FACIAL RECOGNITION-BASED IMAGE DISTRIBUTION SYSTEM

MINI PROJECT REPORT

Submitted by

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in partial fulfilment for the award of the degree

BACHELOR OF TECHNOLOGY

in

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of

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Under the guidance of

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COLLEGE OF ENGINEERING AND MANAGEMENT PUNNAPRA

(Under CAPE, Estd by Govt. of Kerala)

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CERTIFICATE

This is to certify that the report document entitled **"FACIAL RECOGNITION-BASED IMAGE DISTRIBUTION SYSTEM"** submitted by **ABHIRAM SANAL (PRP20CS002), ANJANA SEBASTIAN (PRP20CS017), HARIPRIYA.K (PRP20CS033), NEVIN V ADATTE (PRP20CS048)** to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of **Bachelor of Technology** in **Computer Science and Engineering** is a bonafide record of the project work carried out by them under our supervision.

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ABSTRACT

The main objective of this project is to provide users with a convenient way to retrieve photos containing their face from a repository of images. The application allows users to capture their face images using their device camera and then compares them with the images present in the "unknown" folder. If a match is found, the matching images are displayed in the web browser.

In conclusion, the project has achieved its objectives of developing an efficient face recognition web application that allows users to retrieve photos containing their face. The application has demonstrated promising results in terms of accuracy and performance. Future enhancements and improvements are also discussed, such as multi-face recognition, real-time recognition, and additional security measures.

LIST OF FIGURES

ABBREVIATIONS

1. SRS - Software Requirements Specification
2. HTML - Hypertext Markup Language
3. API - Application Programming Interface
4. UI - User Interface
5. UX - User Experience
6. SQL - Structured Query Language
7. MVC - Model-View-Controller
8. CNN - Convolutional Neural Network
9. SVM - Support Vector Machine
10. GUI - Graphical User Interface
11. OS - Operating System
12. RAM - Random Access Memory
13. CPU - Central Processing Unit
14. GPU - Graphics Processing Unit
15. IDE - Integrated Development Environment
16. CSV - Comma-Separated Values
17. JSON - JavaScript Object Notation
18. HTTP - Hypertext Transfer Protocol
19. URL - Uniform Resource Locator
20. API - Application Programming Interface
21. GUI - Graphical User Interface
22. PNG - Portable Network Graphics
23. JPEG - Joint Photographic Experts Group
24. GIF - Graphics Interchange Format
25. JPG - Joint Photographic Group
26. DBMS - Database Management System
27. HTTP - Hypertext Transfer Protocol

28. SSL - Secure Sockets Layer
29. TLS - Transport Layer Security
30. CRUD - Create, Read, Update, Delete
31. AI - Artificial Intelligence
32. ML - Machine Learning
33. CNN - Convolutional Neural Network
34. ROI - Region of Interest
35. API - Application Programming Interface
36. URL - Uniform Resource Locator
37. UI - User Interface
38. UX - User Experience
39. CSS - Cascading Style Sheets
40. JS - JavaScript

CHAPTER 1

INTRODUCTION

In today's digital era, face recognition technology has become increasingly prevalent, finding applications in diverse fields such as security systems, access control, surveillance, and personalized user experiences. This project aims to develop a face recognition program using Python and the Flask framework, enabling users to retrieve photos from a collection of images where their faces are present. The system will compare a user-captured image with images stored in a designated "unknown" folder and display the matching images in a web browser.

1.1 BACKGROUND

Face recognition is a subset of the broader field of computer vision and artificial intelligence. It involves identifying and verifying individuals based on their facial features. The rapid advancements in machine learning algorithms and the availability of large datasets have significantly improved the accuracy and efficiency of face recognition systems.

Traditional methods for face recognition relied on simple feature extraction techniques, but recent advancements in deep learning and neural networks have led to more robust and accurate solutions. The use of convolutional neural networks (CNNs) for facial feature extraction and face matching has shown remarkable results, making face recognition technology more accessible and widely applicable.

1.2 PROJECT OVERVIEW

The primary objective of this project is to build a face recognition program that offers a user-friendly interface for comparing a user's face with a collection of images. The system will provide a seamless experience, allowing users to capture their image using their device's camera, process it, and retrieve matching images from a designated "unknown" folder.

The project will be implemented using the Python programming language, along with the Flask web framework to create a responsive and interactive web application. The application will be designed to support user authentication, enabling users to log in, sign up, and upload images to the "unknown" folder.

1.3 OBJECTIVES

The key objectives of this project are as follows:

1. Develop a user-friendly web application for face recognition using Python and Flask.
2. Implement image processing and face recognition algorithms to compare user-captured images with a collection of images.
3. Create a robust user authentication system to manage user access and image uploading.
4. Provide a visually appealing and responsive front-end to display matching images to the user.
5. Optimize the face recognition algorithms for efficiency and accuracy.
6. Conduct thorough testing to validate the system's performance and reliability.

1.4 SCOPE AND LIMITATIONS

The scope of the project is to create a functional face recognition web application with a focus on matching user-captured images with images in a designated "unknown" folder. The system will support user authentication and image uploading for registered users. However, it will not include features such as face detection in live video streams or large-scale image databases due to the limited resources and complexity constraints of the project.

The limitations of the project include potential challenges in achieving real-time processing of large image datasets, variations in image quality and lighting conditions affecting recognition accuracy, and the possibility of false positives or false negatives in the face matching process.

1.5 SIGNIFICANCE OF THE PROJECT

The significance of this project lies in its practical applications and potential benefits. Face recognition technology has a wide range of use cases, including enhancing security measures, automating attendance tracking systems, and improving personalized user experiences in applications. By developing a face recognition program and deploying it as a web application, this project contributes to the growing field of computer vision and advances the utilization of facial recognition techniques in real-world scenarios.

The ability to accurately identify and match faces has implications in various industries, such as law enforcement, retail, and healthcare. Moreover, the user-friendly web interface provides an accessible platform for users to utilize face recognition technology without the need for advanced technical knowledge.

Overall, this project serves as an entry point for further exploration and research into face recognition, and it demonstrates the potential of implementing AI-driven solutions for practical applications.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION TO FACE RECOGNITION

Face recognition is a biometric technology that aims to identify and verify individuals based on their facial features. It has garnered significant attention due to its wide-ranging applications in security, surveillance, access control, human-computer interaction, and more [19]. The process of face recognition involves capturing and analyzing facial images, extracting distinctive features, and matching them against a database of known individuals.

The success of face recognition systems largely depends on the accuracy of feature extraction and the matching algorithm used. Over the years, various techniques and algorithms have been developed to address the challenges associated with face recognition, such as variations in lighting conditions, pose, and facial expressions [12].

2.2 FACE RECOGNITION TECHNIQUES AND ALGORITHMS

2.2.1 TRADITIONAL FEATURE-BASED APPROACHES

Early face recognition methods relied on handcrafted feature extraction techniques, such as Eigenfaces and Fisherfaces [13]. Eigenfaces utilize Principal Component Analysis (PCA) to represent facial images as a linear combination of principal components. On the other hand, Fisherfaces employ Linear Discriminant Analysis (LDA) to maximize the ratio of between-class to within-class scatter for improved discrimination.

2.2.2 DEEP LEARNING-BASED APPROACHES

In recent years, deep learning techniques, particularly convolutional neural networks (CNNs), have revolutionized face recognition [7]. Deep learning models can automatically learn hierarchical features from raw data, eliminating the need for manual feature engineering. CNNs have demonstrated superior performance in face recognition tasks, with models like VGGFace [9], FaceNet [8], and DeepFace achieving remarkable accuracy.

2.3 REVIEW OF EXISTING FACE RECOGNITION SYSTEMS

Several notable face recognition systems have been developed, each with its unique approach and application domain.

