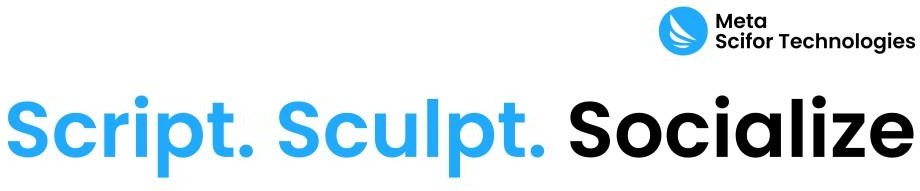
**Face Recognition System**

**-- A Streamlit App**

**by**

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**ABSTRACT**

# The face recognition system is built on a well-defined workflow that begins with image preprocessing. In this step, face images are converted to grayscale, reducing computational complexity while retaining critical facial features. The images are then normalized to ensure uniformity across the dataset, which is essential for achieving consistent recognition results. By standardizing the input data, the model can more effectively learn the distinguishing features necessary for accurate face identification.

# The core of the application relies on OpenCV's powerful tools, particularly the Haar Cascade classifier for face detection. This method is renowned for its efficiency in identifying human faces within images, even in varying lighting conditions or orientations. Once a face is detected, the Local Binary Patterns Histogram (LBPH) technique is employed for face recognition. LBPH is a texture-based method that compares the local structure of the face to identify unique patterns, making it a robust choice for recognizing faces with high accuracy.

# Training and evaluating the model involves a combination of static image datasets and real-time webcam feeds. The system's performance is assessed using metrics like detection accuracy, which measures how well the model identifies faces, and recognition confidence, which indicates the certainty of the recognition process. These metrics provide insights into the model's strengths and areas for improvement, guiding further refinement of the system to enhance its real-world applicability.

# The final face recognition application demonstrates significant potential for various practical uses. Its ability to accurately recognize faces in real-time makes it suitable for security systems, where it can restrict access to authorized individuals. Additionally, the system's adaptability to different environments suggests potential applications in attendance tracking, customer recognition in retail, and even personalized event management. Future developments could include integrating deep learning models to further improve recognition accuracy and expanding the dataset to cover a wider range of facial variations, ultimately broadening the scope of the application's use cases.

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# INTRODUCTION

Face recognition technology has become increasingly prevalent in a wide array of applications, ranging from security systems to customer service enhancements. The ability to accurately identify and verify individuals based on their facial features has revolutionized how organizations manage security, attendance, and personalized services. This report delves into the development of a face recognition application using traditional computer vision techniques and Python-based tools. The project leverages OpenCV, a leading open-source computer vision library, to implement a system that is both effective and accessible for real-time face recognition tasks.

The application is built around two core functionalities: adding new faces to a recognition database and identifying faces using a webcam in real-time. These features are integrated into a user-friendly interface powered by Streamlit, a Python framework designed for creating interactive web applications. The simplicity of the interface makes it easy for users to upload images and manage the face recognition process without requiring deep technical knowledge. This approach ensures that the application can be adopted by a broad audience, including those in non-technical fields.

A key component of the application is the use of the Haar Cascade classifier for face detection. Haar Cascades are known for their high efficiency in detecting objects, particularly human faces, across varying conditions. Once faces are detected, they are recognized using a Local Binary Patterns Histogram (LBPH) approach. LBPH is a widely used method in face recognition that captures local texture information from grayscale images, making it highly effective for distinguishing between different faces in the database.

The report also explores the implementation process, starting with the collection and preprocessing of face images. Image preprocessing steps, such as grayscale conversion and normalization, are crucial for enhancing the performance of the recognition model. By standardizing the input data, the system can more accurately learn and differentiate between the unique features of each face, thereby improving the overall accuracy of the recognition process. The model is then trained and evaluated using a combination of static datasets and real-time webcam inputs, with performance metrics analyzed to assess the system's efficacy.

This face recognition application is designed with practical applications in mind. It has the potential to be deployed in various settings, including security systems that require access control, attendance management systems for educational or corporate environments, and retail scenarios where customer recognition could enhance service delivery. The project demonstrates the capabilities of traditional machine learning techniques in real-world face recognition tasks, while also setting the stage for future enhancements through the integration of more advanced deep learning models.

# TECHNOLOGY USED

The technology stack used in this face recognition project can be summarized as follows:

1. **Programming Language:**

* **Python**: Python was chosen for this project due to its simplicity and extensive library support, making it ideal for implementing computer vision tasks and managing the overall workflow of the face recognition system.

