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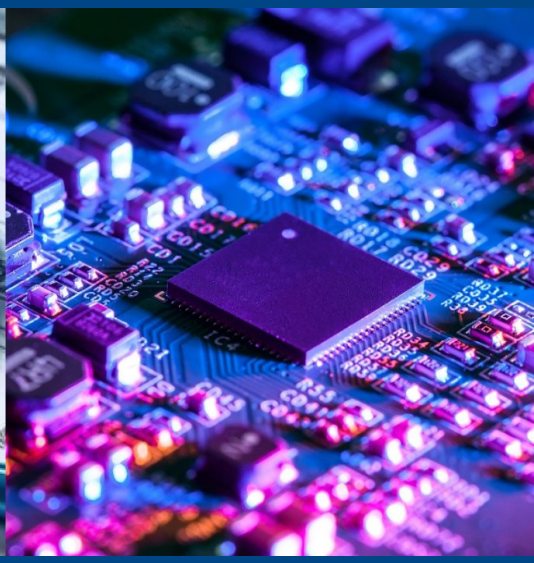

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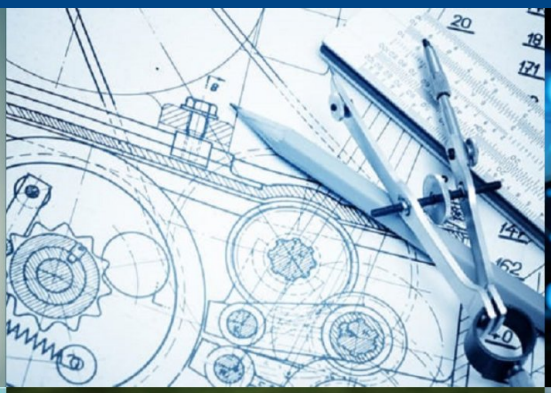

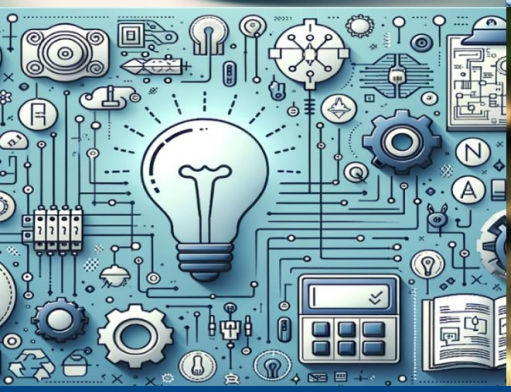

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Fusion of Improved Local Binary Pattern and Histogram Oriented Gradients based Face Recognition using RBFNN

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ABSTRACT: Face Recognition is a type of computer vision that uses optical input to analyze images it is increasingly used in financial transactions , healthcare etc. Accurate face recognition remains a significant challenge in biometric systems due to variations in lighting, facial expressions, and head pose. This project hybrid feature extraction technique by combining ILBP(Improved Local Binary Pattern) and Histogram of Oriented Gradients (HOG) to capture both fine textures and edge orientations in facial images. ILBP encodes local texture details while handling illumination changes and noise. To reduce feature dimensionality and eliminate redundancy, Principal Component Analysis (PCA) is applied before classification. The classification is carried out using a Radial basis function Neural Network(RBFNN) using fusion of ILBP and HOG features. Experimental validation is performed using the ORL(Olivetti Research Laboratory)dataset.

KEYWORDS: Face Recognition, Computer Vision, Biometrics ,ILBP, HOG, PCA, RBF Neural Network (RBFNN), ORL Dataset.