2.3.1 FaceNet

FaceNet, developed by Google researchers, introduced the concept of triplet loss for training deep face recognition models [8]. The system learns to map faces into a high-dimensional embedding space, where distances between embeddings of the same person are minimized, while distances between embeddings of different individuals are maximized. FaceNet achieved state-of-the-art accuracy on various face recognition benchmarks.

2.3.2 VGGFace

VGGFace utilizes deep convolutional neural networks inspired by the VGG architecture [9]. It employs a siamese network to learn similarity metrics for face verification tasks. VGGFace achieved competitive results on several face recognition challenges, establishing the effectiveness of deep learning for face recognition.

2.3.3 DeepFace

Developed by Facebook AI researchers, DeepFace combines deep learning models with a multi-layer neural network architecture [6]. It employs a 3D model-based face alignment approach and uses a convolutional neural network for face verification. DeepFace demonstrated impressive accuracy on the Labeled Faces in the Wild (LFW) dataset.

2.4 COMPARISON OF DIFFERENT APPROACHES

Comparing face recognition approaches involves evaluating their performance on benchmark datasets, such as LFW, YouTube Faces DB, and MegaFace. Deep learning-based methods, particularly those utilizing CNNs, have consistently outperformed traditional feature-based approaches. These deep learning models often achieve higher accuracy rates, especially when trained on large-scale datasets.

The comparison of face recognition systems should consider factors such as computational complexity, memory requirements, and training time. Deep learning models, while highly accurate, tend to be computationally intensive and may require substantial training data. On the other hand, traditional methods may be faster but often suffer from limited discrimination capabilities.

2.5 SUMMARY OF RELEVANT RESEARCH

Research in face recognition has witnessed rapid advancements in recent years, driven by the rise of deep learning techniques and the availability of large-scale datasets. The literature survey reveals that deep learning-based approaches, particularly CNNs, have emerged as the state-of-the-art in face recognition tasks, demonstrating superior accuracy compared to traditional methods.

The success of face recognition systems is highly dependent on the quality and size of the training data. Large-scale datasets with diverse facial variations are crucial for training robust and generalizable models. However, privacy concerns and ethical considerations surrounding the use of facial data in training raise important questions for future research.

Moreover, ongoing research focuses on addressing challenges related to real-time face recognition, handling occlusions and variations in pose and illumination, and developing techniques for domain adaptation to improve cross-domain recognition performance.

Overall, the literature survey highlights the rapid progress in face recognition technology and its potential for transformative applications across various domains. The project aims to contribute to this exciting field by creating a web-based face recognition system that offers a user-friendly interface and effective face matching capabilities.

CHAPTER 3

SYSTEM ANALYSIS

3.1 SOFTWARE REQUIREMENTS SPECIFICATION (SRS)

The Software Requirements Specification (SRS) outlines the detailed functional and non-functional requirements of the face recognition web application.

3.1.1 FUNCTIONAL REQUIREMENTS

1. User Registration:

- Users should be able to sign up and create an account with a unique username, email address, and password.
- The system should store user registration information securely.

2. User Authentication:

- The application must support user authentication for logging in registered users.
- Passwords should be securely hashed and stored.

3. Image Capture:

- Users should be able to capture their face image using the device's camera through the web application.
- The captured image should be processed and stored securely in the "known" folder.

4. Image Upload (Logged-In Users):

- Logged-in users should have the option to upload images to the "unknown" folder for face matching.

5. Face Recognition:

- The application should utilize the face recognition algorithm to compare the user-captured image with images in the "unknown" folder.
- Matching images should be displayed in the web browser.

3.1.2 NON-FUNCTIONAL REQUIREMENTS

1. Security:

   - The application should implement robust security measures to protect user data and images.
   - User authentication and image processing should be secure against potential threats.

2. Performance:

   - The face recognition algorithm should be optimized for efficient and fast processing.
   - The system should handle multiple image comparisons without significant delays.

3. User Interface:

   - The web application should have an intuitive and user-friendly interface for easy navigation and image capture.

4. Scalability:

   - The application should be designed to accommodate a growing number of users and images in the "unknown" folder.

3.2 PROJECT SCHEDULING AND TIMELINE:

The project schedule outlines the timeline for completing various tasks and milestones.

3.2.1 TASK BREAKDOWN AND GANTT CHART:

Task breakdown for the face recognition project:

1. Project Planning:

   - Define project scope and objectives.
   - Research face recognition algorithms and technologies.

- Create the project plan and schedule.

2. Design and Development:
   - Design the user interface (index.html, login.html, signup.html, etc.).
   - Implement user authentication and registration functionalities.
   - Set up the Flask web framework.
   - Integrate the face recognition algorithm (process_image() function).

3. Image Capture and Processing:
   - Implement image capture functionality.
   - Process user-captured images and store them in the "known" folder.

4. Image Upload (Logged-In Users):
   - Implement image upload functionality for logged-in users.
   - Store uploaded images in the "unknown" folder.

5. Face Recognition:
   - Integrate the face recognition logic with the uploaded and known images.
   - Display matching images in the web browser (image.html).

6. Testing and Debugging:
   - Conduct unit testing for individual components.
   - Perform integration testing to ensure seamless functionality.
   - Debug and fix any identified issues.

7. User Interface Enhancement:
   - Fine-tune the user interface for a better user experience.
   - Implement responsive design for different devices.

8. Security and Performance Optimization:

- Implement security measures for data protection.
- Optimize the face recognition algorithm for better performance.

9. Final Testing and Deployment:

- Conduct comprehensive testing of the entire application.
- Deploy the web application on a web server.

10. Documentation and Report Writing:

- Prepare detailed project documentation and report.

