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Automated Attendance Marking System Using CNN-Based Face Recognition

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Abstract- **The project is a Flask-based application designed for face recognition and attendance tracking. It includes functionality for training a convolutional neural network (CNN) model using the InceptionV3 architecture, which is fine-tuned to classify faces. The application supports registering users by capturing and saving their facial images, which are then organized into directories. These images undergo data augmentation to enhance model robustness during training. A pre-trained CNN model is employed to detect and identify faces, allowing attendance to be marked automatically based on face recognition results. Attendance data is recorded in an Excel file, where new entries are added dynamically for each date.The application also provides an analysis feature that processes attendance data, generates visual summaries for different dates, and displays trends in a userfriendly format. Interactive web pages enable users to train the model, register faces, upload images for marking attendance, and review attendance statistics. The project incorporates image preprocessing, realtime face detection, and the use of cascaded classifiers, with seamless integration of attendance tracking into the system. The intuitive interface and automated processes aim to enhance efficiency and accuracy in attendance management.**

Key words- Flask Framework, Face Recognition, Attendance Tracking, CNN, InceptionV3, Data Augmentation, Face Detection, Image Preprocessing, Haar Cascade, Excel Attendance, OpenCV, Machine Learning, Data Visualization, User Registration, TensorFlow, Softmax Activation, Multi-class Classification, Attendance Reports.

Introduction

This paper introduces the creation and evaluation of a real-time face recognition system utilizing Convolutional Neural Networks (CNNs). Driven by advancements in high-speed processors and high-resolution cameras, the study explores face recognition's application in both offline and real-time scenarios. The proposed system was initially evaluated using AT&T datasets before extending to real-time applications. A systematic approach for tuning CNN parameters was adopted to enhance accuracy, achieving recognition rates of 98.75% and 98.00% for standard datasets and real-time inputs, respectively [1]. The work highlights CNN's capability to balance computational efficiency and accuracy in real-time face recognition.

Addressing the challenges posed by mask-wearing during the COVID-19 pandemic, this study focuses on developing a lightweight, mobile face recognition system capable of identifying masked and unmasked individuals [2]. Leveraging fine-tuned CNN models and transfer learning, the system achieves 90.40% validation accuracy using a novel masked face dataset . The research underscores the integration of deep learning into mobile applications, offering real-time recognition and mask compliance checks. The work contributes to public health efforts by demonstrating a practical solution for enforcing mask usage and identity verification.

This review presents a comprehensive exploration of face recognition technology, covering its development stages, methodologies, and applications. Emphasizing its integration into attendance, security, and biometric systems, the paper delves into early algorithms, such as PCA and LDA, and modern deep learning approaches [3]. The study also highlights the importance of evaluation standards, datasets, and challenges like environmental variations and dataset limitations. It provides a forwardlooking perspective on enhancing face recognition systems for real-world applications, making it a valuable resource for researchers and practitioners.

This systematic review investigates the application of Convolutional Neural Networks (CNNs) in face recognition. By analyzing 150 studies, it identifies prevalent CNN architectures, datasets, and accuracy levels while addressing challenges such as bias, robustness, and privacy [4]. The review emphasizes the evolution of CNN designs and their transformative impact on face recognition. It also explores future directions, including transfer learning and multimodal approaches, providing a comprehensive resource for advancing CNN-based face recognition research.

The paper details the design of an efficient face recognition system that integrates advanced image preprocessing and machine learning techniques. Emphasizing the system's adaptability to real-world scenarios, the study examines the use of robust algorithms for feature extraction and classification [5]. The design addresses critical challenges like varying illumination and facial expressions, highlighting the potential for practical deployment in security and identification applications.

