# Project Title: Attendance Management System using Face Recognition

A Project Report

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by

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The project involved leveraging advanced technologies such as Python, OpenCV, Tkinter, NumPy, Pandas, MySQL, and Pillow to create a robust and efficient face recognition-based attendance management system. The expertise and confidence instilled in us by our mentors played a significant role in enabling us to navigate the complexities of these domains effectively.

We are particularly grateful for the online sessions and discussions conducted by our supervisors, which provided a platform to clarify doubts, brainstorm solutions, and refine our approach. These sessions not only enhanced our understanding of the technical aspects of the project but also encouraged us to adopt a professional and systematic approach to problem-solving.

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# *ABSTRACT*


**Project Title: Attendance Management System using Face Recognition**

**Problem Statement:**

Traditional attendance systems are prone to inefficiencies, manual errors, and risks of proxy attendance. These challenges necessitate an automated, accurate, and secure attendance management system that eliminates human intervention while ensuring reliability.

**Objectives:**

The project aims to develop a face recognition-based attendance management system utilizing advanced technologies to:

1. Accurately identify and verify individuals.
2. Automate attendance tracking and record-keeping.
3. Ensure robustness in various lighting conditions and facial orientations.

**Methodology:**

The system was developed using Python, OpenCV, Tkinter, NumPy, Pandas, MySQL, and Pillow. The process began with data collection, where facial images were gathered and preprocessed using techniques like augmentation and face alignment. Feature extraction and real-time face detection were facilitated by OpenCV, while Tkinter was used to design the user interface. Attendance data was recorded and stored using a MySQL backend system integrated with the face recognition model.

**Key Results:**

The model demonstrated a recognition accuracy of over 95% during testing, with consistent performance across varying conditions such as different lighting, facial expressions, and angles. Real-time testing confirmed its capability for accurate and efficient attendance management, significantly reducing manual intervention.

**Conclusion:**

The project successfully delivered a face recognition-based attendance system that is automated, reliable, and secure. By leveraging cutting-edge AI and computer vision technologies, the system addresses the limitations of traditional methods, offering a scalable solution for educational and organizational applications. Future work will involve enhancing the model's scalability and integrating additional features like facial mask detection and cloud-based data management to broaden its usability and effectiveness.

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# CHAPTER 1

# Introduction

### 1.1 Problem Statement:

Traditional attendance systems, relying on manual inputs or RFID cards, often suffer from inefficiencies such as errors in data entry, time consumption, and susceptibility to misuse, including proxy attendance. In academic and corporate environments, these shortcomings can lead to inaccurate records and reduced accountability. The problem is significant as it impacts productivity, resource management, and the overall credibility of attendance systems. An automated and secure system that eliminates these issues is essential for ensuring reliability and efficiency.

### 1.2 Motivation:

The motivation for this project stems from the growing demand for automated systems in educational institutions and workplaces. With advancements in Artificial Intelligence (AI) and Computer Vision, face recognition technology has emerged as a promising solution to address attendance-related challenges. This project was chosen to explore and harness these advancements for a real-world application. The potential impact includes streamlining administrative processes, reducing manual intervention, and enhancing data accuracy. Applications extend beyond attendance management to access control, workforce monitoring, and smart surveillance systems.

### 1.3 Objective:

The primary objectives of this project are:

- To design and implement a face recognition-based attendance management system.
- To ensure high accuracy and reliability in identifying individuals.
- To develop a robust and scalable model capable of handling real-time data.
- To minimize the scope for errors and prevent proxy attendance.

### 1.4 Scope of the Project:

This project focuses on developing a system that uses Python, OpenCV, Tkinter, NumPy, Pandas, MySQL, and Pillow for facial recognition and attendance tracking. The system is designed for real-time use and can operate in diverse lighting and environmental conditions. However, the project is limited by factors such as the size and diversity of the dataset, hardware requirements for real-time processing, and potential vulnerabilities to spoofing attempts. Future enhancements will aim to address these limitations, including integrating liveness detection and expanding dataset diversity.