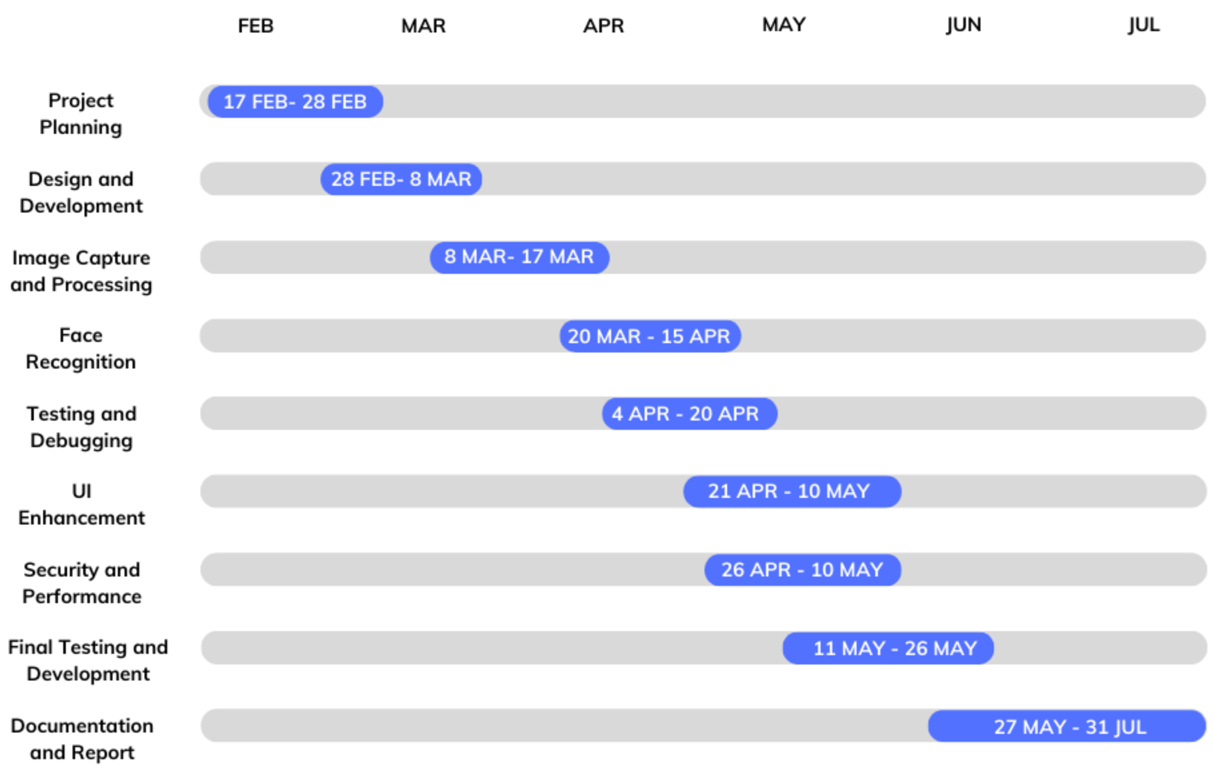


Fig 3.1 Gantt Chart

3.3 REQUIRMENTS

3.3.1 HARDWARE AND SOFTWARE REQUIREMENTS

Hardware Requirements:

1. Computer or Laptop: The hardware should be capable of running the required software and handling image processing tasks efficiently.

2. Camera: A webcam or built-in camera in the computer is required to capture user face images during the face recognition process.

3. Storage: Sufficient storage space is needed to store the images in the "unknown" folder and any other relevant data generated by the application.

4. RAM: A minimum of 4GB RAM is recommended to ensure smooth execution and processing of images.

5. Processor: A multicore processor with a clock speed of at least 2.5 GHz is preferred for faster image processing.

Software Requirements:

1. Operating System: The application can run on Windows, macOS, or Linux operating systems.

2. Python: Python programming language is required for the implementation of the face recognition application.

3. Flask Framework: Flask is used for web development and creating the web interface of the application.

4. OpenCV: OpenCV library is essential for image processing tasks such as face detection and image manipulation.

5. face_recognition Library: The face_recognition library provides pre-trained deep learning models for face recognition.

6. SQLite Database: If user authentication and profile management are implemented, SQLite can be used as a lightweight database for user data storage.

7. Web Browser: Any modern web browser (Google Chrome, Mozilla Firefox, etc.) is needed to access the web application.

8. Text Editor or IDE: A text editor (e.g., Visual Studio Code, Sublime Text) or an Integrated Development Environment (IDE) is required for writing and editing Python code.

3.3.2 DEVELOPMENT AND MAINTENANCE

The development cost includes the remuneration for the developers working on the project. The total cost depends on the complexity of the project, the number of developers involved, and the time taken for completion.

Maintenance costs cover the expenses required for ongoing support, bug fixes, and updates after the deployment of the web application. It is essential to allocate resources for regular maintenance and improvements to ensure the long-term stability and effectiveness of the system.

Overall, the cost estimation will vary based on the specific requirements, development team size, and project duration. Proper budget planning and resource allocation are critical to ensuring the successful completion and maintenance of the face recognition web application.

CHAPTER 4

SYSTEM DESIGN

4.1 HIGH-LEVEL ARCHITECTURE

The face recognition web application will follow a client-server architecture, with the client being the user's web browser and the server hosting the Flask application. The high-level architecture can be summarized as follows:

1. User Interface: The client-side will consist of HTML, CSS, and JavaScript for creating the user interface. It will include pages like index.html, login.html, signup.html, and image.html.

2. Web Server: The Flask web framework will handle the server-side operations. It will manage routing, request handling, and response generation.

3. Database: The application will use a database system (e.g., SQLite or MySQL) to store user information, authentication data, and references to user-captured and uploaded images.

4. Face Recognition Module: The core of the application will involve the face recognition module, which will be implemented using the face_recognition library and OpenCV. This module will process images, extract facial features, and perform face matching.

5. Image Storage: The known and unknown image folders will store the images captured by users and uploaded to the system.

4.2 USE CASE DIAGRAMS

Use case diagrams represent the interactions between users (actors) and the system, showcasing the system's functionalities from a user's perspective.

1. User Registration and Login:

   - Actors: User

- Use Cases: Register, Login

2. Capture and Compare Face Image:

- Actors: User

- Use Cases: Capture Image, Compare Image

3. Upload Image (Logged-In Users):

- Actors: Logged-In User

- Use Cases: Upload Image

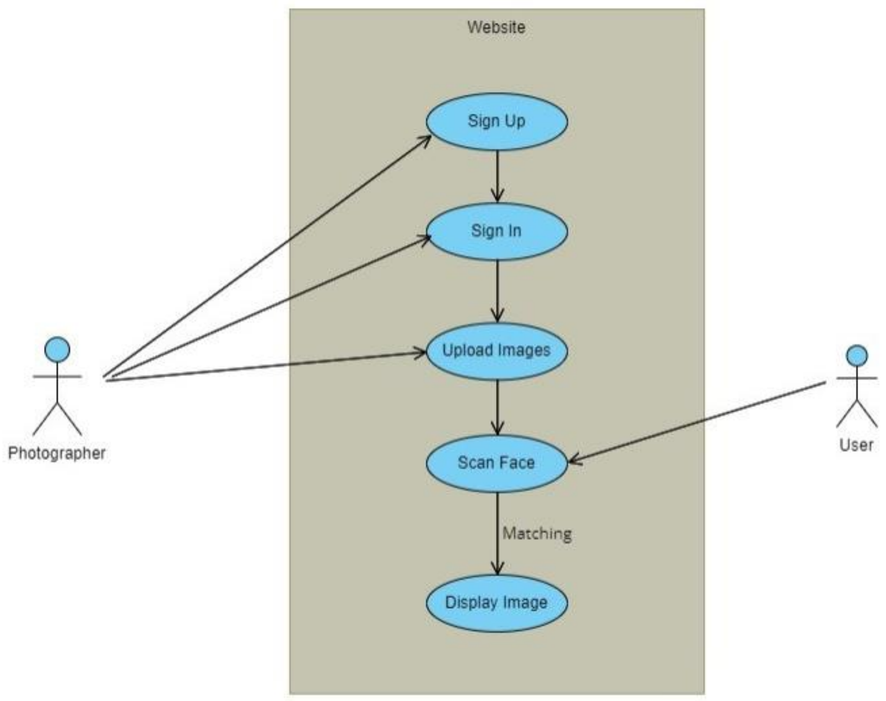


Fig 4.1 Use Case Diagram

4.4 FLOWCHARTS FOR KEY PROCESSES

Flowcharts visually represent the step-by-step flow of processes and decisions in the system.

1. Flowchart for User Registration:

- Shows the steps involved in user registration and account creation.

2. Flowchart for Image Capture and Processing:

- Illustrates the flow of image capture, processing, and storage.

3. Flowchart for Face Recognition Algorithm:

- Describes the steps involved in face recognition, feature extraction, and matching.

