PRML PROJECT REPORT

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Abstract

In this report, we present a comprehensive study on the identification of faces in images by classifying them into one of K given classes using various feature extraction techniques. Specifically, we explore the Local Binary Patterns (LBP), Histogram of Oriented Gradients (HoG), and Convolutional Neural Networks (CNN) methods.

Firstly, we provide an overview of each technique, explaining its underlying principles and how it extracts features from images. Then, we describe our experimental setup, including the dataset used, preprocessing steps, and evaluation metrics.

Subsequently, we present the results of our experiments, comparing the performance of LBP, HoG, and CNN in terms of accuracy, computational efficiency, and robustness.

Finally, we conclude with insights gained from our study and potential avenues for future research in the field of face identification using different feature extraction techniques.

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1 Introduction

Face identification is a fundamental task in computer vision with numerous applications ranging from security and surveillance to human-computer interaction. The ability to accurately classify faces into predefined classes plays a crucial role in various domains, including law enforcement, access control systems, and personal device authentication.

In this report, we address the problem of face identification by exploring three distinct feature extraction techniques: Local Binary Patterns (LBP), Histogram of Oriented Gradients (HoG), and Convolutional Neural Networks (CNN). These techniques have been widely studied and applied in the field of computer vision for their effectiveness in capturing discriminative features from images.

1.1 Figures

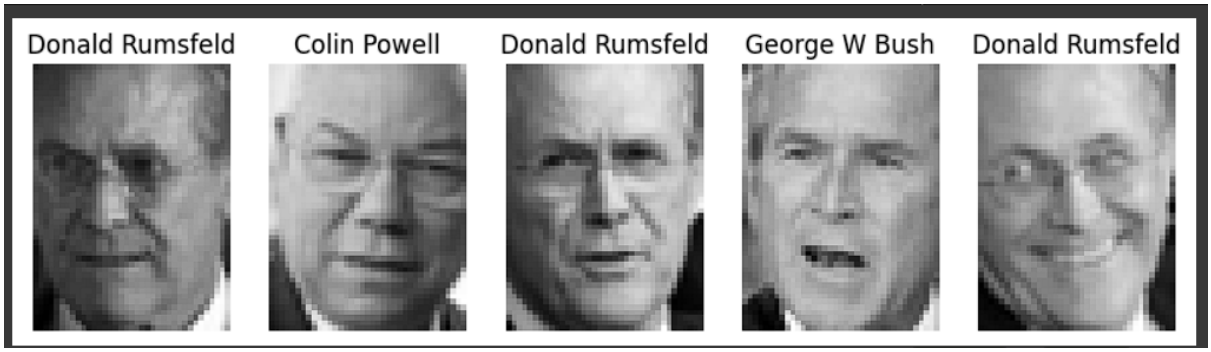


Figure 1: Randomly generated LFW images

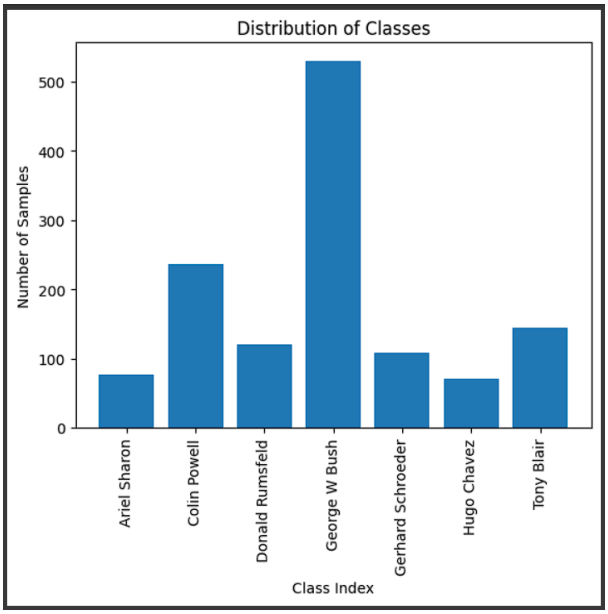


Figure 2: Bar chart representing numbers of samples among different classes

(a) Original Image

(b) LBP Feature Extracted (Scratch)