Literature Survey

Makrem Beldi et al. [6] The study explores the application of CNNs to enhance face recognition, leveraging the TensorFlow framework for efficient implementation. The research emphasizes the benefits of Python-based tools in simplifying complex tasks, particularly for newcomers. By refining a CNN model with the AT&T dataset, the paper demonstrates significant accuracy improvements through strategic parameter tuning. The authors also highlight the balance between operational efficiency and resource allocation, proposing a practical approach to face recognition that integrates machine learning with deployment considerations. **Aneesa M. P. et al. [7]** This systematic review examines the role of CNNs in advancing face recognition systems. The authors delve into CNN's ability to manage large datasets and extract hierarchical features, which enhance recognition accuracy. By analyzing different CNN architectures and datasets, the paper provides insights into the technological advancements in biometrics and authentication. The study underscores the importance of deep learning for user security, offering a roadmap for future research in robust facial identification systems. **Peng Lu et al. [8]** This research presents a hybrid approach combining CNNs with augmented datasets to address challenges posed by small original datasets in face recognition. By leveraging data augmentation techniques, the authors enhance the diversity and volume of training data, enabling higher accuracy and generalization. The paper validates the effectiveness of the approach through comprehensive experiments and comparisons with traditional face recognition methods, demonstrating CNN's adaptability to diverse datasets. **Pranav K. B. and Manikandan J. [9]** The authors focus on designing a real-time face recognition system utilizing CNNs. The study evaluates the system's performance using AT&T datasets and extends its application to real-time inputs. With a systematic approach to tuning CNN parameters, the research achieves high recognition accuracies of 98.75% and 98.00% for datasets and realtime inputs, respectively. The work highlights the synergy between hardware advancements and CNN architectures in developing efficient recognition systems. **Rondik J. Hassan and Adnan Mohsin Abdulazeez [10]** This review provides an in-depth analysis of CNN-based face recognition techniques, examining datasets, architectures, and algorithms. The authors explore the evolution of deep learning and its transformative impact on biometric applications. By comparing existing methods, the paper identifies the strengths and limitations of CNNs, proposing enhancements for feature extraction and classification. The review serves as a comprehensive resource for advancing CNN-based face recognition technologies. **Marcin Kowalski et al. [11]** The study investigates thermal-visible face recognition for identity verification in low-light conditions. By introducing a novel "triple triplet" method that employs three CNNs, the authors address the modality gap between thermal and visible light images. The research, funded under the European Union's Horizon 2020 program, emphasizes the importance of combining thermal and visible imaging for robust biometric verification, particularly for border security and on-themove identity checks. **Di Wang et al. [12]** This paper presents an optimized CNN-based algorithm for face recognition, focusing on addressing challenges posed by internal and external variations. By refining CNN architectures and utilizing advanced preprocessing techniques, the authors achieve significant accuracy improvements. The research validates the algorithm's effectiveness through structured experiments and highlights CNN's potential in transforming face recognition for practical applications in computer vision and AI.

Preliminaries

1.Framework and Libraries

- **Flask**: Acts as the web framework for handling HTTP routes, requests, and rendering templates.
- **OpenCV**: Utilized for image and video processing tasks, including real-time face detection.
- **TensorFlow/Keras**: Provides tools to create, train, and deploy Convolutional Neural Networks (CNNs) for face recognition.
- **Matplotlib**: Used for generating attendance analysis visualizations.
- **Pandas and Openpyxl**: Handle reading, writing, and managing attendance data stored in Excel files.
- **Base64 and io**: Enable encoding and handling images for web display.

2. Core Functionality

- **Dataset Management**: Stores face images in directories under face_recognition_dataset for training and identification purposes.
- **Model Training**:
  - CNN model based on the InceptionV3 architecture. ○ Incorporates data augmentation using the

ImageDataGenerator class to increase robustness during training.

- Supports transfer learning by freezing pre-trained layers.

- **Face Registration**:
  - Captures and processes 250 grayscale face images per user using OpenCV.
  - Saves images in user-specific directories for training and identification.

Fig: Faces Dataset

- **Attendance Marking**:

○ Identifies faces in uploaded images using the trained CNN model. ○ Updates an Excel file (attendance1.xlsx) to track attendance by marking the corresponding date.