1. **Computer Vision Library:**

* **OpenCV**: OpenCV is the core library used for image processing and face detection in this project. It provides efficient tools for real-time face detection using Haar Cascade classifiers and face recognition using the Local Binary Patterns Histogram (LBPH) method.

1. **Libraries:**

* **OpenCV**: Essential for handling images and performing face detection and recognition. OpenCV simplifies the process of loading, preprocessing, and analyzing images.
* **Streamlit**: Streamlit is used to create the user interface for the face recognition system. It enables the development of an interactive web application where users can upload images, add faces to the database, and perform real-time face recognition.
* **NumPy**: NumPy is crucial for handling and manipulating image data as arrays, allowing efficient processing during face detection and recognition.
* **Pillow**: The Pillow library is utilized for image processing tasks such as opening, converting, and saving images, ensuring they are in the correct format for further processing by OpenCV.

1. **Data Handling and Manipulation:**

* **Face Image Dataset**: The project involves collecting and organizing a dataset of face images, which are preprocessed to ensure they are in the correct format for face detection and recognition.
* **NumPy and OpenCV**: These libraries are used to process the image data, ensuring it is correctly structured and normalized for the face recognition model.

1. **Model Building:**

* **Haar Cascade Classifier**: OpenCV’s Haar Cascade Classifier is used for real-time face detection. It scans images to detect faces by identifying regions that match learned patterns of facial features.
* **Local Binary Patterns Histogram (LBPH)**: The LBPH method is used for face recognition. It creates a histogram based on local binary patterns extracted from the face image, allowing the system to identify unique facial features.

1. **Training and Evaluation:**

* **Model Training**: The face recognition model is trained using images from the dataset, which are divided into training and test sets to monitor the model’s performance.
* **Evaluation Metrics**: The model’s performance is tracked using metrics such as detection accuracy and recognition confidence. These metrics help assess the effectiveness of the face recognition system.

1. **Visualization and Performance Tracking:**

* **Streamlit Interface**: The performance of the face recognition model is made accessible through the Streamlit interface, allowing users to interact with the system and visualize results in real-time.
* **Debugging and Testing**: The application provides real-time feedback through the interface, making it easier to diagnose issues and ensure that the face recognition system operates smoothly.

**8. Testing and Predictions:**

* **Image Preprocessing**: Before making predictions, images are resized, converted to grayscale, and normalized to fit the model’s input requirements.
* **Model Predictions**: The trained face recognition model is then used to identify faces in real-time, determining which known faces are present in the input images or video streams.

These technologies work together to create a comprehensive face recognition system. Python’s flexibility and extensive library support make it easy to manage various tasks, from image preprocessing and model training to real-time face detection and recognition. OpenCV handles the core image processing functions, while Streamlit provides an intuitive interface for interacting with the system. This technology stack ensures that the face recognition application is both powerful and accessible, suitable for various real-world applications.

**DATASET INFORMATION**

* **Source:** The face recognition dataset consists of images collected manually or through various image sources, including personal collections and publicly available datasets.
* **Storage:** The images are stored locally within the project directory on the user's system. Each image is organized and accessed via the directory structure defined in the project.
* **Folder Structure:** The dataset and application files are organized within a hierarchical directory structure, ensuring that the images and scripts are easy to manage and access. The structure is as follows:
* **Folder Structure**
* face-recognition-app/
* │
* ├── app.py # Main application script
* ├── requirements.txt # List of dependencies
* ├── .gitignore # Files and directories to be ignored by git
* └── README.md # Project description and setup instructions

# Image Formats: The allowed image formats in the dataset are JPEG, JPG, BMP, and PNG. Any images that do not conform to these formats are filtered out during the preprocessing stage to ensure consistency in data handling.

# Validation: Each image in the dataset is validated using OpenCV's cv2.imread function to ensure it can be correctly read and processed. Additionally, the image format is checked using Python's imghdr module to verify that it matches the expected formats.

# Loading: The images are loaded into the application using OpenCV functions within the Python environment. The images are read and converted to grayscale, normalized, and then used for face detection and recognition within the application. The structured loading process ensures that the images are ready for efficient real-time processing by the recognition model.

# METHODOLOGY

# The methodology for developing the face recognition application is structured into several key phases, each involving specific tasks and technologies to ensure the system's effectiveness and usability. The process encompasses data collection, preprocessing, model selection, training, evaluation, and deployment. Each phase is meticulously designed to build a robust and efficient face recognition system capable of performing in real-time.

