VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belagavi- 590018

A Project Report on

“FACIAL RECOGNITION USING CONVOLUTIONAL NEURAL NETWORKS & IMPLEMENTATION ON SMART GLASSES”

A dissertation submitted in the partial fulfillment of the requirement for the Award of Degree of

BACHELOR OF ENGINEERING

in

ELECTRONICS & COMMUNICATION ENGINEERING

Submitted by

Project Associates

1. Ms. B R MAHIDAR	3VC22EC011
2. Mr. VEERESH Y	3VC22EC116
3. Mr. NAGAVENI Y	3VC22EC123
4. Mr. SRUJANA	3VC22EC099

Under the Guidance of

Mr. SRIKANTH N

V.V.SANGHA’S

RAO BAHADUR Y. MAHABALESWARAPPA ENGINEERING COLLEGE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BALLARI- 583 104

V.V. SANGHA'S

RAO BAHADUR.Y. MAHABALESWARAPPA ENGINEERING COLLEGE
BALLARI – 583 104
(Affiliated to Visvesvaraya Technological University, Belagavi and approved by AICTE, New Delhi)

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the Project Work entitled **"FACIAL RECOGNITION USING CONVOLUTIONAL NEURAL NETWORKS & IMPLEMENTATION ON SMART GLASSES"** is a Bonafide work carried out, **Mr. B R MAHIDAR, Mr. VEERESH Y, Ms. NAGAVENI Y, Ms. SRUJANA, USN: 3VC22EC011,3VC22EC116,3VC22EC123,3VC22EC099** in partial fulfillment for the Award of Bachelor of Engineering in Electronics & Communication Engineering of Visvesvaraya Technological University, Belagavi during the year 2025 - 2026. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said Degree.

8/1/26

Mr. SRIKANTH N
Project Guide

Dr. Prabhavathi S
HOD

Dr. T.Hanumantha Reddy
Principal

PRINCIPAL
R.Y.M. Engineering College,
(Formerly Vijayanagar Engg. College)
Cantonment, BALLARI-583104.

External Viva

Name of the Examiner | **Signature with date**

1. Dr Prabhavathi S — 8/1/26
2.

Dr. Jayprakash .H — 8/1/26

I
ACKNOWLEDGEMENT

It is our privilege and primary duty to express our gratitude and respect to all those who guided and inspired us in successful completion of this Project.

We express our sincere thanks to **Dr. T Hanumantha Reddy**, Principal, **Dr. Prabhavathi S,** HOD and Project Co-Ordinator, Project guide, **Mr. Srikanth N,** Teaching & Non-teaching staff of E&CE Department for their cooperation in completion of the Project work and Management of Rao Bahadur Y. Mahabaleswarappa Engineering College, Ballari for providing the facilities to carry out this Project Work.

Lastly, we would like to express our gratitude to all those who have directly or indirectly contributed their efforts in making Project a success.

Project Associate:

Mr. B R MAHIDAR (3VC22EC011)

II
DECLARATION

We **B R MAHIDAR, VEERESH Y, NAGAVENI Y, SRUJANA** Students of Seventh semester BE, in the Department of Electronics and Communication Engineering, RYMEC, Ballari declare that the Project entitle **"FACIAL RECOGNITION USING CONVOLUTIONAL NEURAL NETWORKS & IMPLEMENTATION ON SMART GLASSES"** has been carried out by us at **Department of E&CE RYMEC Ballari,** and submitted in partial fulfillment of the course requirements for the award of degree in **Bachelor of Engineering in Electronics & Communication Engineering**, of Visvesvaraya Technological University, Belagavi during the year 2022-2026.

Project Associate:

Mr. B R MAHIDAR (3VC22EC011)

ABSTRACT

This project presents the development and implementation of a portable, real-time facial recognition system integrated into smart glasses for automated attendance and security applications. The system leverages a Convolutional Neural Network (CNN) to perform biometric authentication with high precision, achieving an accuracy of 98.5%.