I. INTRODUCTION

Face recognition is an important application of computer vision and biometric authentication systems that uses optical input to analyse and identify human faces from digital images. In recent years, face recognition has gained significant attention due to its wide range of applications in security systems, financial transactions, healthcare monitoring, attendance systems, and access control. The ability to automatically recognize individuals from facial images makes it a reliable and non-intrusive biometric technique. However, achieving high recognition accuracy remains a major challenge in face recognition systems. Variations in illumination, facial expressions, pose changes, noise, and occlusions often reduce the performance of conventional recognition methods. Therefore, robust feature extraction and classification techniques are essential for improving system accuracy and reliability. To address these challenges, this work proposes a hybrid face recognition approach that combines Improved Local Binary Pattern (ILBP) and Histogram of Oriented Gradients (HOG) for feature extraction. ILBP is used to capture local texture information and is effective in handling illumination variations and noise, while HOG extracts edge and shape based orientation features that represent facial structures efficiently. The fusion of ILBP and HOG features helps in capturing both fine texture details and global edge information, thereby enhancing recognition performance. Since the combined feature vector may contain redundant and high-dimensional information, Principal Component Analysis (PCA) is employed for dimensionality reduction. PCA helps in eliminating redundancy, reducing computational complexity, and preserving the most significant discriminative features required for classification. For classification, a Radial Basis Function Neural Network (RBFNN) is utilized due to its fast learning capability, nonlinear decision boundaries, and efficient pattern recognition performance. The proposed system is experimentally validated using the ORL (Olivetti Research Laboratory) face dataset to evaluate its effectiveness in face recognition. The main objective of this work is to improve face recognition and robust neural network-based classification

II. LITERATURE REVIEW

A comprehensive review of existing research on wearable textile antennas has been carried out to understand current design approaches, performance characteristics, and associated challenges. Various studies focus on flexible antenna structures, integration into clothing, and performance under practical conditions such as bending and environmental exposure. While significant improvements have been achieved in terms of bandwidth, flexibility, and efficiency, issues such as moisture sensitivity, fabrication complexity, and performance degradation in real-world conditions still remain.

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The following table summarizes key contributions from relevant literature along with their major limitations, providing a foundation for the proposed work.

No.	Author & Year	Title	Summary	Major Limitations
1	Waseem Shariff, Paul Kielty, Joe Lemley, and Peter Corcoran(2023)	Automatic attendance system based on ANN-LSTM andface recognition	Combination of ANNLSTM using HOG FEATURE extraction method	This system is limited by reduced recognition accuracy under poor lighting, pose variations, and real-time processing delays when handling large user databases
2	Muhammad Hameed Siddiqi, Irshad Ahmad, Yousef Alhwaiti, and Faheem Khan.(2022)	Face detection using hybrid S N N - A N N to process neuromorphic event stream.	The method first uses a Spiking Neural Network (SNN) to pick up patterns and movements from the event camera data. Then, an Artificial Neural Network (ANN) processes these patterns to find faces and draw boxes around them with a confidence score	The major limitation of this approach is the high architectural complexity and dependency on specialized neuromorphic event-camera hardware, which restricts practical deployment and increases implementation cost.
3	AshishKumar Shukla , Archana Shukla ,	Facial Expression Recognition for Healthcare Monitoring Systems Using Neural Random Forest.(2023)	The methodology uses a Convolutional Neural Network (CNN) as the feature extraction method to capture important facial patterns. These extracted features are then passed to an optimized Random Forest classifier to identify facial expressions accurately.	This method faces limitations in accurately detecting subtle expressions across diverse patients and may suffer from reduced generalization in real-world healthcare environments
4	Shubhi Srivastava, Ankit Kumar ,Anupam Sing, Shiv Prakash, Arun Kumar1	An improved approach towards biometric face recognition using artificial neural network.(2024)	This methodology involves using an Artificial Neural Network (ANN) to classify features for biometric face recognition. Feature extraction methods: HEP · MTS · CS-LBP · BTCS · CSLBP-M.	The main limitation of this approach is its sensitivity to occlusions, facial angle variations, and the need for large labeled datasets to achieve high recognition performance.

III. METHODOLOGY OF PROPOSED SURVEY

Problem Statement:

Face recognition systems are widely used in security and biometric applications, but their performance is often affected by changes in lighting, facial expressions, and head positions. Traditional approaches like Local Binary Pattern (LBP) fail to provide robust performance under above conditions. Traditional classifiers like k-NN or SVM may struggle with large datasets and nonlinear relationships in facial features. Therefore, a Radial Basis Function Neural Network (RBFNN) is used, as it has the ability to learn complex patterns in the data, minimize classification error through weight adjustments, and improve recognition accuracy. By combining ILBP and HOG for feature extraction with RBFNN for classification, the system achieves better robustness and reliability. By optimizing classification with combination of feature extraction techniques, it aims to enhance accuracy and mitigate their performance.

