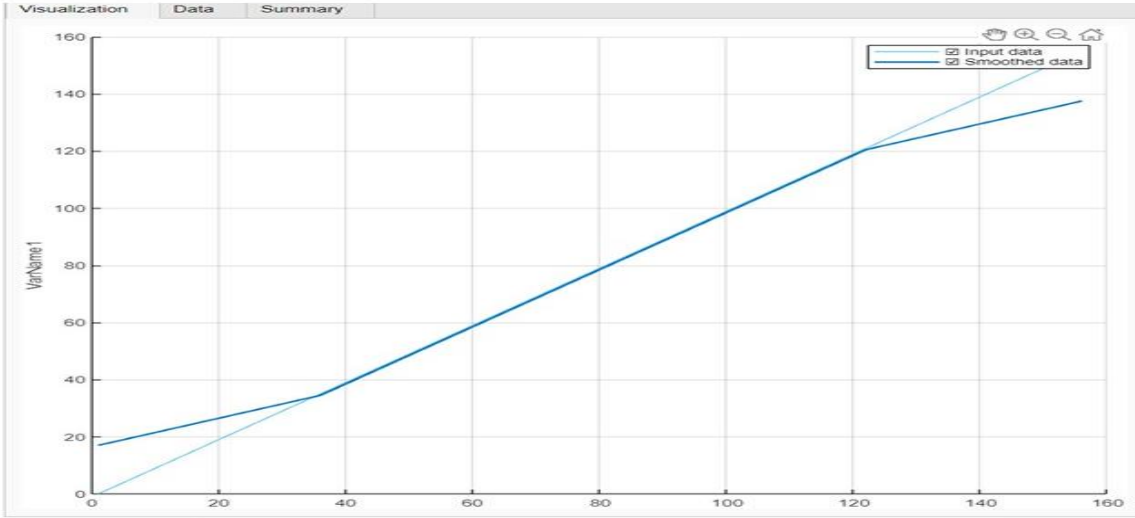

Figure 2: Result of the data filtration processes.

The graph in Figure2 above, describes the results of the data filtration process. Gaussian filter was used as an image processing technique to remove noise to enhance the image quality by removing noise and smoothing fine details on the data.The Gaussian filter is employed to preprocess the image before the classification step. This technique involves a linear filter with weighted values assigned to each element, chosen according to the Gaussian function's characteristics. The selection of this method was grounded in its ability to enhance images through a refinement process, leveraging the pivotal notion that this filter centers around a kernel (Khan et al., 2017).

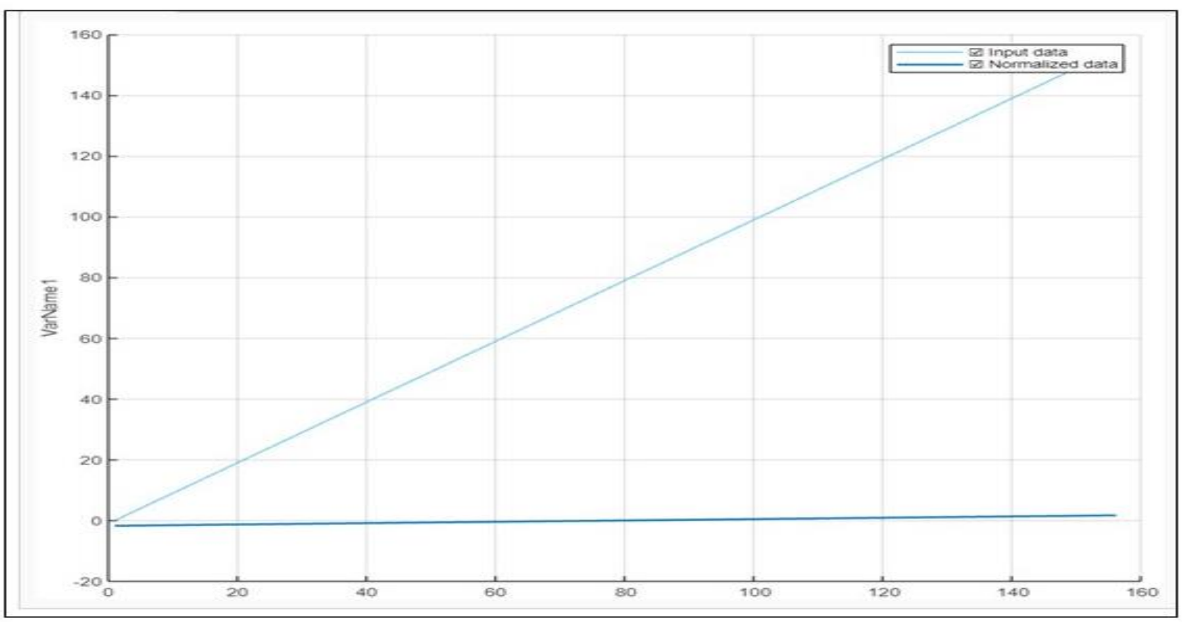

Figure 3:Result of the data normalization process.