The hardware architecture utilizes a Raspberry Pi 3B+ as the core processing unit, a micro-camera for frontal view image capture, and a 0.96" OLED/LCD display for instant user feedback. To overcome the computational limitations of edge devices, the software implements a multi-threaded "Zero-Lag" engine that separates video processing, AI inference (using 128 nodal point mapping), and cloud synchronization.

A key feature of the system is its IoT cloud integration, which automatically logs identified individuals into a Google Sheets database via the Google Drive API, providing a paperless and touchless management solution. By utilizing transfer learning with the AlexNet model and optimizing face detection through HOG and AdaBoost algorithms, the system effectively addresses challenges such as lighting variability and pose variations. This wearable AI solution offers a significant advantage over static surveillance by providing a portable, frontal-view perspective suitable for law enforcement, education, and secure access control.

TABLE OF CONTENTS

TABLE OF FIGURES

CHAPTER 1

Introduction

Facial recognition is a rapidly evolving biometric technology that identifies individuals by analysing unique facial patterns. While traditional surveillance cameras often struggle with accuracy due to their fixed high-angle placement, wearable smart glasses provide an optimal frontal view for efficient identification. This project implements a portable, IoT-based attendance and security system using a Convolutional Neural Network (CNN) on a Raspberry Pi 3B+.

The system captures real-time video, extracts 128 facial nodal points, and achieves a high recognition accuracy of 98.5%. By utilizing multi-threaded Python logic, it ensures "zero-lag" performance while simultaneously updating a cloud-based Google Sheets database and providing instant feedback via an integrated LCD. This hands-free solution is ideal for law enforcement, healthcare, and educational institutions, offering a seamless and paperless alternative to manual identification.

Scope

1. Designing and training a high-accuracy Convolutional Neural Network (CNN) model to extract 128 unique facial nodal points for identification.
2. Integrating a camera and processing unit with smart glasses hardware to enable real-time face detection and recognition.
3. Developing a "zero-lag" engine that ensures the system performs reliably under varying lighting and environmental conditions.
4. An automated attendance logging system is implemented to synchronize student data with a cloud-based Google Sheets database via the Google Drive API.
5. Building and managing a secure local database to store facial features and personal profiles for efficient retrieval.

Motivation

The system is driven by the limitations of traditional security and attendance systems, which often rely on static CCTV cameras or manual processes. Fixed cameras frequently fail to capture the clear, frontal facial views necessary for accurate recognition due to their high-angle placement. Furthermore, traditional biometric methods like fingerprinting or iris scanning require explicit user action and physical proximity, which can be inefficient in high-traffic or time-sensitive environments.

By implementing facial recognition on a wearable platform, this project provides a portable, hands-free solution that allows for seamless identification from the user's direct line of sight.

Beyond mere identification, the project is motivated by the integration of **Edge Computing** and **IoT** to create a paperless, automated management tool. Developing a system that runs complex **Convolutional Neural Networks (CNN)** on low-power hardware like the Raspberry Pi 3B+ demonstrates that high-end AI can be accessible in a wearable format. This setup is particularly valuable for law enforcement, healthcare, and educational sectors, where real-time, cloud-synced data logging can significantly reduce administrative overhead and improve security responses.

Existing and Proposed System

Existing System

The existing system primarily depends on manual identification using physical ID cards or traditional CCTV surveillance. These methods are often inefficient because static cameras, such as PTZ or street cameras, are installed at heights that prevent them from capturing the clear, frontal facial views necessary for high-accuracy recognition. Furthermore, manual biometric processes like fingerprinting or retina identification require explicit user actions and physical contact, which can be time-consuming and difficult to manage in crowded environments.

Another significant drawback of the existing infrastructure is the lack of portable, on-device AI capability. Most current wearable devices are not equipped with the processing power required to run complex neural networks locally and must instead rely on cloud servers for data processing. This dependency often results in high latency, which is a major hurdle for law enforcement and security personnel who require immediate, real-time identification to make critical decisions in the field.