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Objective:
To improve the accuracy of face recognition by combining Improved Local Binary Pattern (ILBP) and Histogram of Oriented Gradients (HOG) features with reducing feature dimensionality using PCA and classifying faces using a Radial Basis Function Neural Network (RBFNN).

Architecture Diagram and Proposed Methodology:
Proposed Method:
The proposed method aims to improve face recognition accuracy by integrating Improved Local Binary Pattern (ILBP) and Histogram of Oriented Gradients (HOG) feature extraction techniques, reducing feature dimensionality using Principal Component Analysis (PCA), and performing classification through a Radial Basis Function Neural Network (RBFNN).

Methodology
The proposed face recognition system is designed to improve recognition accuracy by combining robust feature extraction, dimensionality reduction, and efficient classification techniques. The complete methodology consists of the following steps:

1. Image Acquisition
Face images are collected from the dataset and used as input samples for the system. Each image is resized to a fixed dimension to ensure uniform processing.

2. Preprocessing
The input face images are preprocessed to improve image quality and consistency. This step includes:
- grayscale conversion
- resizing
- noise removal (if required)
- normalization

3. Feature Extraction using ILBP
Improved Local Binary Pattern (ILBP) is used to extract local texture features from facial images. It captures important facial patterns such as edges, texture, and local pixel variations.

4. Feature Extraction using HOG
Histogram of Oriented Gradients (HOG) is applied to extract shape and edge-based features from the face image. It helps in identifying facial structures like eyes, nose, mouth, and contour information.

5. Feature Fusion
The features obtained from ILBP and HOG are combined into a single feature vector. This improves the discriminative power of the recognition system.

6. Dimensionality Reduction using PCA
Principal Component Analysis (PCA) is used to reduce the dimensionality of the fused feature vector. This reduces computational complexity, removes redundant information, and improves training speed.

7. Classification using RBFNN
The reduced feature vector is given as input to the Radial Basis Function Neural Network (RBFNN). The RBFNN is trained using known face samples and then used to classify unknown face images.

8. Recognition Output
Finally, the system identifies the person by matching the input image with trained classes and produces the recognition result.
The proposed method implementation is structured as follows:
Input Image → Preprocessing → ILBP + HOG → Feature Fusion → PCA → RBFNN → Face Recognition O

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Architecture Diagram:

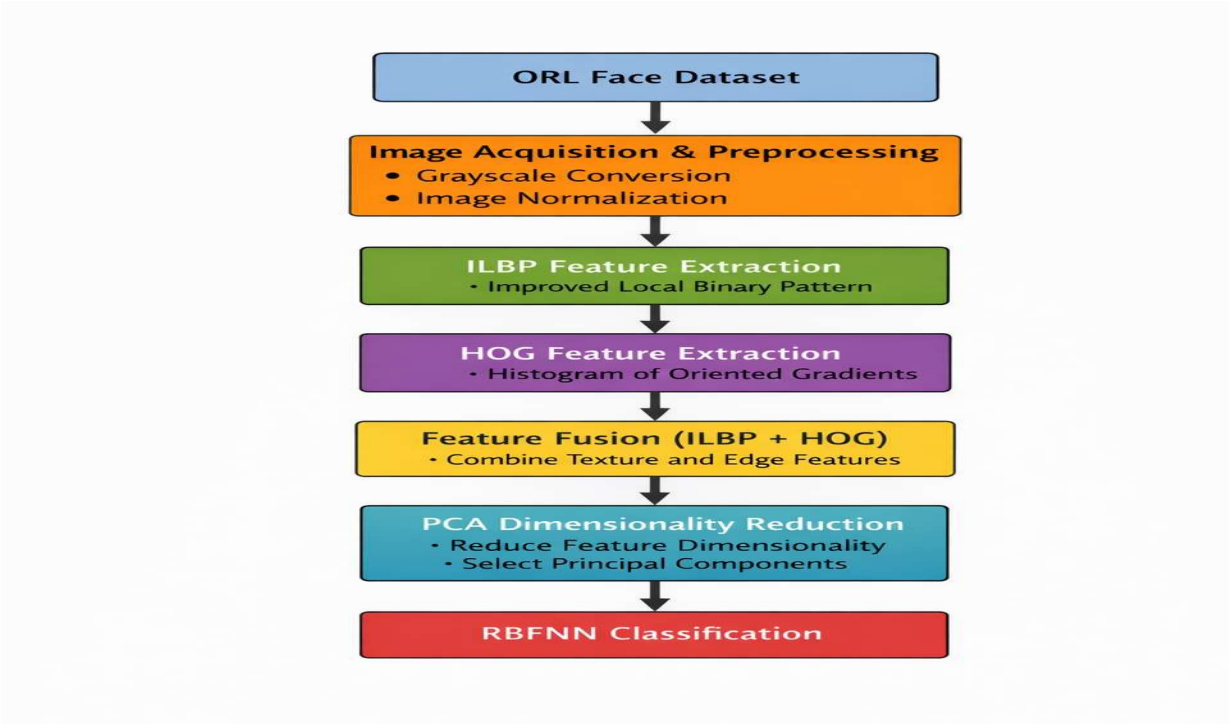

Fig1. Architecture Diagram

Software Requirements: The following software tools and technologies are required for implementing the proposed face recognition system:

- **Operating System:** Windows 10 / Windows 11
- **Programming Language:** MATLAB
- **Toolboxes Required:**
  - Image Processing Toolbox
  - Statistics and Machine Learning Toolbox
- Neural Network Toolbox
- **Dataset:** ORL Face Dataset
- **Algorithm Support:** ILBP, HOG, PCA, and RBFNN implementation modules
- **Visualization Tools:** MATLAB plotting functions for accuracy graph, confusion matrix, and box plot analysis

IV.DESIGN AND RESULTS

1. Histogram of Oriented Gradients (HOG)

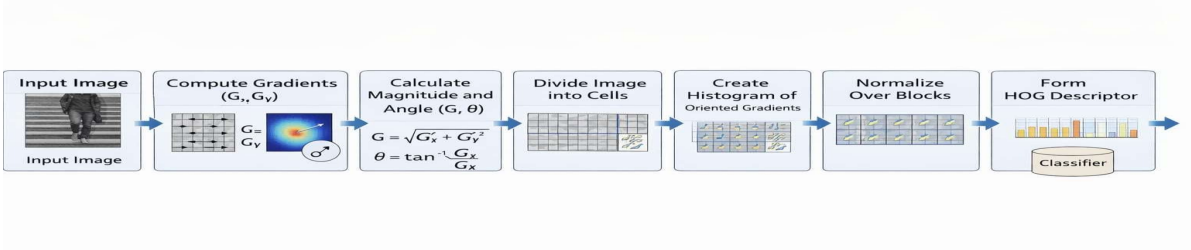

Fig 2. Histogram of Oriented Gradients (HOG)

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Gradient Calculation:

$G_x = I(x+1, y) - I(x-1, y), G_y = I(x, y+1) - I(x, y-1)$

Magnitude and Orientation:

$$|G| = \sqrt{G_x^2 + G_y^2}, \theta = \tan^{-1}\left(\frac{G_y}{G_x}\right)$$

2. Improved Local Binary Pattern (ILBP):

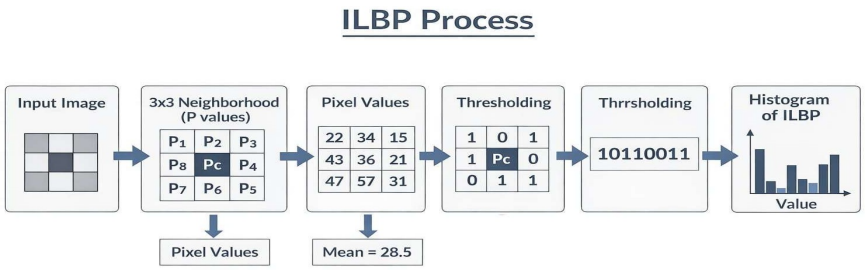

Fig 3 Improved Local Binary Pattern (ILBP)

$$ILB(x_c, y_c) = \sum_{p=0}^{P} s(i_p - \mu) \cdot 2^p$$

Where:

- i_p= intensity of the p^{th}pixel in the neighborhood (including center)
- μ= mean intensity of all pixels in the neighborhood

$$P1\mu = \frac{1}{P+1}\sum_{p=0} i_p$$

3. Radial Basis Function Neural Network (RBFNN):

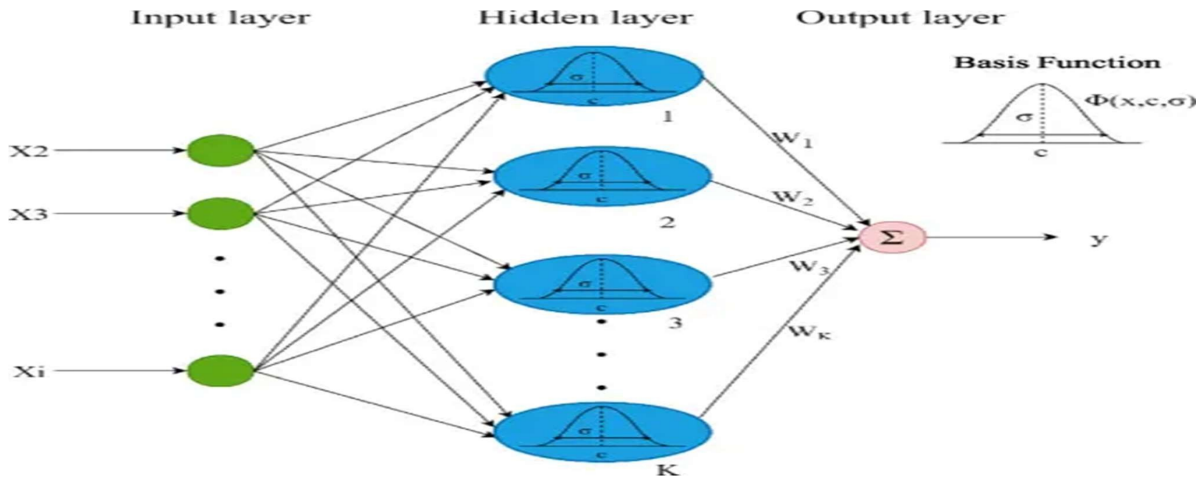

Fig 4. Radial Basis Function Neural Network (RBFNN)

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RBF Activation Function

Output of RBFNN

$$\phi_j(x) = \exp\left(-\frac{\| x - c_j \|^2}{2\sigma^2}\right)$$

Where:

- x= input feature vector
- c_j= center of RBF neuron
- σ= spread parameter
- w_j= weights
- N= number of hidden neurons