- **Data Analysis**:
  - Analyzes attendance records from the Excel file.
  - Generates date-wise attendance summaries as bar plots.
  - Renders these plots on a web page using Base64-encoded images.

3. File Structure and Paths

- **Dataset Directory (face_recognition_dataset)**: Organized to store face images categorized by user.
- **Model Path (model.h5)**: Stores the trained CNN model.
- **Attendance File (attendance1.xlsx)**: Tracks attendance records and updates dynamically.

4. Endpoints

- /: Renders the home page.
- /train: Initiates model training using the dataset.
- /register: Handles new user registration by capturing face images.
- /mark_attendance: Processes uploaded images for attendance marking using the CNN model.
- /analysis and /analysis1: Generate and display attendance analysis visualizations.

5. Preprocessing and Augmentation

• Data augmentation involves random transformations such as rotation, zoom, and flipping to improve the model's generalization capabilities. • Images are resized to match the model's input shape (100x100 pixels) and normalized for better training convergence.

6. Key Algorithms

- **Convolutional Neural Network (CNN)**:
  - Built on the InceptionV3 architecture for feature extraction and classification.
  - Custom dense layers with softmax activation adapt the model for multi-class face recognition.
- **Face Detection**:

○ Uses Haar Cascade Classifier to locate faces in images for both registration and attendance marking.

7. Outputs

- **Model File**: A serialized .h5 file for the trained CNN model.
- **Attendance Excel File**: A dynamically updated spreadsheet containing user names and attendance status for each date.
- **Web-Based UI**: User-friendly pages for training, registration, attendance marking, and data analysis.

Methodology

1. System Initialization

- **Dataset Directory Setup**:
  - The face_recognition_dataset directory organizes face images into subdirectories named after users.
  - Each subdirectory contains images captured during user registration.
- **Attendance File Creation**:

○ If attendance1.xlsx does not exist, it is initialized with a column for user names and dynamic columns for each attendance date. **2. User Registration**

- **Process**: ○ Users can register through the /register endpoint.
  - A webcam captures 100 grayscale face images per user using OpenCV.
  - Haar Cascade Classifier detects faces, cropping and saving them to the user's subdirectory.
- **Preprocessing**:
  - Images are resized and saved in .jpg format for uniformity.
  - This ensures that all registered users have labeled datasets for training. **3. Data Preparation**
- **Data Loading**: ○ The ImageDataGenerator class loads images from face_recognition_dataset.
  - Training and validation splits are created automatically (70% training, 30% validation).

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- **Data Augmentation**: ○ Images are augmented with transformations like rotation, zoom, flips, and normalization.
○ Augmentation improves the model's robustness to variations in image conditions.

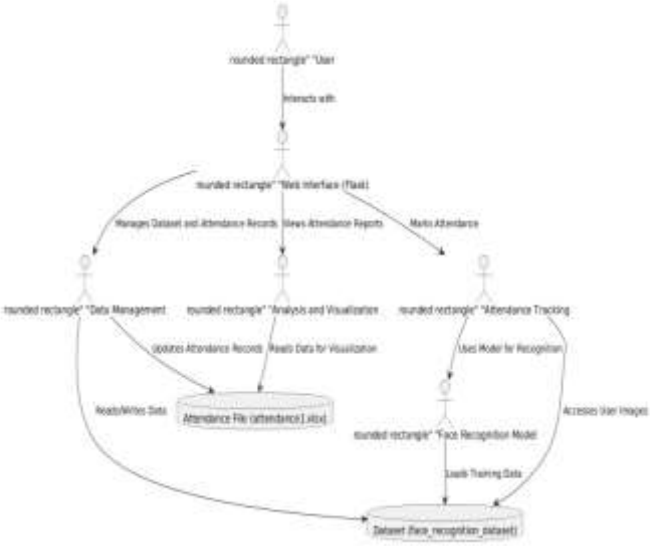

Fig: Architecture Diagram

4. Model Architecture

- **Base Model**:
  - ○ InceptionV3 is used as the backbone model with pretrained weights (imagenet).
  - ○ Transfer learning is applied by freezing the base layers to retain pre-trained features.
- **Custom Layers**:
○ A Global Average Pooling (GAP) layer reduces feature dimensions. ○ A Dense layer with softmax activation maps features to the number of classes (users).
- **Compilation**: ○ The model is compiled with the Adam optimizer, categorical cross-entropy loss, and accuracy as the evaluation metric.