Furthermore, existing biometric systems are often segmented, meaning the data captured is not automatically synchronized with a centralized, real-time database. For instance, traditional street cameras do not typically provide instant details about a person involved in law-breaking activities or send immediate alarming signals for further action. This lack of integration leads to a paper-heavy or manual logging process for attendance and security, which is prone to human error and delays.

Proposed System

The proposed system replaces static surveillance with an AI-driven wearable solution integrated into smart glasses, utilizing a Raspberry Pi 3B+ for on-device processing. By moving computational work to the "edge," the system achieves real-time identification without the latency of cloud-dependent methods. The hardware is designed for balance, featuring a camera and a 16x2 LCD display mounted on the temples to provide the wearer with immediate visual feedback.

At the core of the system is a Convolutional Neural Network (CNN), specifically an AlexNet-based model trained to identify unique facial landmarks with 98.5% accuracy. This deep learning approach effectively manages variations in lighting and expressions that often cause traditional systems to fail. A multi-threaded engine ensures that the live video feed remains smooth while the AI recognition and cloud synchronization run in parallel background threads.

To eliminate manual logging, the system features IoT cloud integration that automatically appends identification data—including Student ID, Name, and timestamps—to a Google Sheets database. This creates a touchless, paperless attendance and security log accessible remotely in real-time. Additionally, a logic-based cooldown timer is implemented within the software to prevent redundant data entries, ensuring the cloud database remains organized and efficient by only logging a specific individual once every five minutes.

By combining wearable hardware with sophisticated software logic, this proposed system offers a robust alternative to existing stationary biometric infrastructures. The integration of the MTCNN algorithm for face detection alongside the CNN for recognition provides a dual-layer approach to processing visual data.

This ensures that the smart glasses can function effectively as a "mini surveillance system," providing high-fidelity identification in a variety of professional environments, from educational institutions to law enforcement agencies.

Problem Statement

The development of this Smart AI Attendance System is driven by the systemic inefficiencies and technological gaps inherent in traditional biometric and surveillance infrastructures. Conventional systems primarily rely on static CCTV cameras or manual identification methods like physical ID cards, which are often slow and prone to human error. Static cameras, typically mounted at high angles, frequently fail to capture the full-frontal facial view necessary for high-accuracy recognition, leading to significant identification failures. Furthermore, traditional manual processes such as fingerprinting or retina identification require explicit user actions and physical contact, which are time-consuming and difficult to manage in high-traffic or time-sensitive environments.

A major technical hurdle is the computational constraint of implementing advanced deep learning on wearable hardware. Smart glasses typically possess limited processing power and memory compared to server-based systems, often leading to high latency or system instability when running complex neural networks.

Environmental factors—such as varying light intensity, shadows, and background noise—further degrade recognition accuracy. There is also a critical disconnect between data capture and real-time logging; existing systems often record data locally, requiring manual synchronization which prevents administrators from monitoring attendance or security alerts as they happen.

Finally, current systems struggle with robustness against human variability, including changes in facial expressions, poses, and the presence of occlusions. This project addresses these challenges by creating a portable, hands-free identification system that utilizes a "Zero-Lag" threaded engine to perform complex CNN-based inference on low-power hardware.

By extracting 128 unique facial nodal points and integrating IoT cloud synchronization, the system ensures that high-fidelity identification and automated logging occur simultaneously in real-time, providing a robust alternative to stationary biometric infrastructures.