(c) LBP Feature Extracted (Using scikit-learn)

Figure 3: Comparison of LBP Feature Extraction

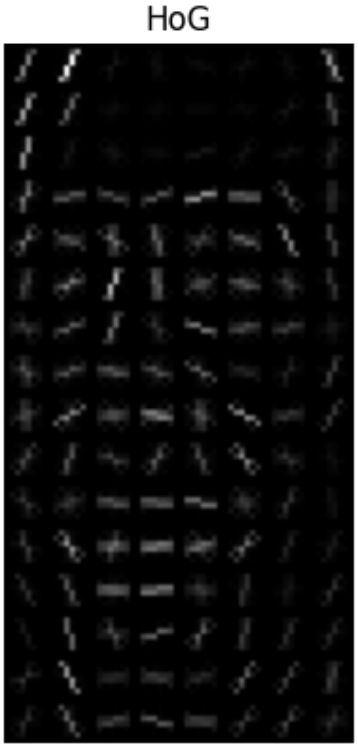
(a) Original Image

(b) vertical Gradient Detection using HOG

(c) Horizontal Gradient Detection using HOG

(d) Representation of magnitude of gradient

(e) Representation of angle



(f) Final Histogram of Oriented Gradients Image

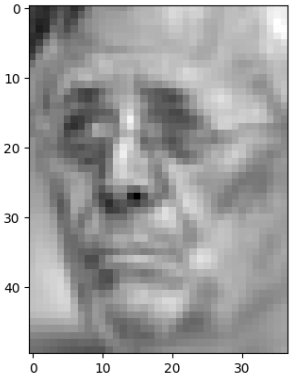
Figure 4: HOG feature Extraction

(a) Horizontal edge detection using CNN

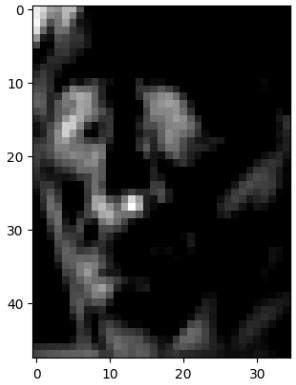
(b) Vertical edge detection using CNN

(c) CNN : gabor filter application

Figure 5: Comparison of Feature Extraction using convolution

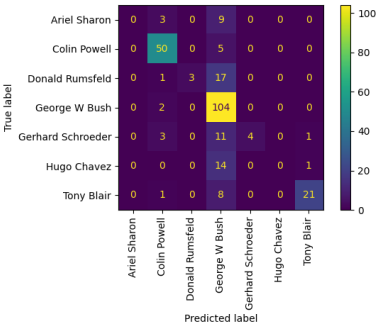


(a) Sample image

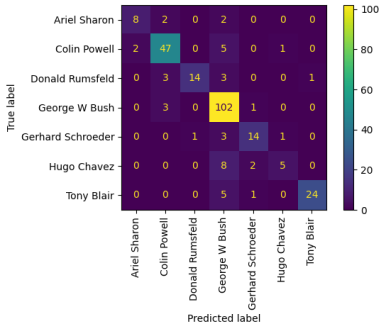


(b) Convolved image with trained filter

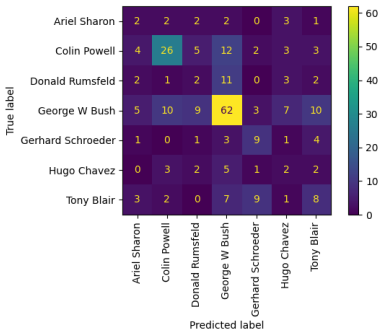
Figure 6: Employing CNN



(a) Confusion Matrix using SVM

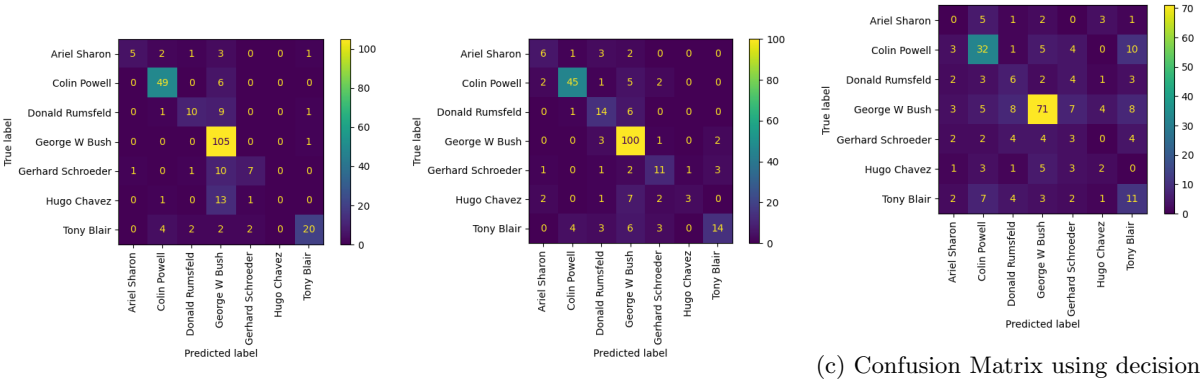


(b) Confusion Matrix using KNN



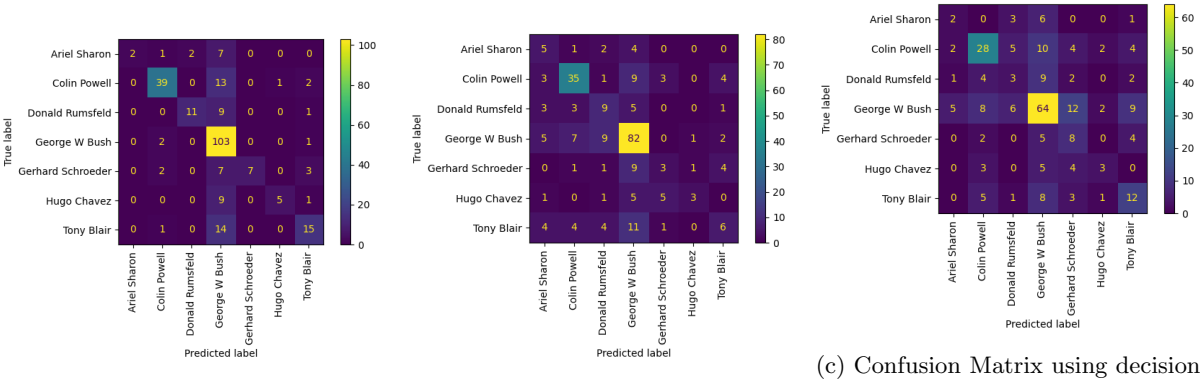
(c) Confusion Matrix using decision tree

Figure 7: Results of LBP using different classifiers



(a) Confusion Matrix using SVM (b) Confusion Matrix using KNN (c) Confusion Matrix using decision tree

Figure 8: Results of HOG using different classifiers



(a) Confusion Matrix using SVM (b) Confusion Matrix using KNN (c) Confusion Matrix using decision tree

Figure 9: Results of CNN using different classifiers

2 Approaches Tried

- Various approaches were tried for image classification

Support Vector Machine (SVM): SVM is a powerful classification algorithm used to find the hyperplane that best separates the classes in the feature space. It works well for both linearly separable and non-linearly separable data. SVM was applied to the extracted features from various techniques including:

1. Local Binary Patterns (LBP)
2. Histogram of Oriented Gradients (HOG)
3. Convolutional Neural Network (CNN)-based edge detection

K-Nearest Neighbors (KNN): KNN is a simple yet effective classification algorithm that assigns a class label based on the majority class among its k nearest neighbors in the feature space. It is a non-parametric and lazy learning algorithm. KNN was utilized on the extracted features from different techniques including:

1. LBP
2. HOG
3. CNN-based edge detection

Decision Tree: Decision Tree is a hierarchical tree-like structure that recursively splits the feature space based on feature values to create decision rules for classification. It is easy to interpret and visualize. Decision Tree was employed on the extracted features from various techniques such as:

1. LBP
2. HOG
3. CNN-based edge detection

PCA: The PCA was tried for classification but due to low cumulative variance ratios it is not used for classification.