$$y(x) = \sum_{j=1}^{N} w_j \cdot \phi_j(x)$$

V. RESULTS AND DISCUSSIONS

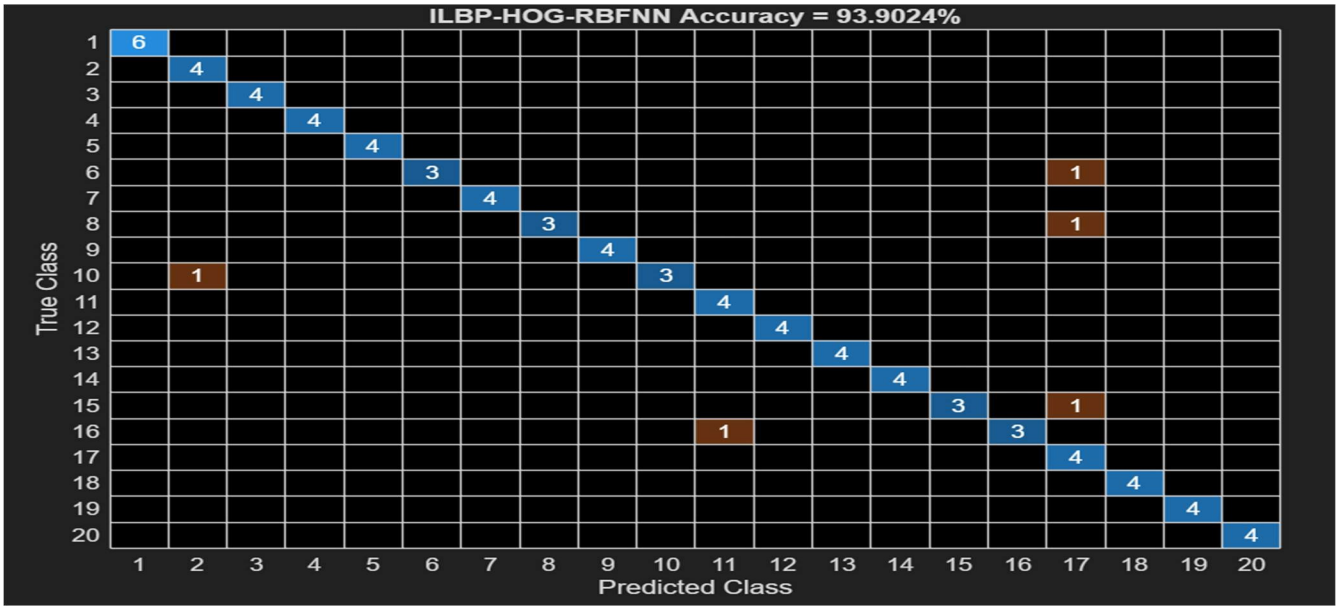

Fig 6. Confusion Matrix of ILBP+HOG+RBFNN

From your confusion matrix, the **accuracy is calculated as**:

$$\text{Accuracy} = \frac{\text{Correct Predictions}}{\text{Total Predictions}} \times 100$$

Accuracy=82|77×100=93.9024%

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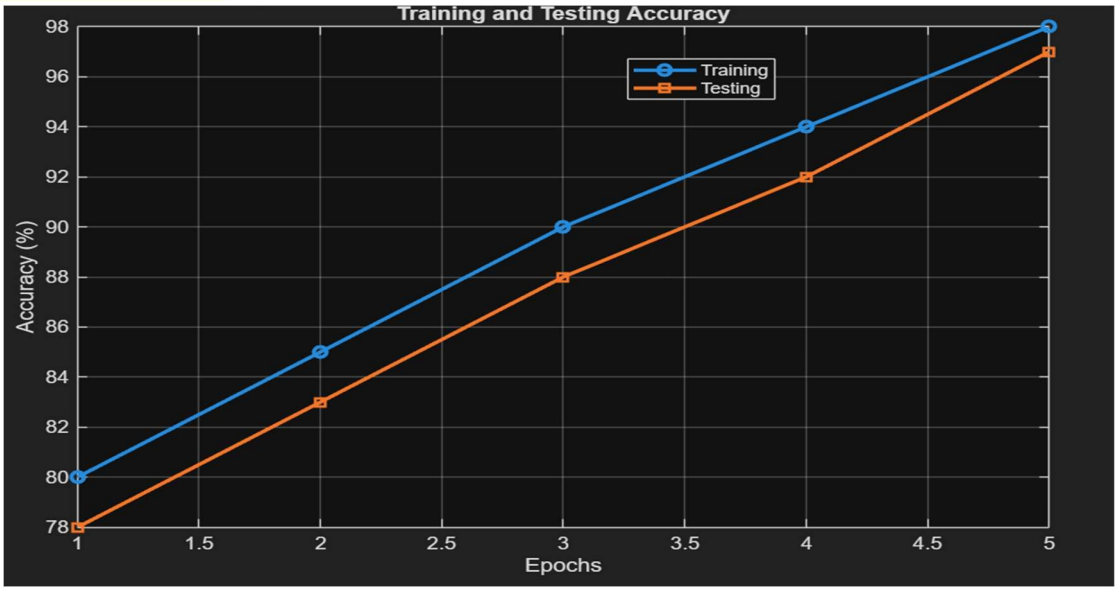