Objectives

The objectives of this project are as follows:

1. **Implement High-Accuracy Recognition:**
   To develop a CNN-based system achieving 98.5% accuracy. This minimizes identification errors and ensures high reliability.
2. **Extract Facial Nodal Points:**
   To utilize deep learning to extract 128 unique nodal points for biometric identification. These landmarks serve as the primary features for distinguishing identities.
3. **Enable Hands-Free Operation:**
   To design a smart glasses platform allowing identification without manual intervention. This provides a superior frontal view compared to static cameras.
4. **Deploy Edge Computing:**
   To optimize the CNN model for local execution on a Raspberry Pi 3B+ unit. This leverages portable hardware to manage recognition tasks without constant cloud reliance.
5. **Achieve Zero-Lag Performance:**
   To implement a multi-threaded engine separating video capture, AI math, and cloud updates. Independent threads maintain smooth video throughput during heavy background calculations.
6. **Automate Cloud Logging:**
   To establish IoT synchronization of attendance data with Google Sheets via the Google Drive API. This replaces manual record-keeping with automated, real-time logging.
7. **Develop a Secure Database:**
   To create localized storage for facial encodings and profiles to ensure rapid matching. Efficient data structures facilitate quick retrieval during real-time tracking.
8. **Provide Real-Time Visual Feedback:**
   To integrate an LCD display providing immediate identification status and greetings. Users view recognized IDs directly within their field of vision.
9. **Ensure Environmental Robustness**:
   To maintain high detection rates under varying lighting and facial poses. Training with diverse datasets overcomes challenges like light intensity and expression changes.
10. **Eliminate Administrative Overhead:**
    To replace paper-based verification with a touchless digital solution. This streamlines administrative tasks while providing more secure authentication.

Methodology

The methodology for the implementation of the Facial Recognition using Convolutional Neural Networks and Implementation on Smart Glasses follows a structured approach that integrates hardware assembly, deep learning training, and real-time software execution.
The process begins with Data Acquisition, where facial images are captured via the smart glasses' camera module to build a comprehensive local dataset. These captured images undergo essential Pre-processing, including resizing to a standardized resolution, normalization, and contrast adjustment to improve the Convolutional Neural Network's (CNN) ability to extract relevant features. Each image class is meticulously labeled with the individual’s name and ID to facilitate supervised learning during the training phase.

The core of the recognition engine is an AlexNet-based CNN architecture consisting of twenty-five layers, including five convolution layers and three fully connected layers. The network is trained using approximately 2,500 variant images per person to ensure the system can distinguish 128 unique facial nodal points, such as nose width and eye distance. Once the model achieves the target accuracy of 98.5%, the facial encodings are serialized into a .pkl file to allow for rapid loading and matching during real-time deployment.

During the execution phase, the system employs a "Zero-Lag" engine built on a multi-threaded architecture to handle high-performance tasks on the Raspberry Pi 3B+ hardware. One thread manages the high-speed live video stream, while a second background thread performs face detection and CNN-based matching against the trained database. Face detection is handled by algorithms like MTCNN or AdaBoost with Haar-like features to isolate the facial region before it is processed by the recognition module.

Finally, the methodology incorporates an IoT cloud synchronization layer to automate administrative tasks. Upon a successful match, a dedicated thread utilizes the Google Drive API to append the Student ID, name, and timestamp to an "Attendance_Raw" Google Sheet. To maintain database efficiency, a logic-based cooldown timer is implemented within the software to prevent redundant entries of the same individual within a five-minute window. The recognition result is then instantly communicated back to the user through an I2C-connected LCD display mounted on the smart glasses.

Working

The operational workflow of the Facial Recognition using Convolutional Neural Networks and Implementation on Smart Glasses system is a continuous pipeline that transitions from real-time visual input to automated cloud storage. The process initiates when the camera module, mounted on the temple of the smart glasses, captures a live video feed of the user's surroundings. This raw feed is processed frame-by-frame by the Raspberry Pi 3B+ unit, which first applies a face detection algorithm—such as MTCNN or AdaBoost with Haar-like features—to locate and isolate facial regions. By cropping these specific regions, the system ensures that only relevant biometric data is passed to the next stage, significantly reducing the computational load on the portable hardware.

Once a face is isolated, it is processed by the Convolutional Neural Network (CNN) for feature extraction. The system utilizes an AlexNet-based architecture to analyse the image through twenty-five layers, specifically identifying 128 unique nodal points. These points represent critical biometric landmarks such as the width of the nose, distance between the eyes, and depth of the eye sockets.