1. **Data Collection and Preparation**
2. **Data Collection:** The dataset for this project consists of images representing different individuals, collected from various sources, including personal collections and publicly available datasets. The images are gathered manually and organized into folders, each corresponding to a specific individual. This structured organization is critical for the subsequent stages of face detection and recognition.
3. **Directory Structure Setup:** The collected images are stored in a well-defined directory structure within the project. Each individual's images are placed in a separate sub-directory named after the person or labeled with a unique identifier. This hierarchical organization allows for easy access and management of the dataset during the model training and recognition processes.
4. **Image Preprocessing:** Preprocessing is a crucial step to ensure the images are in a consistent format suitable for face recognition. The images are first converted to grayscale using OpenCV to reduce computational complexity while retaining essential facial features. This conversion simplifies the recognition process by focusing on the structural details of the faces rather than color variations.

After grayscale conversion, images are resized to a uniform size to match the input requirements of the face detection and recognition algorithms. Normalization is then applied to the images to standardize pixel values, ensuring uniformity across the dataset. Images that do not conform to the required formats (JPEG, JPG, BMP, PNG) are filtered out during this phase.

1. **Validation:** The validity of each image is checked using OpenCV's cv2.imread function, which ensures that all images can be correctly read and processed by the application. Additionally, Python’s imghdr module is used to confirm that the images are in one of the accepted formats. This dual-layer validation process helps maintain data integrity and ensures that only usable images are fed into the model.

#### 2. **Face Detection and Recognition Model Development**

1. **Face Detection Using Haar Cascade Classifier:** The first step in recognizing a face involves detecting it within the image. The Haar Cascade classifier provided by OpenCV is employed for this purpose. Haar Cascades are machine learning-based classifiers that are trained with positive and negative images to detect objects, in this case, human faces.

The classifier scans the image at multiple scales, detecting faces by identifying regions that match the learned patterns of facial features. This method is highly efficient and can detect faces in real-time, making it ideal for applications that require quick and accurate face detection.

1. **Face Recognition Using Local Binary Patterns Histogram (LBPH):** Once a face is detected, the next step is to recognize the individual. The LBPH method is used for face recognition, which is particularly effective in capturing local texture information. LBPH works by converting the face image into a series of binary patterns based on pixel intensity comparisons, which are then compiled into a histogram representing the face’s unique features.

This histogram serves as a “fingerprint” for each face, enabling the model to distinguish between different individuals. LBPH is chosen for its simplicity and robustness, especially in handling varying lighting conditions and facial expressions, making it suitable for real-time applications.

1. **Training the Recognition Model:** The face recognition model is trained using the images in the dataset. Each image is processed to extract its LBPH histogram, which is then used to train the model. The training process involves associating each histogram with its corresponding label (the individual’s name or identifier). The model learns to recognize the unique histograms of each person in the training set.

The training is performed using OpenCV’s built-in LBPH face recognizer. The model is evaluated during training by dividing the dataset into training and validation sets. The performance is monitored through metrics such as accuracy and recognition confidence, which provide insights into the model’s effectiveness.

**3. User Interface Development with Streamlit**

1. **Streamlit for Interface Creation:** Streamlit, a Python-based framework, is used to create a user-friendly web interface for the face recognition application. Streamlit is chosen for its simplicity and ability to rapidly develop interactive applications. The interface allows users to upload images, add new faces to the recognition database, and perform real-time face recognition using a webcam.

The main application script (app.py) integrates the face detection and recognition functionality with the Streamlit interface. Users can interact with the system through a series of buttons and input fields, making the application accessible to those with minimal technical expertise.

1. **User Interaction and Experience:** The interface is designed to be intuitive, with clear instructions and feedback provided to the user. For example, when a user uploads an image, the system immediately processes it to detect and recognize faces, displaying the results in real-time. Users can also view the faces stored in the recognition database and add new images to improve the model’s accuracy.

Streamlit’s real-time feedback and visualization capabilities enhance the user experience, providing an interactive platform where users can see the effects of their actions immediately.

**4. Testing, Evaluation, and Deployment**

1. **Model Testing:** Once the face recognition model is trained, it undergoes rigorous testing using both the validation dataset and real-time inputs from a webcam. The testing phase is crucial to ensure the model’s reliability in different scenarios, such as varying lighting conditions, angles, and facial expressions.

The model’s performance is measured using evaluation metrics such as detection accuracy (the ability to correctly detect a face) and recognition confidence (the model’s certainty in its recognition). These metrics are visualized using Streamlit’s built-in tools, helping to identify areas where the model may need further refinement.

1. **Model Evaluation:** The evaluation phase involves analyzing the model’s performance across various test cases. The results are reviewed to determine if the model meets the desired accuracy and reliability standards. Any discrepancies or errors identified during this phase guide further training or adjustments to the model.