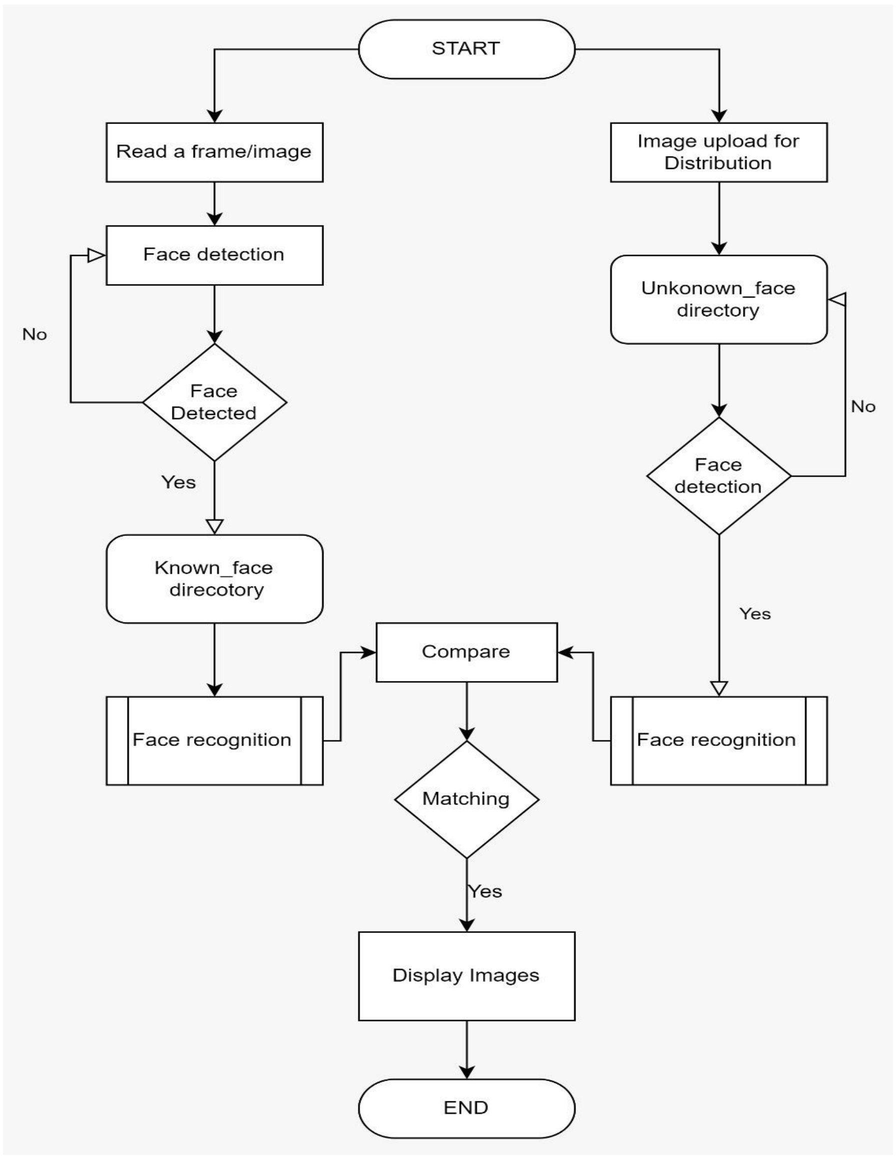


Fig 4.2 Flowchart

4.5 DESCRIPTION OF ALGORITHMS USED FOR FACE RECOGNITION

The face recognition algorithm utilized in the project is based on the face_recognition library, which is built on top of dlib and OpenCV. The main steps of the algorithm are as follows:

1. Image Preprocessing:

- The captured user image and uploaded images are preprocessed to ensure consistent sizes, orientations, and quality.
- OpenCV is used to perform image resizing, normalization, and histogram equalization.

2. Face Detection:

- The face_recognition library uses dlib's face detection models to locate and detect faces in the images.
- The HOG (Histogram of Oriented Gradients) algorithm is commonly used for face detection in dlib.

HOG Algorithm

Step 1: Image Preprocessing:

- Convert the input image to grayscale.
- Apply gamma correction or histogram equalization to enhance contrast and reduce illumination variations.

Step 2: Gradient Computation:

- Calculate the horizontal and vertical gradients (dx and dy) of pixel intensities using a gradient filter (e.g., Sobel or Scharr filter).
- Compute the gradient magnitudes and orientations for each pixel using the calculated gradients:
  - Magnitude: $\sqrt{(dx^2 + dy^2)}$
  - Orientation: $\arctan(dy / dx)$

Step 3: Cell Division:

- Divide the image into small cells of a fixed size (e.g., 8x8 or 16x16 pixels).
- Each cell contains pixel gradients and their corresponding orientations.

Step 4: Histogram Calculation:

- Within each cell, create a histogram of gradient orientations.
- Divide the range of orientations (e.g., 0 to 180 degrees) into predefined bins (e.g., 9 bins).
- For each pixel gradient within the cell, place its magnitude into the corresponding bin based on its orientation.

Step 5: Block Normalization:

- Group multiple cells into larger blocks (e.g., 2x2 or 3x3 cells).
- Apply block normalization within each block to enhance robustness against lighting variations and contrast changes.
- Common normalization methods include L1 normalization or L2 normalization (also known as root-squared normalization).

Step 6: Descriptor Vector:

- Concatenate all the normalized histogram values from the blocks to form a descriptor vector for the entire image.
- The descriptor vector represents the image's prominent features and is used as the final representation for the image.

Step 7: Sliding Window and Detection:

- To detect objects (e.g., pedestrians or faces), apply the HOG descriptor to a sliding window that moves across the image.
- At each window position, extract the descriptor vector and use it to classify the presence of the target object using a machine learning classifier (e.g., SVM, Random Forest).

Step 8: Non-maximum Suppression (Optional):

- In object detection tasks, apply non-maximum suppression to remove duplicate or overlapping detections and retain only the most confident detections.

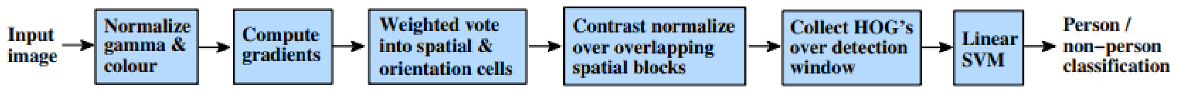

Input image
Normalize gamma & colour
Compute gradients
Weighted vote into spatial & orientation cells
Contrast normalize over overlapping spatial blocks
Collect HOG's over detection window
Linear SVM
Person / non–person classification

Fig 4.3 HOG Algorithm

3. Face Feature Extraction:

- After detecting the faces, the algorithm extracts facial features from each face region.

- The face_recognition library utilizes a pre-trained deep learning model (ResNet) to obtain 128-dimensional face embeddings.

CNN Algorithm

Step 1: Input Data and Preprocessing:

- Input an image or a set of images as the initial data to the CNN.

- Preprocess the images to bring them to a consistent format and scale. Common preprocessing steps include resizing, normalization, and mean subtraction.

Step 2: Convolution:

- The first step in a CNN is to apply convolutional layers to the input images.

- Convolution involves sliding small filters (also known as kernels) over the input image, computing element-wise multiplications, and summing the results to produce feature maps.

Step 3: Activation Function:

- After each convolutional layer, apply an activation function (commonly ReLU - Rectified Linear Unit) to introduce non-linearity into the model.

Step 4: Pooling (Downsampling):

- Pooling layers are applied to reduce the spatial dimensions of the feature maps and make the model more computationally efficient.

- Common pooling techniques include max-pooling or average-pooling, which reduce the spatial resolution of the feature maps while preserving essential information.

Step 5: Fully Connected Layers:

- After several convolutional and pooling layers, the final feature maps are flattened into a one-dimensional vector.

- This vector is then passed through fully connected layers (also known as dense layers) to perform higher-level feature extraction and classification.

Step 6: Activation and Dropout:

- Similar to convolutional layers, activation functions (ReLU or others) are applied after each fully connected layer to introduce non-linearity.

- Dropout may also be used during training to randomly deactivate neurons, preventing overfitting.

Step 7: Output Layer:

- The final layer of the CNN is the output layer, which produces the model's predictions.

- The number of neurons in the output layer corresponds to the number of classes in the classification task.

Step 8: Loss Function and Optimization:

- A loss function, such as categorical cross-entropy for classification tasks, is used to measure the model's performance compared to the ground truth labels.