These approaches were experimented with to classify images using different feature extraction techniques, and their performance was evaluated using various classification algorithms.

3 Experiments and Results

Exploratory Data Analysis:

- The dataset comprises a total of 1288 images, each of size (50, 37) pixels.
- There are 7 unique classes in the dataset, representing different individuals.
- The distribution of samples among different classes is visualized using a bar chart.

Feature Extraction Techniques:

1. **Local Binary Patterns (LBP) Feature Extraction:**
   - **Implemented from Scratch:**
     - The LBP algorithm is manually implemented to extract texture features from images.
     - LBP is computed for each pixel by comparing its intensity with neighboring pixels.
     - The resulting LBP image encodes texture information.
   - **Using scikit-learn:**
     - Scikit-learn library is utilized to perform LBP feature extraction.
     - Scikit-learn provides optimized implementations for efficient feature extraction.
2. **Histogram of Oriented Gradients (HOG) Feature Extraction:**
   - Computation of horizontal gradient, vertical gradient and magnitude and angle of gradients for each pixel in the image is done manually
   - HOG focuses on capturing the distribution of gradient orientations in images.
   - It divides images into cells and computes histograms of gradient orientations within each cell.
   - HOG features are commonly used in object detection tasks.
3. **Convolutional Neural Network (CNN):**
   - Convolution function is employed for vertical and horizontal edge detection.
   - The Colvolution function is made from scratch that can be used to detect vertical and horizontal edges in images.
   - These edge-detected images provide useful features for characterizing image content.
   - The Gabor filter is also applied to images to extract texture features.
   - The convolutional neural network is also made using keras library .
   - CNN sets up and trains a CNN model for image classification, with the ability to extract activation maps for further analysis or visualization.

Classification Results:

1. **Support Vector Machine classifier:**
    - SVM classifier is used for classification of images after application of different feature extraction techniques. The accuracy are as follows:
    - For LBP : 0.71
    - For HOG: 0.76
    - For CNN: 0.71
2. **K nearest neighbour classifier:**
    - KNN classifier is used for classification of images after application of different feature extraction techniques. The accuracy are as follows:
    - For LBP : 0.83
    - For HOG: 0.75
    - For CNN: 0.55
3. **Decision tree classifier:**
    - Decision tree is used for classification of images after application of different feature extraction techniques. The accuracy are as follows:
    - For LBP : 0.43
    - For HOG: 0.48
    - For CNN: 0.47

- The KNN classifier exhibits exceptional performance for LBP and HOG but for CNN it does not performs well.
- The SVM classifier does well for all feature extraction techniques.
- The Decision tree classifier performs poorly for all feature extraction techniques

4 Summary

The experimentation highlighted the importance of feature extraction techniques in the performance of classification tasks. While LBP and HOG provided robust representations of texture and gradient orientations, respectively, CNN-based edge detection offered valuable insights into image structures. The choice of classifier also played a crucial role, with SVM demonstrating remarkable performance across all feature extraction methods. Overall, the experimentation provided valuable insights into the effectiveness of different approaches in face identification tasks, paving the way for future research and applications in the field of computer vision.

References

A Contribution of each member

1. Kruttichhwas Pradhan: Implemented LBP, HOG for feature extraction and done website development
2. Vighnesh Mandavkar: Implemented classifier: KNN, SVM and tabulated results
3. Shubham Banwadikar: Report making using latex, Exploratory data analysis
4. Hanshika Misra: Implemented classifier Dicission tree, done website development
5. Tanisha: Done data preprocessing and tabulated results
6. Vinay Kumar: Implemented CNN for feature extraction and built classifier: CNN