The graph depicted in Figure 1.2 above, also illustrates the data normalization processes. During the data processing,the median filter was used to enhance the data interpretability by effectively filteringthe noise while preserving edges and fine details when processing the data. The median filter was renowned for its exceptional ability to eliminate salt and pepper noise within image processing. It serves as the fundamental basis for more sophisticated image filters such as unsharp masking, rank-order processing, and morphological operations. This technique extendsits utility to advanced applications such as object segmentation, speech, and writing recognition, as well as medical imaging. Among the various strategies, to address impulse noise, the median filter is extensively adopted due to its remarkable capacity for noise reduction and its efficiency in computational processing (Zhu and wang, 2012).

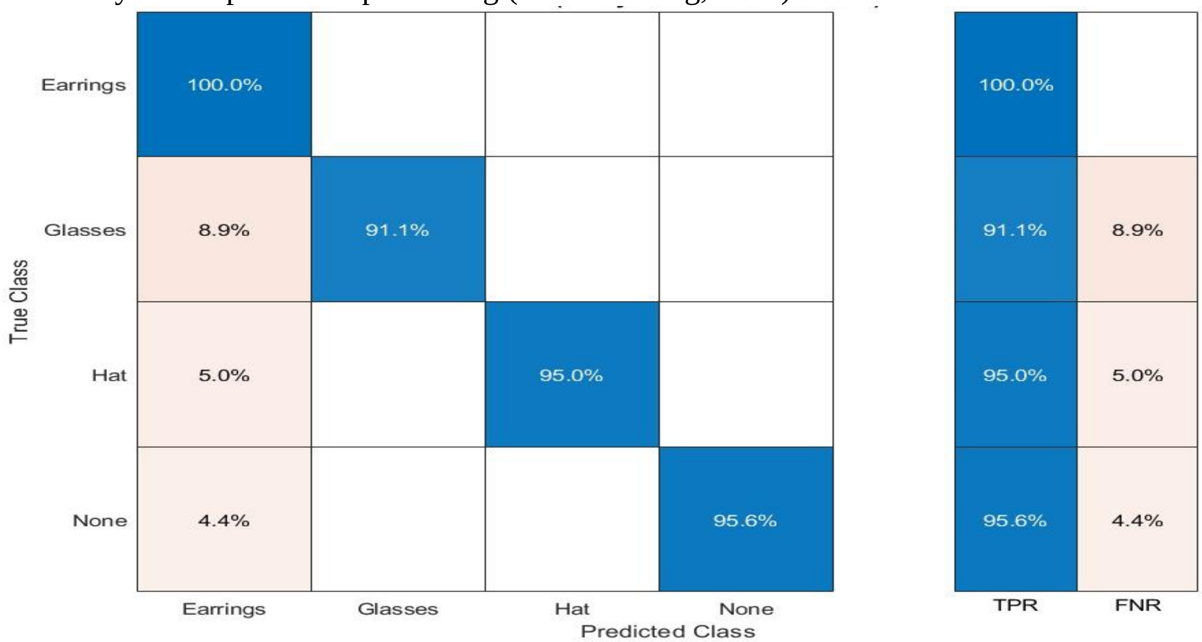

Figure 4: Shows the validation Confusion Matrix of FNN.

The figure above presented the outcome of both the validation matrix and the performance evaluation of the FNN model after training. The evaluation examines the correlation between the True Positive Rate (TPR) and False Negative Rate (FNR) utilizing the predicted class labels in comparison to the actual true class label. The results of TPR shows an average value of 95.43%, indicating that the model performs well in correctly identifying instances of wearing Earrings, Glasses, Hat, and none with the rate of 100%, 91%, 95%, and 95.6% respectively. This showcases a strong level of accuracy in the prediction. Moreover, the assessment also reported an average FNR value of 4.58%. this signifies that the model's classification of instances wearing Earrings, Glasses, Hats, etc., as false negative occurs at the rate of 0%, 8.9%, 5.0%, and 4.4% respectively. The low FNR values indicate a high accuracy in minimizing the misclassificationof those instances.Conclusively, the TPR and FNR analysis demonstrated the model's accuracy in identifying positive instances and reducing false negatives. The high TPR values and low FNR values validated the model's accuracy and efficiency. The overall high accuracy of 99% adds to the model's credibility in the analysis.