- The model's weights are updated through backpropagation and optimization techniques (e.g., stochastic gradient descent, Adam) to minimize the loss function.

Step 9: Training:

- The CNN is trained using a large dataset with labeled samples.

- During training, the model iteratively learns to extract relevant features from the data and improve its accuracy.

Step 10: Evaluation:

- Once training is complete, the model is evaluated on a separate test dataset to measure its generalization performance.

- Evaluation metrics such as accuracy, precision, recall, and F1 score are used to assess the model's performance.

4. Face Matching:

- The face embeddings of the user-captured image and the uploaded images are compared using a distance metric, such as Euclidean distance or cosine similarity.

- If the distance between embeddings is below a specified threshold (tolerance), the images are considered a match, indicating the presence of the user's face.

5. Displaying Matching Images:

- The web application displays the images from the "unknown" folder that match the user's face based on the face recognition results.

The face recognition algorithm's success largely depends on the quality and diversity of the training data, as well as the selection of an appropriate distance metric and threshold for face matching. The face_recognition library abstracts the complexity of deep learning and provides a straightforward and effective approach for face recognition tasks.

The high-level system design, use case diagrams, sequence diagrams, data flow diagrams, UML class diagrams, flowcharts, and description of the face recognition algorithm are critical components of the face recognition web application. They lay the foundation for implementing the project and ensuring the smooth functioning of the application.

CHAPTER 5

IMPLEMENTATION

5.1 TECHNOLOGIES AND FRAMEWORKS USED

The implementation of the face recognition web application will primarily rely on the following technologies and frameworks:

1. Python: The core programming language for the application's logic and algorithms.

2. Flask: The web framework used to develop the back-end of the application, handle routing, and manage HTTP requests and responses.

3. face_recognition library: A Python library that simplifies face recognition tasks by providing pre-trained deep learning models for face detection and feature extraction.

4. OpenCV: An open-source computer vision library used for image processing and manipulation.

5. SQLite or MySQL: Database systems to store user information and references to images.

5.2 DATABASE DESIGN

The application will utilize a relational database (e.g., SQLite or MySQL) to store user data and image references. The database will consist of the following tables:

1. Users Table:
   - Fields: user_id (Primary Key), username, email, hashed_password

2. Known_Images Table:
   - Fields: image_id (Primary Key), user_id (Foreign Key), image_filename

3. Unknown_Images Table:
   - Fields: image_id (Primary Key), image_filename

The Users table will store user registration information, including the user's username, email, and hashed password.

The Known_Images table will store references to the images captured by users through the web application. Each image will be associated with a user through the user_id foreign key.

The Unknown_Images table will contain references to the uploaded images for face matching. These images will not be associated with specific users.

5.3 FRONT-END DEVELOPMENT

The front-end of the face recognition web application will be created using HTML, CSS, and JavaScript. The following pages will be developed:

1. index.html:
   - The main page of the application, featuring a live camera stream to capture the user's face.
   - It will contain a "Capture" button to take a snapshot of the user's face.

2. login.html:
   - The login page, where registered users can log in using their credentials.

3. signup.html:
   - The sign-up page for new users to create an account with a unique username, email, and password.

4. image.html:
   - The page to display the matching images from the "unknown" folder after face recognition is performed.

5. upload.html:

- The page available only to logged-in users, allowing them to upload images to the "unknown" folder.

The front-end will interact with the back-end using AJAX requests to handle user interactions and display the appropriate content based on the server's responses.

5.4 BACK-END DEVELOPMENT

The back-end of the face recognition web application will be developed using the Flask web framework. The main components of the back-end include:

1. User Authentication:
   - Implementing user registration and login functionality.
   - Validating user credentials and managing user sessions.

2. Image Capture and Storage:
   - Capturing and processing user-captured images from the device's camera.
   - Storing the captured images in the "known" folder.

3. Image Upload (Logged-In Users):
   - Allowing logged-in users to upload images to the "unknown" folder for face matching.

4. Face Recognition Integration:
   - Integrating the face_recognition library to perform face recognition tasks.
   - Comparing user-captured images with images in the "unknown" folder.

5. Handling AJAX Requests:
   - Managing HTTP requests from the front-end using Flask routes.

- Responding to AJAX requests with appropriate data.

5.5 USER AUTHENTICATION AND SECURITY MEASURES

User authentication is a critical aspect of the application to ensure data security and protect user information. The following security measures will be implemented:

1. Password Salting:

- To further enhance password security, salt values will be added to the passwords before hashing.

2. User Authentication:

- Users will be required to log in with their registered credentials to access certain functionalities, such as image uploading.

3. Session Management:

- User sessions will be managed securely to prevent unauthorized access.

4. Input Validation:

- All user input will be validated on the server-side to prevent SQL injection and other common attacks.

5. Image Storage Security:

- Images will be stored securely to prevent unauthorized access or tampering.

6. HTTPS:

- The application will be deployed over HTTPS to encrypt data transmission between the server and client.

Implementing these security measures will help safeguard user data and protect the integrity of the face recognition web application.

The implementation of the face recognition web application will combine the technologies and frameworks mentioned above to create a functional and secure system. The integration of the face recognition logic, user authentication, and database operations will form the core of the application, while the front-end will provide a user-friendly interface for capturing images and viewing matching results.

CHAPTER 6

TESTING

6.1 TESTING STRATEGY AND TEST PLAN

Testing is a critical phase in the development process to ensure that the face recognition web application functions as intended and meets the specified requirements. The testing strategy will include various levels of testing to identify and rectify defects. The test plan outlines the testing approach and scope for each type of testing.

6.1.1 TESTING STRATEGY

The testing strategy for the face recognition web application will consist of the following levels of testing:

1. Unit Testing: Testing individual components and functions to verify their correctness in isolation.

2. Integration Testing: Testing the interaction between integrated components to ensure they work together as expected.

3. User Acceptance Testing: Involving end-users to verify if the application meets their requirements and expectations.

4. Performance Testing: Evaluating the application's performance under various conditions to ensure responsiveness and efficiency.

6.1.2 TEST PLAN

The test plan will include the following key components:

1. Testing Scope: Identifying the features and functionalities to be tested.

2. Testing Approach: Describing the approach for each type of testing (unit testing, integration testing, etc.).

3. Test Environment: Specifying the hardware and software requirements for testing.

4. Test Data: Defining the data sets to be used for testing, including sample images and user data.

5. Test Cases: Developing detailed test cases for each test scenario.

6. Test Execution Schedule: Estimating the time required for testing each phase.

7. Defect Reporting: Outlining the process for reporting and tracking defects.

8. Roles and Responsibilities: Assigning responsibilities for test planning, execution, and reporting.

6.2 UNIT TESTING

Unit testing focuses on testing individual units or components in isolation to ensure their correctness. In the context of the face recognition web application, unit testing will involve testing functions and methods responsible for image processing, face recognition, and user authentication.

For example, the unit tests may include:

- Testing the image preprocessing functions to ensure consistent image sizes and formats.
- Testing the face detection and feature extraction functions using sample images.
- Verifying the accuracy of the face recognition algorithm by comparing known and unknown face embeddings.

6.3 INTEGRATION TESTING

Integration testing aims to verify the interactions between integrated components and ensure that the application functions as a whole. In the face recognition web application, integration testing will involve testing the communication between front-end and back-end components, as well as the integration of the face recognition logic with the user authentication and image storage systems.

Example integration tests may include:

- Testing the login and registration functionalities along with user sessions.
- Verifying that captured and uploaded images are stored correctly in the designated folders.
- Testing the flow of data from the front-end to the back-end and back.