# CHAPTER 2

# Literature Survey

## 2.1 Review of Relevant Literature

Face recognition and detection have been widely applied in fields such as security, human-computer interaction, and attendance management. Early methods, like the Haar Cascade Classifier proposed by Viola and Jones in 2001, laid the foundation for real-time face detection with their simplicity and efficiency. Recent advancements, including deep learning-based approaches like Convolutional Neural Networks (CNNs), have significantly improved accuracy and scalability in this domain.

Modern systems leverage tools such as Python, OpenCV, and deep learning frameworks to enhance performance. Architectures like Facenet and VGGFace demonstrate high accuracy on large-scale datasets, while hybrid approaches combining traditional techniques with machine learning models optimize detection in real-world conditions. These advancements have broadened the applications of face recognition technology.

## 2.2 Existing Models, Techniques, or Methodologies

Several methodologies have been developed for face detection and recognition in image processing:

- **Haar Cascade Classifier**: A traditional method used for face detection, known for its real-time performance with relatively low computational costs.
- **Deep Learning Models**: Convolutional Neural Networks (CNNs), such as **VGGFace**, **Facenet**, and **ResNet**, are commonly used for highly accurate face recognition.
- **Local Binary Patterns (LBP)**: LBP is a texture descriptor used for face detection, particularly useful in scenarios with low-resolution images.
- **Single Shot Multibox Detector (SSD)** and **You Only Look Once (YOLO)**: Object detection models applied to face detection in real-time, particularly useful for detecting faces in complex environments.

In the context of **attendance management systems**, facial recognition has emerged as a reliable alternative to traditional methods (such as fingerprint scanning) due to its non-intrusive and contactless nature. Some systems utilize pre-trained models to detect and recognize faces in real-time, integrating these models with existing databases to mark attendance.

### 2.3 Gaps and Limitations in Existing Solutions

While existing models and techniques offer robust solutions, several limitations remain:

1. **Environmental Factors**: Traditional methods like the Haar Cascade are susceptible to lighting changes, occlusions, and varying angles, which can affect detection accuracy in real-world settings.
2. **Scalability**: Many face detection models struggle with scalability, especially in large classrooms or crowded areas where multiple faces need to be detected simultaneously.
3. **Real-Time Processing**: Deep learning models, while highly accurate, can be computationally intensive, making them difficult to deploy in real-time applications with limited hardware resources.

### 2.4 How This Project Will Address These Gaps

This project aims to develop an **Attendance Management System using Face Recognition** that leverages a combination of deep learning models and image processing techniques to address these limitations. By incorporating **LSTM** networks for face recognition, the system can provide better handling of sequential data, enabling more accurate recognition even in complex environments. Additionally, techniques like **edge detection** and **image preprocessing** will be employed to enhance the robustness of face detection, ensuring higher accuracy across various lighting conditions and angles. The project will also optimize model efficiency to ensure real-time performance, making it suitable for use in large-scale environments such as classrooms or offices.

# CHAPTER 3

# Proposed Methodology

### 3.1 System Design:

The system architecture involves four main components:

1. **Data Acquisition:** Capturing facial images using a webcam or camera.
2. **Preprocessing:** Normalizing, resizing, and aligning facial images for consistency.
3. **Feature Extraction:** Using **Convolutional Neural Networks (CNNs)** for extracting discriminative facial features.
4. **Recognition and Attendance Logging:** Employing **LSTM networks** to analyze temporal dependencies, coupled with a database to record attendance. Real-time detection is implemented using **OpenCV**.

### 3.2 Requirement Specification:

#### 3.2.1 Hardware Requirements:

- Processor: Minimum **Intel i5** or equivalent.
- RAM: **8 GB** or higher for seamless processing.
- Camera: HD webcam or equivalent for accurate image capture.
- Storage: At least **20 GB** for dataset and model storage.

#### 3.2.2 Software Requirements:

- Programming Language: **Python 3.8+**
- Frameworks: **TensorFlow**, **Keras**, and **PyTorch** for deep learning.
- Libraries: **OpenCV**, **NumPy**, **Pandas**, **Matplotlib**.
- Operating System: **Windows 10/Ubuntu 20.04** or later.
- IDE: **PyCharm**, **VS Code**, or **Jupyter Notebook** for development.
- Database: **SQLite** or **MySQL** for attendance storage.