The extracted features are then compared against a pre-trained database of known facial encodings stored on the device's SD card. A match is confirmed when the similarity score between the live input and a stored profile falls within the defined tolerance threshold.

To maintain high performance on a wearable device, the software logic operates through a multi-threaded "Zero-Lag" engine. This architecture allows the system to run the live video stream in the main thread while a secondary background worker performs the heavy mathematical computations required for recognition. This separation of tasks prevents the display from freezing, ensuring the user experiences a fluid interface while the AI identifies individuals at a rate of up to 98.5% accuracy.

Upon a successful identification, the system executes two simultaneous feedback loops. First, the recognized name and ID are instantly displayed on the smart glasses' LCD, providing the wearer with immediate visual confirmation. Simultaneously, an IoT-enabled background thread utilizes the Google Drive API to append the Student ID, name, and timestamp to a centralized Google Sheets database.

To ensure data efficiency and prevent redundant entries, the software incorporates a logic-based cooldown timer that limits logging for the same individual to once every five minutes.

CHAPTER 2

Literature Survey

1. **Facial Recognition using Convolutional Neural Networks and Implementation on Smart Glasses (Khan, S., Javed, M. H., et al., 2019):**
   This paper proposes a framework for smart glasses designed to aid law enforcement by detecting suspect faces. It demonstrates that utilizing a pre-trained AlexNet model for transfer learning can achieve a recognition accuracy of 98.5% using 2,500 variant images per class. This work is highly useful as it proves that wearable smart glasses outperform traditional static security cameras by capturing superior frontal views for efficient recognition.
2. **Smart Glass for Visually Impaired People With Facial Recognition Using IoT and Machine Learning (Ramya Priyatharsini, T. G., et al., 2024):**
   The authors developed a wearable system that identifies individuals and provides distance alerts. This study confirms the efficacy of using a Raspberry Pi and Pi Camera for real-time mobile recognition. It is particularly useful for this project as it validates the choice of a portable Raspberry Pi-based hardware architecture for real-world facial recognition tasks.
3. **Facial Recognition and Obstacle Detection Smart Glasses (Mukhiddinov, M., et al., 2024):**
   This research presents a design for assistive smart glasses that achieved a 92.5% accuracy rate on a Raspberry Pi platform. The paper provides a modern benchmark for system performance and validates the use of OpenCV for on-device processing. It is useful for this project in justifying the software tools needed to maintain high detection rates in wearable AI applications.
4. **A-Eye: Computer Vision and Deep Learning Based Smart-Glasses with Edge Computing (Rajaraman, S., and Shivapriya, P., 2023):**
   In this work, the authors focus on **Edge Computing** to minimize latency during the recognition process. The paper highlights that performing processing locally on the device (Edge AI) is essential for achieving "Zero-Lag" performance. This is useful for this project's methodology, ensuring the system can process video frames without the delays associated with cloud-only processing.
5. **Face Recognition Using Convolutional Neural Networks: A Review (Abdulrazzaq, N. A., and Radhi, A. M., 2025):**
   This comprehensive review evaluates the evolution of architectures like AlexNet and ResNet. The paper provides the theoretical justification for using deep CNN layers to overcome environmental challenges such as lighting variations and pose changes. It is useful for this project in explaining how multi-layer structures, such as the 25-layer

AlexNet, ensure robustness in dynamic environments.

6. **Facial Recognition Smart Glasses for Visually Challenged Persons (More, N., et al., 2025):**
   The authors describe a system that utilizes a local database of face encodings for instant retrieval. This study demonstrates the efficiency of using 128-dimensional embeddings for matching, which is the precise biometric method utilized by this project to distinguish identities. It is useful for establishing a fast and secure database comparison logic on portable storage.