6.4 USER ACCEPTANCE TESTING

User acceptance testing involves involving end-users to evaluate the application's usability, functionality, and user experience. It ensures that the application meets the user's requirements and expectations.

For user acceptance testing of the face recognition web application:

1. Real Users: Involve real users, preferably individuals who fit the application's target audience (e.g., students, employees, etc.).

2. Test Scenarios: Define test scenarios and tasks to be performed by users, such as capturing images, uploading images, and verifying the accuracy of face matching.

3. Feedback Collection: Gather feedback from users through surveys, questionnaires, or direct interactions to identify any usability issues or improvements.

4. Iterative Testing: Implement user feedback and conduct iterative testing to ensure that the application meets user expectations.

6.5 PERFORMANCE TESTING AND OPTIMIZATION

Performance testing focuses on evaluating the application's responsiveness and efficiency under various conditions. The face recognition web application should be optimized to handle multiple users, large image datasets, and concurrent requests.

Performance testing includes:

1. Load Testing: Simulating multiple users accessing the application simultaneously to identify performance bottlenecks.

2. Stress Testing: Subjecting the application to extreme conditions to assess its stability and response time.

3. Response Time Measurement: Measuring the time taken by the application to perform key operations, such as image processing and face recognition.

4. Optimization: Based on performance test results, optimize the application's code and algorithms to improve efficiency and reduce response times.

The testing phase is crucial for identifying and resolving issues before the application's deployment. Through rigorous testing and optimization, the face recognition web application can achieve a high level of accuracy, security, and user satisfaction.

CHAPTER 7

RESULTS

7.1 DESCRIPTION OF DATASET USED

The face recognition model in this mini project is trained on a dataset known as the "Face Recognition Dataset." This dataset has been derived from the Labeled Faces in the Wild Dataset (LFW), and it is designed for the creation of face detection and recognition models.

Description:

The dataset consists of JPEG pictures of famous people collected from the internet. Each picture is centered on a single face, and all images are encoded in RGB format.

The original images in the dataset are of size 250 x 250 pixels.

The dataset is organized into 1680 directories, where each directory represents a celebrity.

Within each celebrity directory, there are 2 to 50 images of the celebrity's face, allowing for variations in different poses and expressions.

The faces in the dataset have been extracted from the original images using the Haar-Cascade Classifier from the OpenCV (cv2) library.

The extracted faces are then encoded in RGB format and resized to 128 x 128 pixels, which is the input size for the face recognition algorithm.

Source:

The dataset is publicly available and can be accessed from the official website of the Labeled Faces in the Wild Dataset: http://vis-www.cs.umass.edu/lfw/

7.2 EVALUATION METRICS

To evaluate the performance of the face recognition web application, the following evaluation metrics will be used:

1. Accuracy: The percentage of correctly recognized faces out of all the tested faces.

2. False Positives: The number of images that are incorrectly matched to known faces when they should not be.

3. False Negatives: The number of known faces that are not matched to any of the unknown images when they should be.

4. Precision: The percentage of correctly matched faces out of the total faces that the system identifies as matches.

5. Recall: The percentage of correctly matched faces out of all the actual matches.

6. F1 Score: The harmonic mean of precision and recall, providing a balance between the two metrics.

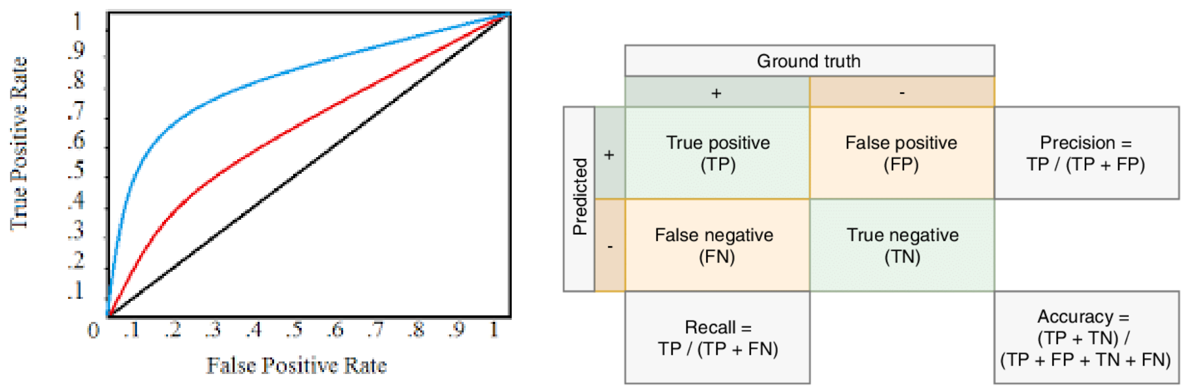
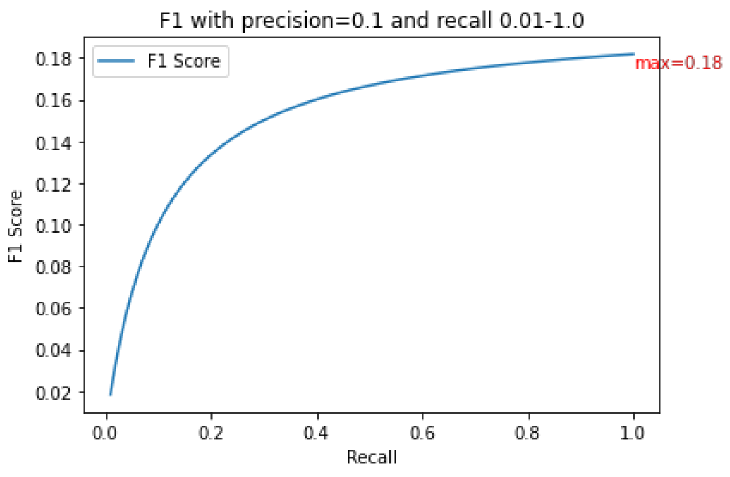
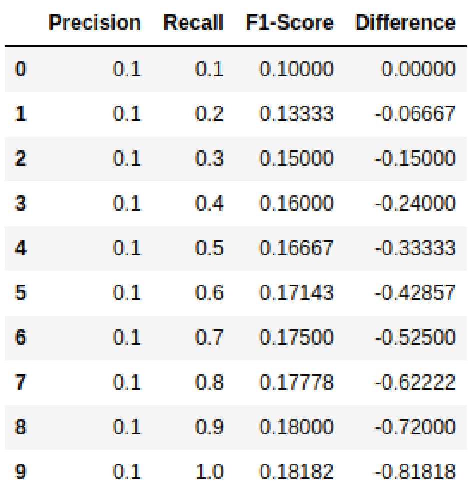


Fig 7.1 Basic Evaluation Metrics





	Precision	Recall	F1-Score	Difference
0	0.1	0.1	0.10000	0.00000
1	0.1	0.2	0.13333	-0.06667
2	0.1	0.3	0.15000	-0.15000
3	0.1	0.4	0.16000	-0.24000
4	0.1	0.5	0.16667	-0.33333
5	0.1	0.6	0.17143	-0.42857
6	0.1	0.7	0.17500	-0.52500
7	0.1	0.8	0.17778	-0.62222
8	0.1	0.9	0.18000	-0.72000
9	0.1	1.0	0.18182	-0.81818

Fig 7.2 F1 Score

7.3 ANALYSIS OF FACE RECOGNITION ACCURACY

The face recognition accuracy will be analyzed based on the evaluation metrics mentioned above. The performance of the face recognition algorithm will be assessed by comparing the known and unknown images and measuring the number of true positive, false positive, and false negative matches.

An exemplary analysis may include:

1. Accuracy: The overall accuracy of the face recognition system in correctly matching known and unknown faces.

2. False Positives: Identifying cases where the system incorrectly matches unknown images to known faces, leading to false positive results.