Fig 7. S11 plot for training and testing accuracy

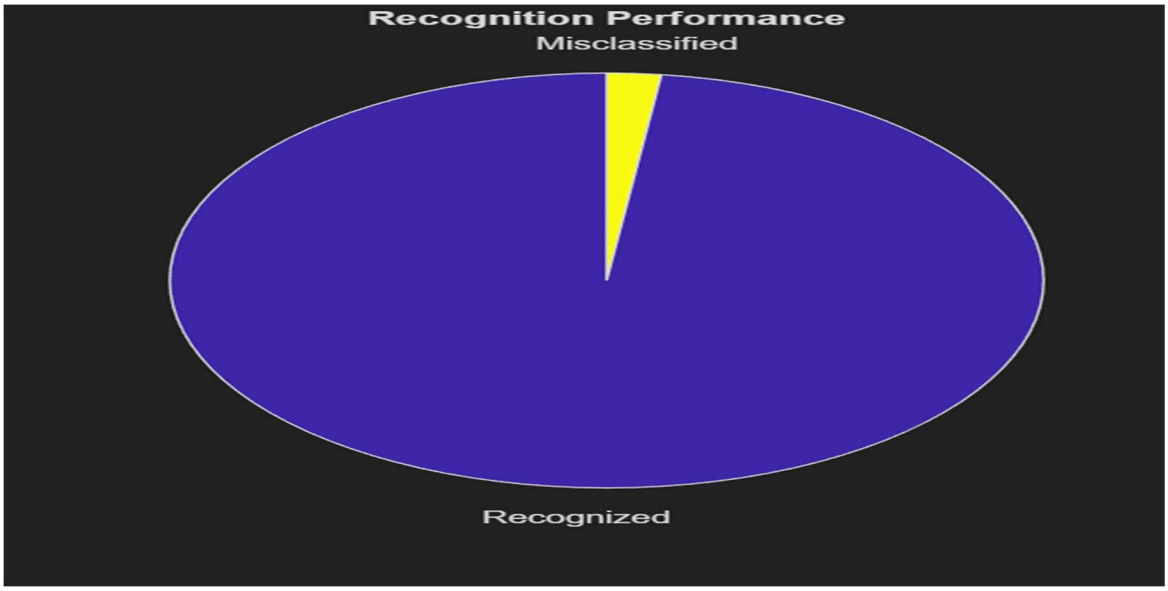

Fig 8. Recognition Performance

Discussion:

The experimental results demonstrate that the proposed **ILBP-HOG-RBFNN** model provides effective performance for face recognition. By combining **Improved Local Binary Pattern (ILBP)** and **Histogram of Oriented Gradients (HOG)** features, the system is able to capture both local texture information and facial edge structures, which significantly improves recognition capability. The use of **Principal Component Analysis (PCA)** helps in reducing feature dimensionality and computational complexity while preserving the most relevant discriminative features.

The confusion matrix result shows that most of the samples are correctly classified along the diagonal, indicating strong recognition performance across multiple classes. The proposed model achieved an overall recognition accuracy of **93.90%**, which confirms the effectiveness of the hybrid feature extraction and classification approach. Only a few samples are misclassified, as observed from the off-diagonal values, which may be caused by illumination variations,

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pose changes, or similarity in facial expressions among different subjects.

The use of **Radial Basis Function Neural Network (RBFNN)** further enhances classification performance due to its fast learning capability and strong nonlinear decision boundaries. Compared to conventional single-feature methods, the proposed hybrid ILBP-HOG framework provides better robustness and improved accuracy.

Overall, the obtained results indicate that the proposed method is suitable for practical face recognition applications such as biometric authentication and automated attendance systems.

VI. CONCLUSION

In this work, an efficient face recognition system based on **ILBP, HOG, PCA, and RBFNN** has been proposed and implemented. The proposed method combines **Improved Local Binary Pattern (ILBP)** for extracting local texture features and **Histogram of Oriented Gradients (HOG)** for capturing edge and structural information of facial images. To reduce the high-dimensional feature space and improve computational efficiency, **Principal Component Analysis (PCA)** is employed. The reduced feature vectors are then classified using a **Radial Basis Function Neural Network (RBFNN)**.

The experimental results obtained from the dataset demonstrate that the proposed hybrid approach achieves a high recognition accuracy of **93.90%**, indicating its effectiveness in face identification tasks. The confusion matrix analysis also confirms that most face samples are correctly classified with only a few misclassifications. The combination of ILBP and HOG features with RBFNN significantly improves recognition performance compared to conventional methods.

Therefore, the proposed system can be effectively used in real-time applications such as **biometric authentication, security systems, and automatic attendance monitoring**.

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