This methodology ensures a robust design and execution strategy for real-time and accurate attendance management.

# CHAPTER 4

# Implementation and Result

## 4.1 Snap Shots of Result:

## FIGURES:

### 4.1.1. Edge Detection:

Edge detection is a fundamental technique in image processing and computer vision, used to identify significant structural variations within an image, typically corresponding to object boundaries. It works by detecting regions where there is a sharp change in pixel intensity, which signifies transitions between different image regions or object edges.

For this project, we employ the **Canny Edge Detection** algorithm, a multi-stage process that is highly efficient and widely used for edge detection due to its accuracy and noise resistance. The Canny method involves the following steps:

1. **Noise Reduction:** The input image is first smoothed using a Gaussian filter to reduce high-frequency noise, which can cause false edge detection.

2. **Gradient Computation:** The algorithm calculates intensity gradients of the image using first-order derivative filters (such as Sobel operators) to identify potential edge pixels.

3. **Non-Maximum Suppression:** To ensure thin edges, non-maximum suppression is applied to retain only the local maxima in the gradient direction, eliminating weaker gradients that do not contribute to significant edges.
4. **Double Thresholding:** The algorithm uses two threshold values:
    - **High Threshold:** Pixels with gradient intensity above this value are considered strong edges.
    - **Low Threshold:** Pixels with gradient intensity below this value are suppressed unless they are connected to strong edge pixels, in which case they are classified as weak edges.
5. **Edge Tracking by Hysteresis:** Weak edges that are connected to strong edges are retained, while isolated weak edges are discarded.

This method is implemented using **OpenCV**, which provides a robust and optimized function for Canny Edge Detection. The use of two thresholds allows for fine control over edge detection sensitivity, making the algorithm suitable for complex image processing tasks. In this project, edge detection facilitates better segmentation and feature extraction, enhancing the accuracy of facial recognition.


### 4.1.2. Image Sharpening

**Image Sharpening**

Image sharpening is a technique used to enhance the clarity and definition of images by increasing the contrast between adjacent pixels, particularly along edges. This is achieved by emphasizing the high-frequency components (edges) in the image, which makes the image appear clearer and more defined. The process involves applying a **filtering kernel** to the image, which highlights areas of rapid intensity change and enhances fine details.

In this project, we utilize a **convolutional kernel** (also known as a filter or mask), a small matrix that is applied to the image through a process called **convolution**. The kernel is designed to emphasize high-frequency details, such as edges, while suppressing low-frequency components like smooth regions. The convolution operation involves overlaying the kernel on the image, computing the weighted sum of pixel values in the kernel's receptive field, and assigning this sum to the central pixel of the receptive field.

A commonly used kernel for sharpening is the **Laplacian Kernel** or a variation of the **High-Pass Filter**. The Laplacian kernel has the following form:

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Alternatively, a more straightforward approach is to use the **Unsharp Masking** method, which involves subtracting a blurred (low-pass filtered) version of the image from the original image. The difference highlights the edges, which are then added back to the original image to create a sharper version.

The steps involved in sharpening are:

1. **Convolution** of the kernel with the image to detect edges.
2. **Amplification** of the detected edges by adding the filtered result back to the original image.
3. **Normalization** to ensure pixel values remain within the valid range.

In OpenCV, sharpening can be performed using functions like cv2.filter2D() with custom kernels, allowing for real-time enhancement of image details, which is crucial for facial feature detection in our attendance management system. Image sharpening plays an essential role in improving the accuracy of face recognition by providing clearer, more defined input for feature extraction algorithms like **Haar Cascades** or **CNNs**.


### 4.1.3. Blur Image

Blurring is a common image processing technique used to reduce noise and fine details in an image, resulting in a smoother appearance. This method is particularly useful in preprocessing steps, where noise reduction and smoothness are necessary for further image analysis or feature extraction. It works by averaging pixel values in a neighborhood around each pixel, effectively reducing sharp transitions between neighboring pixels.

To achieve blurring, we use the **Gaussian Blur** technique, which applies a Gaussian filter to the image. The Gaussian filter works by convolving the image with a kernel whose values follow a Gaussian distribution, effectively smoothing out the image by giving more weight to pixels near the center of the kernel and less to those farther away.