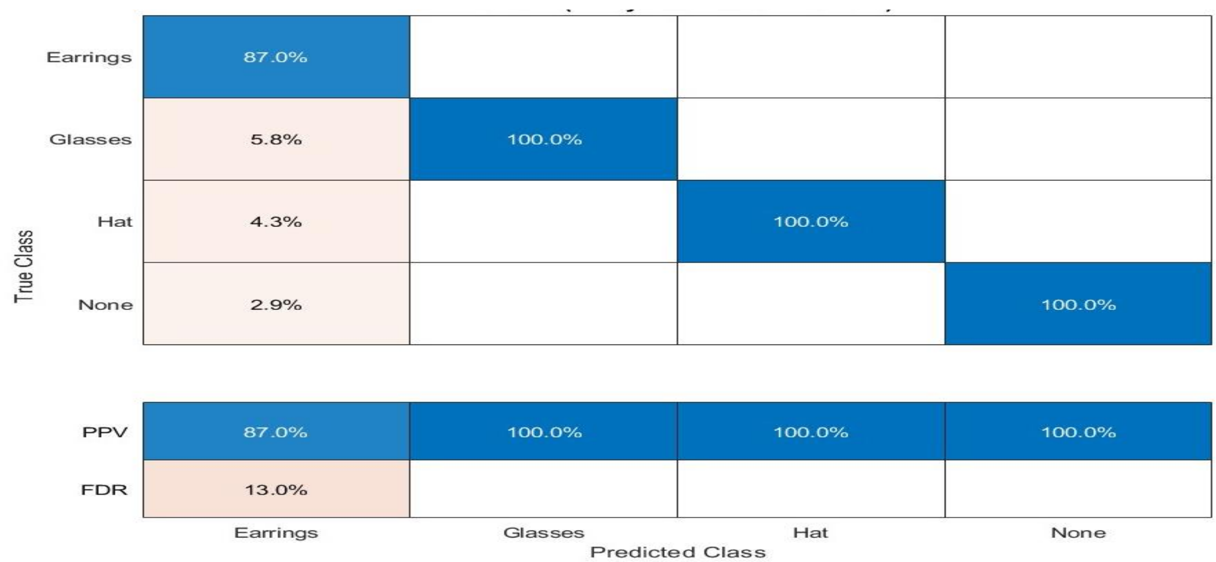

Figure5:Validation result of Confusion matrix 2

Figure 5 displays theValidation result of the Confusion matrixand performance evaluation of the intelligent Feedforward Neural Network (FNN) model. The evaluation specifically considered the relationship betweenPositive Predicted Values (PPV) and Discovery Rates (FDR), employing the predicted class label about the true class labels. The calculated averageof PPV was reported at96.75%, including a notably high degree in predicted class. The accuracy was underscored by the substantial margin between the PPV and the.FDR OF 3.25%. Finally, the validation outcome of the confusion matrix provides a comprehensive evaluation of the intelligent FNN model's performance. The prominent average of PPV suggests the model efficiency identifies positive cases. Furthermore, the considerable margin between the PPV and FDV indicates that the model excels at minimizing the occurrence of false positive prediction. The combinationof high PPV and low FDV underline the model's proficiency in accurate positive classification while mitigating the potential for false positives.