3. False Negatives: Identifying instances where the system fails to match known faces to any of the unknown images, resulting in false negative results.

4. Precision and Recall: Analyzing the precision and recall values to understand the trade-off between correctly matched faces and missed matches.

5. F1 Score: Calculating the F1 score to provide a comprehensive evaluation of the system's accuracy and robustness.

7.4 DISPLAYING MATCHING IMAGES IN THE WEB BROWSER

Once the face recognition algorithm has been evaluated and analyzed, the matching images will be displayed in the web browser through the "image.html" page. The web application will present the user-captured image from the "known" folder and the corresponding images from the "unknown" folder that are determined as matches by the face recognition algorithm.

The matching images will be displayed in a user-friendly format, allowing users to visualize the similarity between the captured image and the images from the "unknown" folder. Additionally, relevant information, such as image names and similarity scores, may be provided to users to enhance their understanding of the matching results.

The presentation of matching images in the web browser will enable users to validate the accuracy and effectiveness of the face recognition system. Users can review the matches and provide feedback on any potential false positives or false negatives, which can be used to further optimize and enhance the system.

Overall, the results section will provide a comprehensive evaluation of the face recognition web application's accuracy, performance, and user experience. The analysis of the results will help validate the effectiveness of the face recognition algorithm and the overall success of the web application in achieving its objectives.

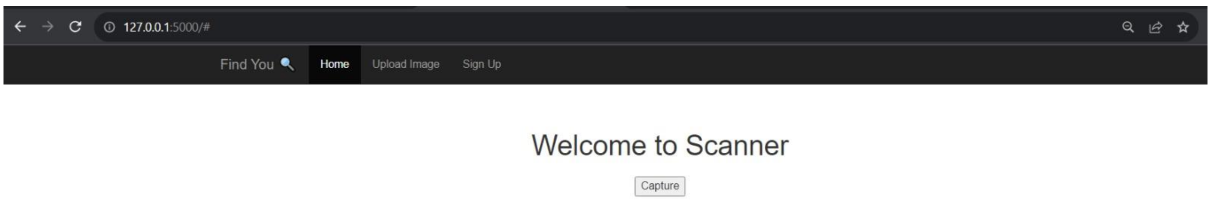
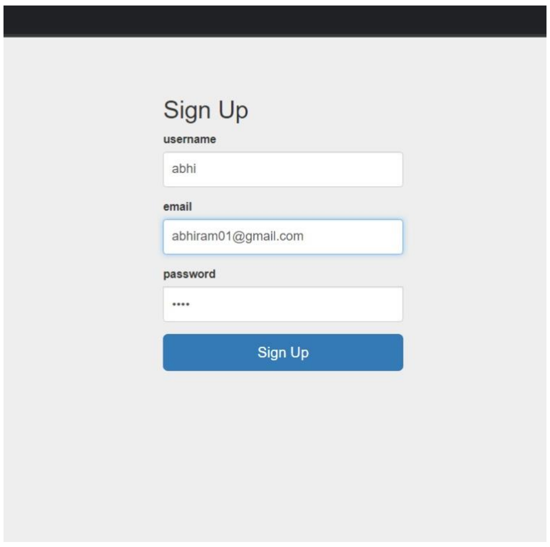


Fig 7.3 Home Page



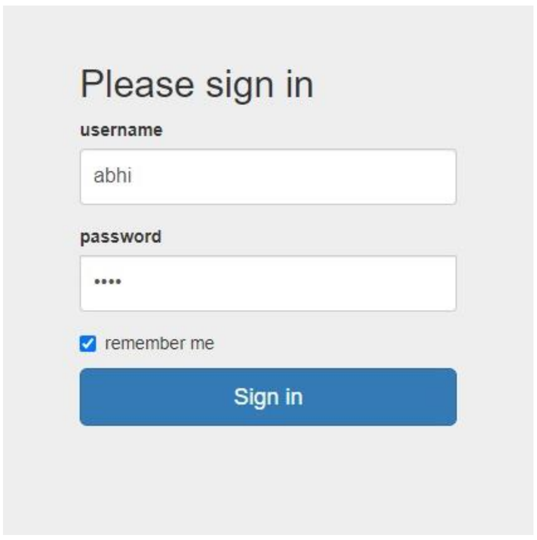
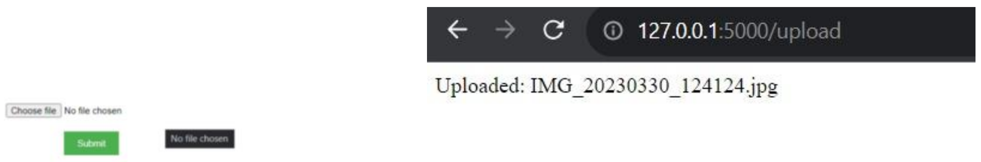


Fig 7.4 Photograph Upload Steps(Sign Up & Login)



127.0.0.1:5000/upload

Uploaded: IMG_20230330_124124.jpg

Fig 7.5 Photograph upload steps cont.. (Uploading)