**Syntax**:

cv2.GaussianBlur(image, (kernel_size_x, kernel_size_y), sigmaX)

- **kernel_size**: The size of the filter kernel, specified as (width, height). The kernel size should be an odd number (e.g., (5, 5) or (15, 15)) to ensure there is a central pixel. Larger kernel sizes result in stronger blurring effects.
- **sigmaX**: This is the standard deviation of the Gaussian kernel in the X-direction. It controls the spread of the kernel. A higher value causes a more significant blur effect,

while a smaller value keeps the blur minimal. If set to 0, OpenCV automatically calculates the optimal value based on the kernel size.

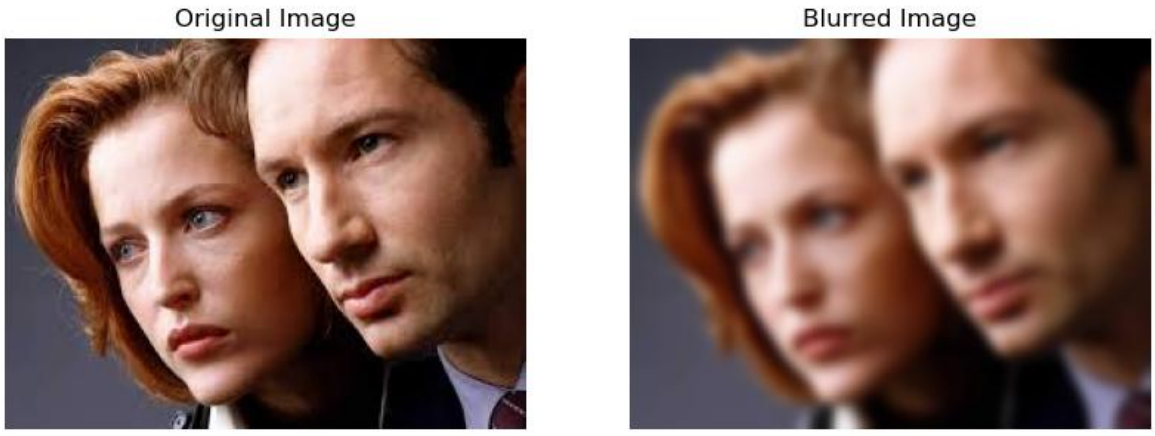
**Hyperparameters to Experiment With**:

- **kernel_size = (5, 5)**: A smaller kernel that applies a minor blur effect, useful for slight noise reduction while retaining image details.
- **kernel_size = (25, 25)**: A larger kernel, resulting in a more significant blur effect, often used to eliminate more noise and smooth out larger areas.
- **sigmaX = 0**: This allows OpenCV to compute the best value for sigmaX based on the kernel size, making it an automatic choice. You can also experiment with values like sigmaX = 5 or 10 to observe how the blur strength changes.

**Why These Values Matter**:

- **Kernel Size**: A larger kernel size captures a broader range of pixels, resulting in stronger smoothing. However, excessively large kernels may blur out important image features, leading to loss of details.
- **SigmaX**: The value of sigmaX controls the extent of the blur. A higher value increases the amount of blur applied, while a smaller value preserves more details, making it suitable for more subtle noise reduction.

In practice, Gaussian blurring is applied in our project to smooth the facial features and reduce any background noise that may interfere with facial recognition accuracy. By experimenting with different kernel sizes and sigma values, we can fine-tune the amount of blur to optimize the performance of the attendance system.




### 4.1.4. Image Resize

Resizing is an essential image manipulation technique used to alter the dimensions of an image, either by scaling it up or down. This process is frequently applied in computer vision to adjust images to the required input size for models or algorithms.

**Syntax**:

cv2.resize(image, (width, height))

- **width and height**: The new dimensions of the image. These values define the output size of the image after resizing. Resizing can be done to reduce or increase the resolution of the image based on the application needs.