5. Model Training

- **Training Process**: ○ The model is trained on augmented data using 20 epochs.
○ The validation dataset evaluates performance during training. • **Output**: ○ The trained model is saved as model.h5.
○ Class indices (class_new.npy) store the mapping between user names and class labels. **6. Attendance Marking**

- **Face Detection**:
  - ○ The /mark_attendance endpoint allows users to upload an image.
  - ○ OpenCV detects faces in the uploaded image using Haar Cascade.
- **Face Recognition**: ○ Each detected face is preprocessed (resized, normalized) and fed into the CNN model for prediction. ○ Predicted labels are mapped to user names using class_new.npy.
- **Attendance Recording**:
  - ○ The user's attendance is marked as "Present" in attendance1.xlsx under the current date.
  - ○ If the current date column does not exist, it is added dynamically.

7. Attendance Analysis

- **Process**:
○ Attendance data from attendance1.xlsx is visualized through the /analysis endpoint. ○ The system generates bar plots for attendance summaries on specific dates.
- **Visualization**: ○ Bar charts show the number of days present for each user.
○ Images of the plots are encoded in Base64 and displayed on the analysis page. **8. Real-Time Features**

- **Web Interface**:
○ Flask provides a user-friendly interface for registration, training, attendance marking, and analysis.
- **Error Handling**:
○ Flash messages guide users during operations like invalid image uploads or missing datasets.
- **Dynamic Updates**:
New users, dates, and attendance data are added to the system dynamically.

Results

The model is run through 20 epochs and the accuracy of the model is as follows:

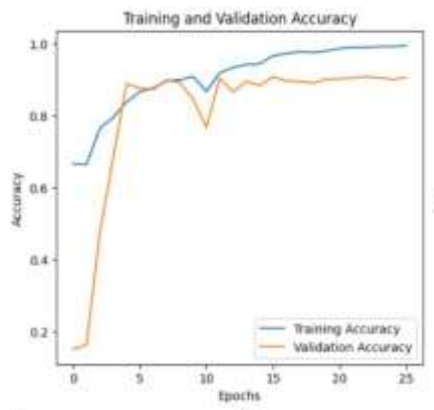

Fig: Accuracy of model

Identifying the roll numbers in given input image.

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Marking Attendence in Excel

	A	B	C
1	Name	2025-02-04	2025-02-06
2	21481A05K5		Present
3	21481A05M3		
4	21481A05M4		
5	21481A05O3	Present	
6	21481A05O8	Present	Present
7	21481A05P4		
8	21481A05P9	Present	Present
9	21481A05Q2		

Conclusion

The face recognition-based attendance management system outlined above demonstrates an efficient integration of machine learning, computer vision, and web technologies to automate attendance tracking. Leveraging Convolutional Neural Networks (CNNs) and transfer learning with InceptionV3, the system achieves high accuracy in recognizing faces. Data augmentation enhances the model's robustness, making it effective in handling variations in lighting, orientation, and facial expressions.

The use of a dynamic dataset structure and automated attendance file updates ensures scalability and adaptability as new users are added. The Flask-based web interface provides an intuitive platform for user registration, model training, attendance marking, and visualization of attendance data. Additionally, the implementation of OpenCV's Haar Cascade Classifier ensures efficient realtime face detection during registration and attendance processes.

This system highlights the potential of integrating modern deep learning techniques into practical applications such as attendance tracking. It offers a foundation for future enhancements, such as real-time video recognition, improved hardware support, or integration with cloudbased services for higher scalability and performance. The project stands as a reliable and user-friendly solution to streamline attendance management in various environments, including schools, workplaces, and events.

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