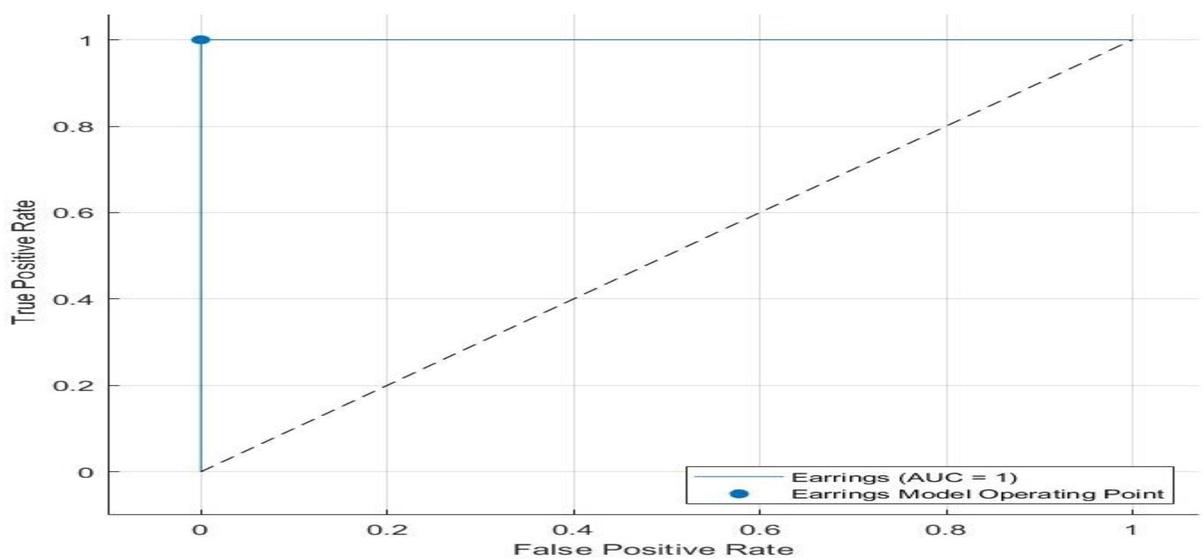

Figure 6: shows the validation of the ROC result of the FNN

Figure 5 displays the ROC performance evaluation of the intelligent Feedforward Neural Network (FNN) model, which was constructed according to the illustration in Figure 1. The relationship between the Receiver Operator Characteristics (ROC) curve and the corresponding Area Under the Curve (RUC) is analyzed. The true positive rate achieved a value of 0.983, indicating a high level of accuracy, as it closely aligns with the false positive rate of 1. This suggests that the intelligent FNN model has been successfully constructed, and its classification performance is evaluated using ROC analysis, demonstrating a high level of accuracy in correctly classifying positive instances while keeping false positives at a minimum.

In this section, the validation of FNNusing a 10-foldvalidation approach was doneconsidering the following parameters such as accuracy, True positive rate (TPR), False positive rate (FNR), and Receiver Operator Characteristic (ROC). The validation of the FNN for the facial recognition modelis shown in Table 1.

Table 1:Validation of Facial Recognition FNN using the K-fold Approach

FOLD	ACCURACY(%)	TPR (%)	FNR (%)	ROC
1.	99.00	95.43	4.48	0.98
2.	99.75	95.44	4.45	0.85
3.	98.64	97.05	3.65	0.91
4.	97.84	95.50	3.55	0.94
5.	98.96	94.86	4. 38	0.75
6.	99.01	95.48	3.75	0.92
7.	98.95	94.85	3.85	0.90
8.	97.85	95.09	4.25	0.65
9.	99.25	95.54	4.22	0.68
10.	98.56	96.58	3.67	0.950
AVERAGE	98.78	95.58	3.98	0.85

The validation process using a 10-fold validation approach yielded insightful results for the FNN-based FR model. Each parameter provides a comprehensive understanding of the model's performance. The accuracy values ranging from 97.84% to 99.78% across different folds demonstrate the model's consistent ability to make correct predictions, including its reliability in identifying individuals accurately. The TPR values, ranging from 94.86% to 97.05%, reflect the model's sensitivity in correctly identifying positive instances, such as matching the face of a registered person. The corresponding FNR values, varying from 3.55% to 4.48%, showcase the model's proficiency in minimizing instances where it wrongly fails to identify actual positive cases.The ROC values, with an average of 0.8, imply that the model efficiency balanced the trade-off between sensitivity and specificity, achieving a strong overall performance. The average accuracy of 98.78% signifies the model's general effectiveness in recognizing faces, while the average TPR and FNR values of 95.58% and 3.98%, respectively, underline its capability to strike a balance between correct identification and false negatives.Notably, the new model achieved a commendable ROC value of 0.85, FNR of 3.98%, TPR of 95.58%, and overall accuracy of 98.78% which showcases the FNN effectiveness, reliability and versatility across various scenarios. In the next result, a comparative analysis considering the new system and other existing systems were presented in Table 2;