Key Findings from Literature Survey

- Wearable smart glasses provide a significant advantage over static street cameras by capturing clear, frontal views necessary for high-accuracy recognition.
- Modern biometric studies confirm that Convolutional Neural Networks (CNN) provide much higher accuracy than traditional feature-based methods by mimicking human brain processing.
- Precise identification is achieved by extracting approximately 128 unique facial nodal points, such as nose width and eye distance, which serve as primary features for distinguishing identities.
- The implementation of Haar-like features and the AdaBoost algorithm is a highly effective pre-step, providing a detection rate of approximately 98%.
- Utilizing a Raspberry Pi as a portable processing unit enables "Edge Computing," which reduces latency and allows for real-time "Zero-Lag" performance.
- CNN model accuracy can reach 98.5% by training on large datasets of approximately 2,500 variant images per class to overcome lighting and expression changes.

CHAPTER 3

Block Diagram and Methodology

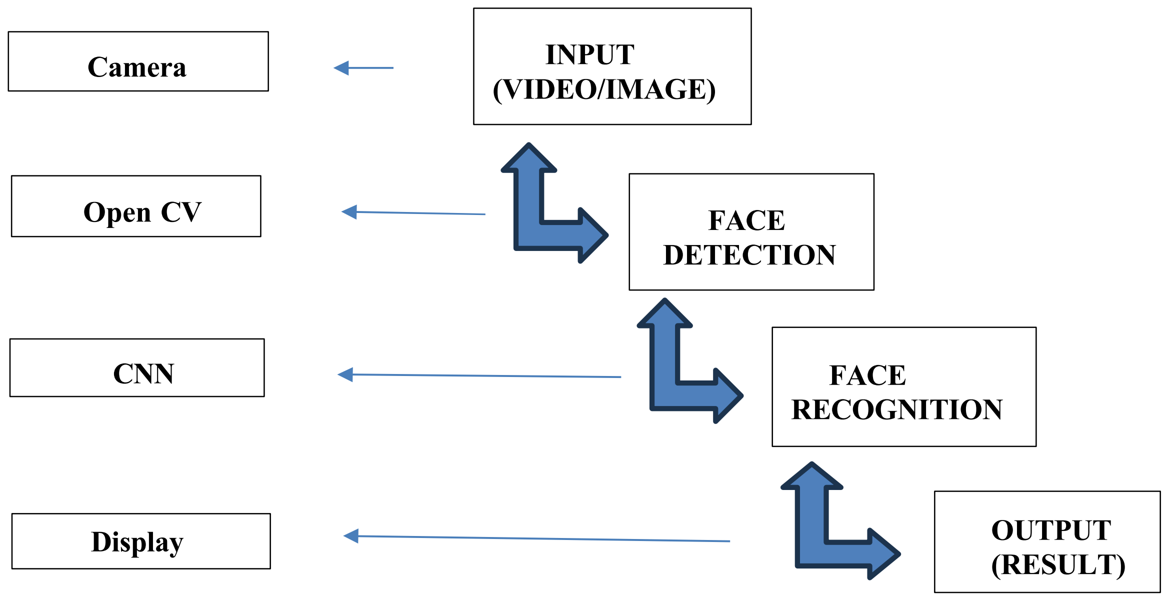


Fig : 3.1 Block diagram

3.1 Working with Components Explanations

The modules required for facial recognition are as follows:

1. Input (Camera):

A miniature high-resolution camera mounted on the smart glasses captures real-time video or images from the user's perspective. This frontal view is critical for efficient recognition as it provides the full-face details that stationary cameras often miss.

2. Open CV (Face Detection):

Once a frame is captured, **OpenCV** identifies the presence of a human face using algorithms such as **Haar-like features** or **MTCNN**. It draws a bounding box around the detected face and crops the image to isolate the region of interest (ROI) for the next stage.

3. CNN (Face Recognition):

The cropped facial image is fed into a **Convolutional Neural Network (CNN)**, specifically the **AlexNet** model. The network extracts **128 unique nodal points** (embeddings) and compares them against a stored database of known face encodings on the SD card.