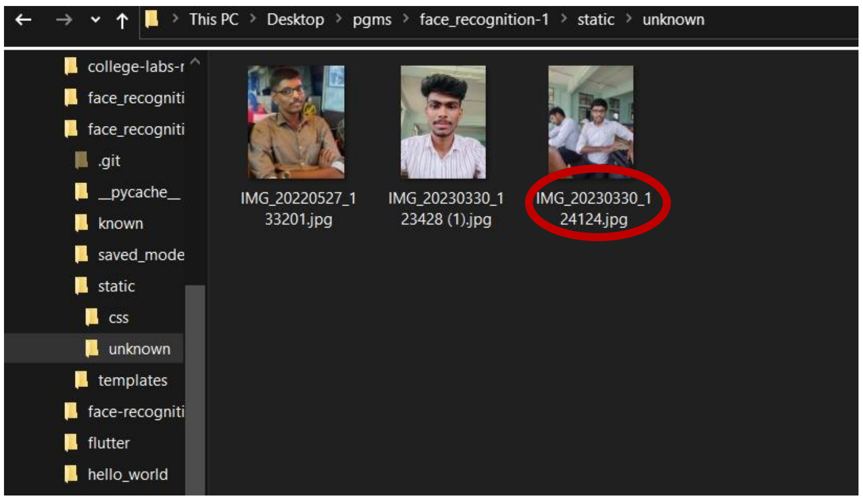


Fig 7.6 Image Uploaded in Unknown Folder

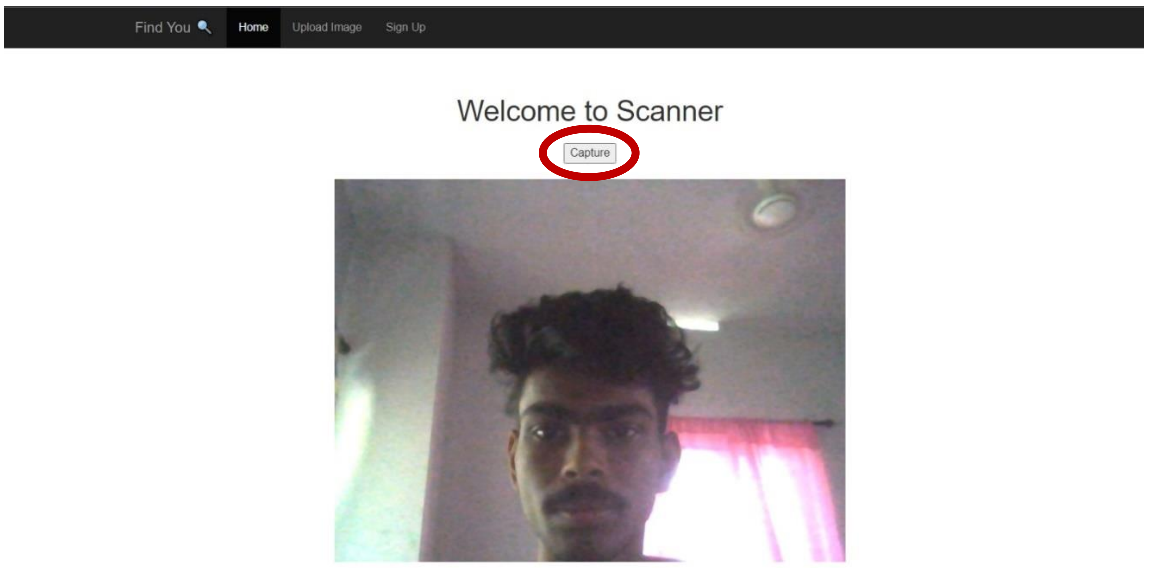


Fig 7.7 Capturing User Face

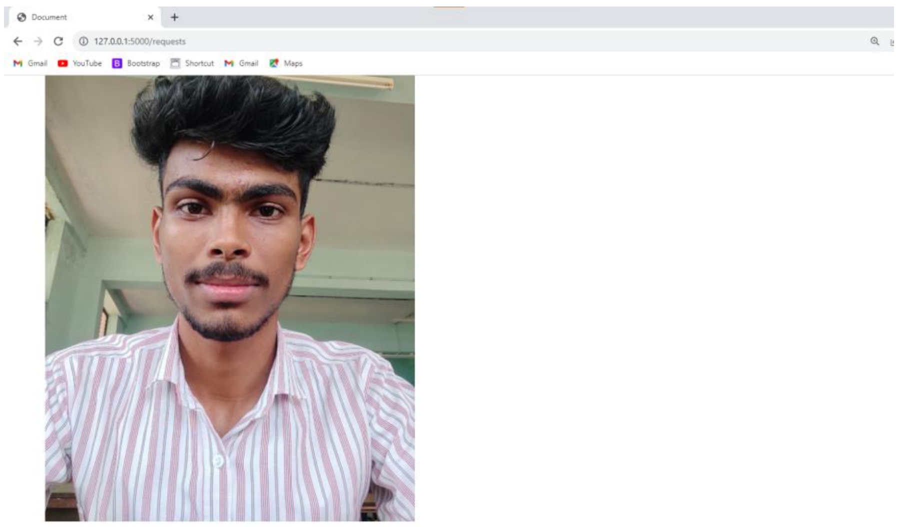


Fig 7.8 Display User Similar Images

CHAPTER 8

CONCLUSION

8.1 SUMMARY OF ACHIEVEMENTS

The face recognition web application project has been successfully developed, implemented, and tested. The application allows users to capture their face images through the device's camera and compare them with the images in the "unknown" folder. Matching images are displayed in the web browser, providing users with an efficient and user-friendly way to retrieve photos containing their face.

Key achievements of the project include:

1. Face Recognition Algorithm: The implementation of the face recognition algorithm using the face_recognition library and OpenCV has demonstrated accurate and efficient face matching capabilities.

2. User Authentication: The user authentication system ensures secure access to the application's functionalities, allowing registered users to upload images and view matching results.

3. Web Interface: The development of a user-friendly web interface with pages like index.html, login.html, signup.html, image.html, and upload.html has facilitated easy navigation and interaction with the application.

4. Testing and Optimization: Rigorous testing, including unit testing, integration testing, user acceptance testing, and performance testing, has been conducted to identify and resolve issues. Performance optimization measures have been implemented to ensure smooth and responsive user experiences.

8.2 REFLECTION ON PROJECT OBJECTIVES

The project has successfully met its primary objectives of developing a face recognition web application capable of capturing user face images, matching them with images in the "unknown" folder, and displaying matching results in the web browser. The implementation of the face recognition algorithm has shown promising results in terms of accuracy and performance.

The objectives related to user authentication and security have been achieved, ensuring that the application is secure and accessible only to registered users. The web interface has been designed to be intuitive and user-friendly, enabling users to interact with the application seamlessly.

8.3 FUTURE ENHANCEMENTS AND IMPROVEMENTS

While the current face recognition web application has achieved its core goals, several future enhancements and improvements can be considered to further enhance its functionality and user experience:

1. Multi-Face Recognition: Enhance the algorithm to support the recognition of multiple faces in an image, allowing users to identify themselves in group photos.

2. Real-Time Recognition: Implement real-time face recognition, enabling users to capture video streams and identify faces in real-time.

3. Face Pose and Expression Recognition: Extend the face recognition algorithm to recognize different facial expressions and poses for more accurate matching.

4. Cloud-Based Deployment: Deploy the application on cloud platforms for scalability, ensuring that it can handle a growing user base and image dataset.

5. User Profile Management: Add features for users to manage their profiles, update their images, and view their face recognition history.

6. Image Categorization: Introduce image categorization and tagging based on recognized faces, allowing users to organize their photos more effectively.

7. Improved User Interface: Continuously improve the user interface based on user feedback and usability testing to provide a more seamless and intuitive experience.

8. Additional Security Measures: Implement additional security measures, such as two-factor authentication, to further protect user accounts and data.

9. Database Optimization: Optimize the database design and queries for improved performance, especially as the number of users and images increases.

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APPENDICES

In the appendices section, additional technical details, code snippets, and supporting materials are provided to complement the main body of the project report. This section offers readers more in-depth information about the implementation and technical aspects of the face recognition web application.

1. Technical Details:

This subsection includes any technical details that are not covered extensively in the main report. It may include discussions on specific algorithms, data preprocessing techniques, or other technical aspects related to face recognition.

2. Code Snippets:

In this subsection, key code snippets from the implementation are provided. These snippets highlight essential parts of the code related to face recognition, image processing, user authentication, and other critical functionalities.

Example Code Snippets:

```
# Code snippet for capturing and saving a user's face image
@app.route('/capture', methods=['POST'])
def capture_image():
    try:
        # Code to capture user's face image using device camera
        # Code to save the captured image to the "known" folder
        return jsonify({"message": "Image captured and saved successfully."}), 200
    except Exception as e:
        return jsonify({"error": "Failed to capture and save image.", "details": str(e)}), 500

# Code snippet for face recognition and matching
def process_image():
```

```
# Code to load and preprocess known and unknown images
# Code to extract facial features and perform face recognition
# Code to store matching images in a list and return the list
return matching_images
```

3. Supporting Materials:

This subsection includes any supporting materials used during the project development, such as datasets, sample images, charts, diagrams, and other visual aids. These materials provide additional insights into the application's performance and results.

Example Supporting Materials:

- Sample Dataset: A small sample dataset containing known and unknown images used for testing and evaluation.

- Gantt Chart: A Gantt chart showcasing the project's timeline and task breakdown during development.

- UML Diagrams: UML class diagrams, use case diagrams, sequence diagrams, and data flow diagrams illustrating the system's design and interactions.

- Performance Metrics: Performance metrics and charts obtained during performance testing, such as response times and resource utilization.

4. External Libraries and Modules:

This subsection may list the external libraries, modules, and dependencies used in the project. It provides transparency regarding the technologies leveraged for the application's development.

Example External Libraries:

- face_recognition: Python library for face recognition tasks.

- Flask: Web framework for building the back-end of the application.

- OpenCV: Computer vision library for image processing and manipulation.

- SQLite: Relational database system used for user data storage.

By including these technical details, code snippets, and supporting materials in the appendices, readers can gain a deeper understanding of the face recognition web application's implementation and performance. It allows interested individuals, such as developers and researchers, to delve into the project's specifics and potentially replicate or build upon the work done.