Table 2: Comparative Analysis

AUTHORS	TECHNIQUES	ACCURACY

		(%)
Zhang et al., (2017)	Ada Boost, Local Binary Pattern (LBP), and Principal Component Analysis (PCA).	99.2
Ullah et al., (2022)	Decision Tree (DT), Random Forest (RF), and K-Nearest Neighbor (KNN).	95.67
LazariniandHirama, (2022)	Principal Component Analysis (PCA)	93.0
Ravinder and Kaur (2015)	skin color model	96.25
Janarthanan et al., (2022)	RVJA and SCNN.	97.14
Narayan and Deshpande (2017)	Viola-Jones, a fusion of Principal Component Analysis (PCA) and Artificial Neural Network (ANN)	92.0
Sunardi et al., (2022)	Support Vector Machine (SVM), with Principal Component Analysis (PCA)	99.0
Bharadi et al., (2022)	Convolutional Neural Networks (CNN)	99.0
Kaplan et al., (2022)	Adaboost classifier	99.27
Xianwei, (2022)	wavelet denoising method	97.3
Sakshi (2023)	Face Net algorithm	98
New System	Feedforward Neural Network	98.78

Table 2 presents a comparative analysis between the previously reviewed models and the newly introduced system. This analysis takes into consideration the image processing techniques (Gaussian and Median) and PCA-based feature extraction used in this study and other parameters such as TPR, FNR, ROC, and accuracy as indicated in Figure 7 above. A detailed examination of the figures unequivocally demonstrated that the FNN-based model attained an impressive accuracy rate of 98.78%, TPR with a commendable value of 95.58%, FNR of 3.98%, and ROC of 0.85 which demonstrated the reliability of the model. while it is evident that this particular accuracy percentage might not rank as the highest among the various models, a more comprehensive evaluation highlights the multifaceted nature of success. In addition, despite achieving an accuracy rate of 98.78%which may appear marginally lower compared to other reviewed models utilizing different methods boasting higher accuracies, it is essential to emphasize that the effectiveness and efficiency of facial recognition systems cannot be solely determined by accuracy figures alone. The newly introduced model brings a unique set of advantages and contributions to the broader landscape of facial recognition technology. Furthermore, while the aforementioned reviewed models may exhibit slightly higher accuracy rates, the 98.78% accuracy achieved by the new FNN-based system should not be dismissed outright. It’s crucial to understand that accuracy alone doesn’t encompass the entire story. The comprehensive evaluation of a system includes factors such as speed, resource, utilization, robustness to varying conditions, and scalability.The nuanced consideration of these factors may reveal that the new system achieved a more balanced trade-off between accuracy and other performance metrics. The accuracy of a facial recognition system in a controlled environment might not fully represent its performance in real-world scenarios. The reviewed models boasting of higher accuracy might be more sensitive to lighting changes, pose variations, robustness, and reliability when dealing with such real-world scenarios, ultimately translating to a more dependable solution. Moreover, the introduction of a novel FNN-based approach signifies an important contribution to the field of facial recognition. While higher accuracy models might have employed well-established techniques, the FNN approach could bring fresh insight and advancements. This innovation has the potential to inspire further research and lead to the development of hybrid models that combine the strengths of both established and novel methods. This model, despite its accuracy slightly trailing some other reviewed models, brings a host of advantages that deserve careful consideration.Its balanced approach to accuracy, efficiency, robustness, and innovation considerations makes it a valuable contribution to the field. Emphasizing the comprehensive evaluation of a system's performance and the broader implications it entails will help justify its acceptance as an efficient and effective solution that enriches the collective knowledge of facial recognition technology.The study made a valuable contribution to the field of facial recognition technology by presenting a novel approach that balances accuracy, efficiency, and robustness. It offers fresh insight and inspires further research, enriching the collective knowledge and understanding of facial recognition technology.

5. Conclusion

In conclusion, this study aimed to develop an effective and efficient facial recognition system usingcomprehensive metrology. The workflow encompassed literature review, data collection, image processing using Gaussian and Median filters, robust feature extraction with PCA, and trainingwith a Feedforward Neural Network (FNN) algorithm. The resulting FNN-based model achieved a commendable ROC value of 0.85, FNR of 3.98%, TPR of 95.58%, and overall accuracy of 98.78% which indicated the model's efficiency, effectiveness, reliability, and versatility across various scenarios. While the accuracy slightly trails some higher-performance models,it's important to emphasize the multifaceted nature of success. The model's balanced performance of TPR-FNR, combined with its consistent accuracy and strong ROC value reflected its reliability. Furthermore, the model's innovative approach and consideration of various performance metrics make it a valuable contribution to the field of facial recognition technology. The knowledge generated from this work contributes to the field's advancement by showcasing the effectiveness of the FNN approach in FR. Notably,this study can further the understanding of how to strike the right balance between accuracy and sensitivity, enhancing the broader knowledge base and application of facial recognition technology.

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