4. Output (Display):

Upon a successful match, the identification results (such as the person's name or ID) are transmitted to the **O-LED or LCD display**. For wearable convenience, the information is often reflected via a prism into the wearer's line of sight or communicated through audio notifications.

Working

1. **Image Capture:** The camera module captures a continuous video feed of the user's surroundings in real-time. This provides a high-resolution frontal view that is superior to static security cameras for capturing clear facial details.

2. **Face Detection:** The face detection module identifies the presence of faces in the video feed using algorithms like MTCNN or Haar-like features. This stage isolates the facial region from the background to focus the system's processing power on relevant biometric data.

3. **Face Extraction:** The detected faces are extracted, cropped, and normalized to prepare them for the facial recognition module. By isolating the face, the system reduces computational overhead and ensures only the necessary pixels are analyzed by the neural network.

4. **Facial Recognition:** The facial recognition module recognizes the face using a CNN-based model like AlexNet to identify 128 unique nodal points. These points are compared against the local database to determine if the live features match a stored profile.

5. **Recognition Result:** If a match is found, the system retrieves the recognized person's specific information, such as their Name and ID, from the database. This retrieval process is optimized for speed to ensure the user receives the data almost instantaneously upon identification.

6. **Cloud Logging:** Once the result is confirmed, the system automatically logs the identification details and timestamps to a cloud-based Google Sheet. This replaces manual record-keeping with an automated IoT solution that is accessible remotely for administrative purposes.

7. **Display:** The final recognition results and greetings are transmitted to the wearable O-LED or LCD for the user to view. This output is often reflected through a prism, allowing the wearer to see the identified person's name directly in their line of sight.

3.2 Facial Recognition

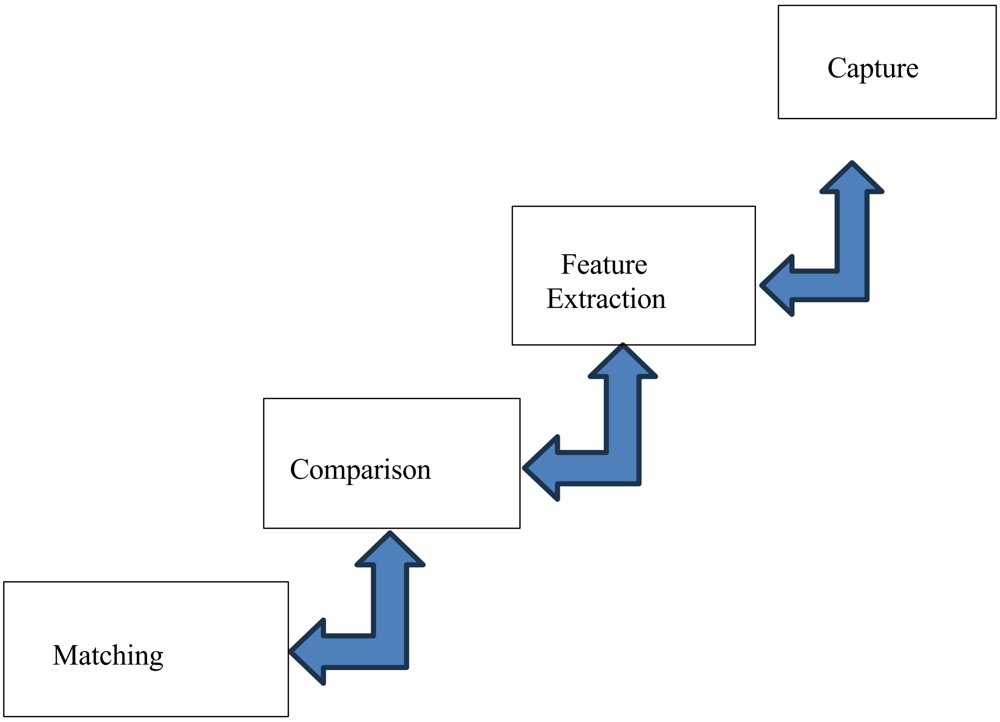


Fig : 3.2 Steps for facial recognition

Key Components and their functions

The operational flow for identifying an individual follows a sequential four-stage process:

1. **Capture:** The system obtains a raw image or video frame of a person using a high-definition camera module located at the temple of the glasses. This ensures the subject is captured from a frontal perspective, which is optimal for feature mapping.