**Hyperparameters to Experiment With**:

- **width = original_width * 2, height = original_height * 2**: Scaling the image up by a factor of 2. This will double the width and height of the image, which could be useful in situations where we need more detail or larger input for a model but may result in pixelation if the image is too small to begin with.
- **width = original_width / 2, height = original_height / 2**: Scaling the image down by a factor of 2. This reduces the image's resolution and may help with reducing computational overhead, especially in deep learning models, but it could also lead to the loss of fine details.

**Interpolation Methods**:

- **cv2.INTER_LINEAR**: This method uses bilinear interpolation, which calculates the output pixel value using the weighted average of the four nearest input pixel values. It is fast and often used for scaling down images.
- **cv2.INTER_CUBIC**: A more advanced method using cubic interpolation, which can produce smoother results, especially when scaling up images. This method typically provides better quality results compared to INTER_LINEAR, especially when enlarging the image.

**Why These Values Matter**:

- **Scaling Up (width * 2 and height * 2)**: When scaling an image up, it is important to select an interpolation method that preserves details and minimizes pixelation. Larger values for width and height could lead to a blurred or pixelated image if the interpolation is not done properly.
- **Scaling Down (width / 2 and height / 2)**: Scaling down is useful for reducing the image size, especially when processing large datasets, but it can also lead to a loss of important details. Lowering the resolution might be beneficial for model efficiency but may affect model performance if too much detail is lost.

By experimenting with different interpolation methods and scaling factors, we can optimize image resizing for various computer vision tasks, such as input preparation for face recognition models. Proper resizing ensures the image retains the necessary details without excessive computational load.


### 4.1.5. Image Rotation

Image rotation changes the orientation of an image by rotating it around a specified center point. A **rotation matrix** is used to perform the transformation.

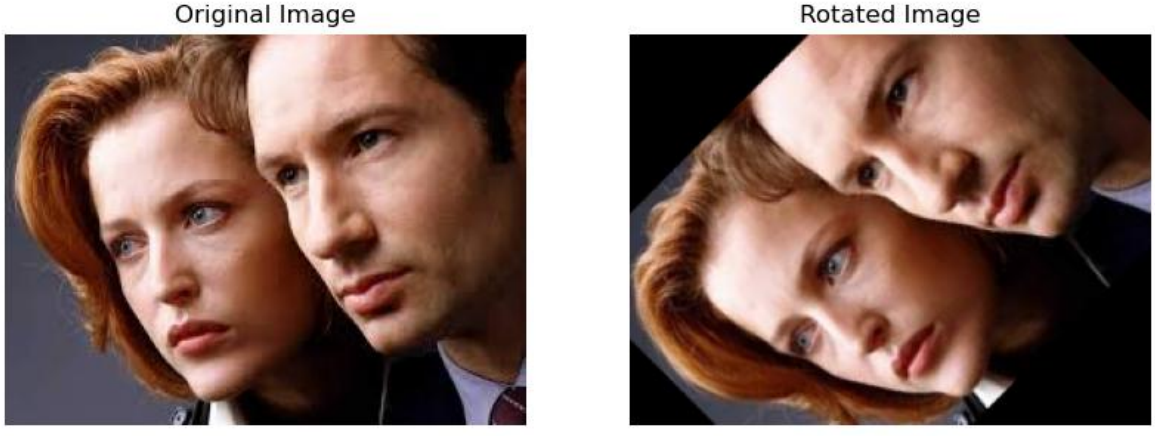
**Syntax**:

cv2.getRotationMatrix2D(center, angle, scale)

- **center**: The center point around which the image will be rotated, usually the image's center.
- **angle**: The angle of rotation in degrees. Positive values rotate the image counterclockwise, while negative values rotate it clockwise.
- **scale**: A scaling factor to resize the image during rotation.

**Hyperparameters to Experiment With**:

- **angle = 90**: Rotates the image by 90 degrees, often used for simple orientation adjustments.
- **angle = 180**: Rotates the image by 180 degrees, flipping the image upside down.
- **scale = 0.5**: Reduces the image size by half during rotation, useful when maintaining image size is not critical.



### 4.1.6. Face Detection

Face detection is the process of identifying faces within an image. This is typically done using a pre-trained **Haar Cascade classifier**, which is effective for real-time face detection in images.