The evaluation also considers the system’s responsiveness and efficiency, particularly in real-time face recognition scenarios. The goal is to ensure that the model can operate smoothly and accurately in a live environment.

1. **Deployment:** After successful testing and evaluation, the face recognition application is prepared for deployment. The application can be hosted on a local server or cloud-based platform, making it accessible over the internet. The deployment process includes setting up the environment, ensuring all dependencies are installed, and configuring the server to run the application.

Streamlit’s deployment options make it easy to share the application with users, allowing them to access the face recognition system through a web browser. The final product is a fully functional face recognition system capable of real-time detection and recognition, suitable for various practical applications.

The methodology outlined in this report demonstrates a systematic approach to building a robust face recognition application. From data collection and preprocessing to model development and deployment, each phase is carefully designed to ensure the system’s accuracy, efficiency, and usability. The combination of Python, OpenCV, and Streamlit creates a powerful tool capable of real-time face recognition, with potential applications in security, attendance tracking, and personalized services. This methodology sets the foundation for future enhancements, including integrating deep learning models and expanding the system’s capabilities to handle a wider range of facial variations and conditions.

# 

# CODE SNIPPET

# Requirements.txt:

# 

# App.py

# 

# 

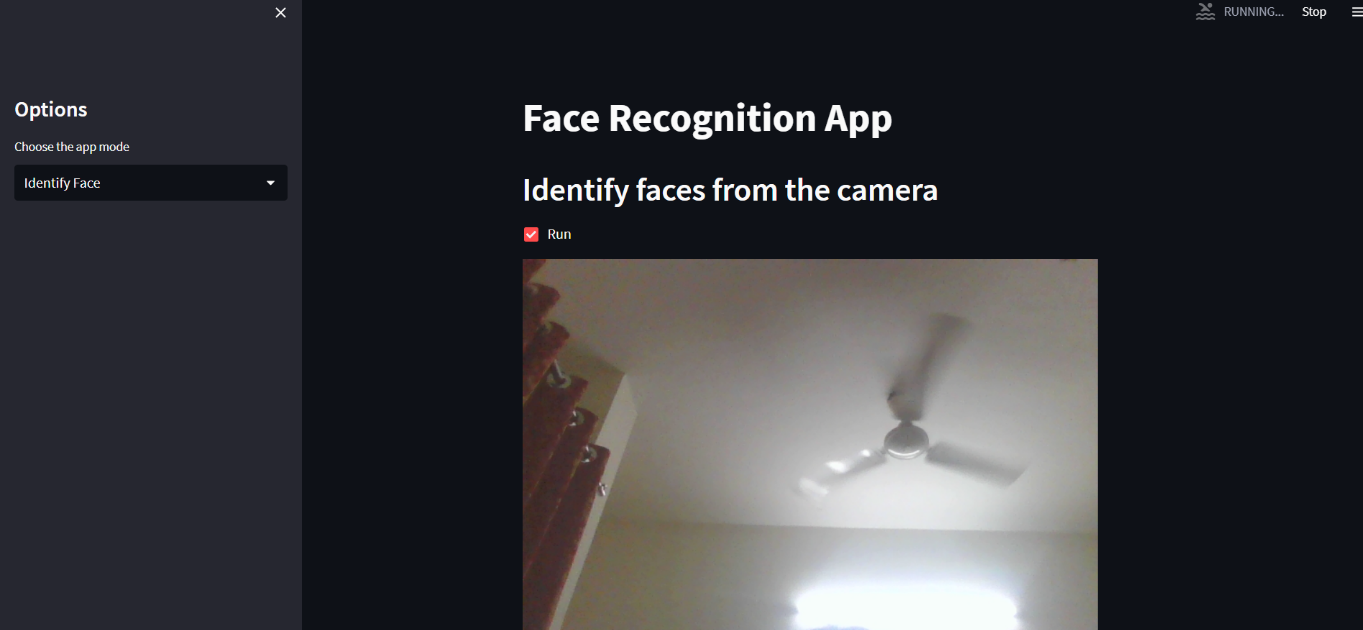
# Commands to run in terminal:

# Install the required packages: pip install -r requirements.txt

# Run the Streamlit app: streamlit run app.py

# RESULT

# 



# CONCLUSION

# This project successfully demonstrates the implementation of The Face Recognition App is built using Streamlit and OpenCV, designed to be both powerful and user-friendly. It enables users to add and identify faces easily, making it valuable for various real-world applications. Developed in Python 3.7 and above, the app features a simple and intuitive user interface. It supports real-time face recognition with seamless webcam integration. The app is open-source and customizable, offering the flexibility to extend it with additional features as needed.

# .

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