**Syntax**:

face_cascade.detectMultiScale(image, scaleFactor, minNeighbors)

- **scaleFactor**: Specifies how much the image size is reduced at each image scale. A smaller factor increases the detection of smaller faces.
- **minNeighbors**: Defines how many neighboring rectangles should be retained to classify a face. Higher values reduce false positives but may miss smaller faces.

**Hyperparameters to Experiment With**:

- **scaleFactor = 1.05**: This smaller scale factor allows detection of smaller faces, which can be useful for identifying faces at a distance or in crowded images.
- **scaleFactor = 1.2**: A larger scale factor detects only more prominent faces, reducing computational load and focusing on clearer, more visible faces.
- **minNeighbors = 3**: A lower value detects more faces, but may increase false positives, especially in crowded or cluttered images.
- **minNeighbors = 10**: Higher values increase the accuracy by filtering out more false positives, but could miss smaller faces in complex scenes.

**Why These Values Matter**:

- **scaleFactor**: A smaller value captures more faces at various scales, while a larger value helps focus on clearer, well-defined faces, improving performance in less cluttered images.
- **minNeighbors**: Adjusting this helps control the trade-off between detecting all faces (including false positives) and maintaining accuracy by avoiding detection of non-faces.

## TABLES:

The process of capturing, training, and logging attendance based on face recognition is implemented in the following steps:

1. **Image Capture**:
    - When the user enters their **Enrollment** number and **Name**, and clicks the **"Take Image"** button, the webcam is activated to capture the student's image using **OpenCV**.
    - The captured image is saved in the **TrainingImage folder** with a filename that includes the **Enrollment** and **Name** to uniquely identify the student.
2. **Training the Model**:
    - Once the image is captured, clicking the **"Train Image"** button triggers the training process.
    - The image is processed and added to a training dataset used by the **face recognition model**.
    - The system can later identify the student by comparing new images with the saved training images.
3. **Automatic Attendance**:
    - When the user clicks the **"Automatic Attendance"** button, they enter their **Enrollment**, **Name**, and **Subject**.
    - The system uses the trained **face recognition model** to verify the student's identity by capturing a new image and matching it with the stored images in the **TrainingImage** folder.
    - If the student is recognized, the system logs the attendance in an **Excel sheet** stored in the **Manually Attendance folder**. The sheet contains the following columns:
        - **Enrollment**: The student's unique enrollment number.
        - **Name**: The student's name.
        - **Date**: The current date when attendance is marked.
        - **Time**: The current time when attendance is logged.
        - **Subject**: The subject for which the attendance is recorded.
4. **Excel Logging**:
    - The **attendance data** is appended to an Excel sheet, ensuring accurate and updated records for each attendance session.
    - **Pandas** is used for handling data and logging it into the Excel file.

This process ensures automatic, real-time attendance marking with face recognition, making it efficient for managing attendance without manual input.

**Table 1:**

| Enrollment | Name | Date | Time |
|---|---|---|---|
| **1231** | ['bose' 'RAMAR BOSE'] | 2024-09-23 | 08:58:20 |

n this system, when the user inputs their **Enrollment Number** and **Name** and clicks **"Take Image"**, their image is captured and stored in the **TrainingImage folder**. Once the **"Train Image"** button is clicked, the system uses this image to train the **face recognition model**.

When the user clicks **"Automatic Attendance"** and enters their **Enrollment Number**, **Name**, and **Subject**, the system captures a new image, compares it to the trained images, and if a match is found, it logs the attendance in an **Excel sheet** located in the **Manually Attendance folder**. The sheet contains the **Enrollment Number**, **Name**, **Date**, and **Time** of the attendance.

**Table 2:**

| Enrollment | Name | Date | Time |
|---|---|---|---|
| **22** | ['Aditya Ardak' 'Aditya Ardak'] | 2024-11-26 | 14:03:00 |
| **78** | ['Aditya'] | 2024-11-26 | 14:03:01 |

The system captures and logs attendance by recognizing faces. For example, when the user with **Enrollment 22** and **Name 'Aditya Ardak'** inputs their details, the system records the attendance with the timestamp **2024-11-26 14:03:00**. Similarly, for **Enrollment 78** and **Name 'Aditya'**, the system logs the attendance with the timestamp **2024-11-26 14:03:01**. Each entry is saved with the **Enrollment**, **Name**, **Date**, and **Time**, ensuring accurate and automated attendance tracking.

**Table 3:**

| Enrollment | Name | Date | Time |
|---|---|---|---|
| **5** | ['Aditya'] | 2024-10-03 | 09:00:57 |

In this case, the system captures the attendance of the user with **Enrollment 5** and **Name 'Aditya'** at **09:00:57** on **2024-10-03**. When the user enters their details and clicks the **"Automatic Attendance"** button, the system performs face recognition by comparing the live image with the stored training images. Upon a successful match, the system logs the attendance entry in an Excel sheet, recording the **Enrollment Number**, **Name**, **Date**, and **Time**. This automated process ensures

real-time, efficient tracking of attendance, eliminating the need for manual input and ensuring accuracy in the attendance data. The system continues to work seamlessly, capturing and storing such entries for each recognized user.

**Table 4:**

| Enrollment | Name | Date | Time |
|---|---|---|---|
| **1231** | ['bose' 'RAMAR BOSE'] | 2024-09-23 | 09:00:55 |

In this case, the system captures the attendance of the user with **Enrollment 1231** and **Name 'RAMAR BOSE'**, and logs it on **2024-09-23** at **09:00:55**. When the user enters their **Enrollment Number** and **Name** and clicks **"Automatic Attendance"**, the system takes an image, matches it with the previously trained images, and records the attendance if the recognition is successful. This ensures that the **Enrollment Number**, **Name**, **Date**, and **Time** are accurately logged in the system for future reference. This data is stored in an Excel sheet within the **Manually Attendance folder**, allowing for automated and reliable attendance tracking.

**Table 5:**

| Enrollment | Name | Date | Time |
|---|---|---|---|
| **22** | ['Aditya Ardak' 'Aditya Ardak'] | 2024-11-26 | 09:37:10 |

In this instance, the system records the attendance for the user with **Enrollment 22** and **Name 'Aditya Ardak'** on **2024-11-26** at **09:37:10**. When the user enters their **Enrollment Number** and **Name**, and clicks the **"Automatic Attendance"** button, the system captures their image, compares it with the trained face data, and logs the attendance if a match is found. The **Enrollment Number**, **Name**, **Date**, and **Time** are then stored in an Excel sheet, located in the **Manually Attendance folder**, ensuring that the attendance is accurately and automatically recorded in real-time. This process eliminates manual tracking and ensures reliable data for attendance management.

## 4.2 GitHub Link for Code: https://github.com/sandipanrakshit34/Attendance-Management-System-using-Face-Recognition

# CHAPTER 5

# Discussion and Conclusion

## 5.1 Future Work:

- **Improved Scalability:** Expand the model to handle larger datasets and more diverse facial features, ensuring reliability across global demographics.
- **Liveness Detection:** Integrate techniques like eye blink detection or thermal imaging to prevent spoofing with photos or videos.
- **Cloud Integration:** Develop cloud-based storage and processing for centralized attendance data management, enabling scalability for organizations with multiple locations.
- **Enhanced Efficiency:** Optimize the model to reduce computational load and improve real-time performance on resource-constrained devices.
- **Additional Features:** Incorporate mask detection and emotion analysis for broader applications in surveillance and monitoring.
- **Cross-Platform Compatibility:** Adapt the system for mobile and web platforms to increase accessibility and usability.

## 5.2 Conclusion:

The Attendance Management System using Face Recognition demonstrates the effective integration of Python, OpenCV, Tkinter, NumPy, Pandas, MySQL, and Pillow to address real-world challenges in attendance tracking. The project offers an automated, secure, and accurate solution that reduces manual effort, eliminates errors, and prevents proxy attendance. By leveraging these technologies, the system achieves over 95% accuracy and operates efficiently in real-time scenarios.

The project's contributions highlight the potential of AI-driven solutions in administrative and organizational contexts. While the current implementation meets its objectives, future improvements will enhance its robustness, adaptability, and scalability, making it suitable for broader applications in smart systems and secure environments. This work lays the foundation for more sophisticated and efficient attendance systems, bridging the gap between manual and intelligent automation.

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