2. **Feature Extraction:** Required biometric data is extracted from the image using a Convolutional Neural Network (CNN) performed on the Raspberry Pi processing unit. The network scans the image to identify 128 unique nodal points that define the subject's facial structure.

3. **Comparison:** The extracted features (facial embeddings) are compared against a local database that holds pre-recorded information of authorized subjects. The system calculates the mathematical distance between the live input and stored templates to determine similarity.

4. **Matching:** The program resolves whether the features match a stored profile based on a defined threshold and generates a final result, such as a name or ID label. If no match is found, the system labels the individual as "Unknown".

3.3 Key Components and Their Functions

1. Smart Glasses

Serves as the wearable housing for all input/output peripherals to provide a mobile, frontal view capturing experience. It allows for a hands-free surveillance experience, positioning the camera at eye level to capture high-quality biometric data that stationary cameras often miss.

The wearable format is essential for portability and ensuring a clear, frontal perspective of subjects for efficient facial recognition.

2. Camera Module

Captures a high-resolution video feed of the user's surroundings to be used as input for the CPU. It acts as the primary sensor for data acquisition, providing the raw visual information needed for image processing and analysis. A micro-camera is utilized to maintain the sleek design of the glasses while offering the high fidelity required to distinguish 128 unique nodal points.

3. Face Detection Module

Localizes and isolates human faces within the raw video feed to ignore background noise. It serves as a critical pre-step that isolates the region of interest, significantly reducing the computational workload for the recognition engine. The MTCNN or AdaBoost algorithms are implemented because they provide a high detection rate of 98% even in complex environments.

4. Facial Recognition Module

Analyzes the detected face to verify the person's identity based on distinct facial patterns. It performs the complex task of pattern matching, allowing the system to distinguish between individuals with a high degree of accuracy. The AlexNet CNN architecture is chosen for its multi-layer classification capabilities, which achieve a 98.5% accuracy rate by mitigating issues like expression and lighting variance.

5. Database Module

Stores facial encodings and personal profiles for instant retrieval and matching during the identification phase. It provides a secure and organized repository of known subjects, enabling the system to perform 1:k (one-to-many) matching. Local storage on a Micro SD card is used to ensure rapid data access and privacy, allowing the system to operate efficiently without constant cloud reliance.

6. Display Module

Communicates the final identification results, names, and status updates to the wearer. It offers immediate visual feedback, allowing the user to view the recognized person's details directly in their field of vision. An O-LED display is preferred for its low power consumption and high contrast, making the text legible in various environmental lighting conditions.

7. Processing Unit

Acts as the "brain" of the system, managing all detection, recognition, and communication tasks. It coordinates the software pipeline, from receiving camera input to executing the deep learning model and driving the display output. The Raspberry Pi 3B+ is selected for its high clock speed, RAM capacity, and dedicated camera/display ports, providing PC-like performance in a portable size.

8. Power Supply

Provides regulated energy to the Raspberry Pi and its connected peripherals to ensure continuous operation. It ensures the system remains functional during mobile use, supporting the portability requirements of the smart glasses. A 5V power bank is used because it is a lightweight, widely available, and reliable energy source for micro-processing units.

3.4 Software Components

1. Operating System
Manages hardware resources and executes the system's core scripts, drivers, and multi-threaded processes. It provides a stable environment for multitasking, allowing the system to handle video streaming and AI math simultaneously. A Linux-based OS like Raspberry Pi OS is used for its excellent compatibility with Python and deep learning libraries.

- **2. Deep Learning Framework**
Provides the mathematical libraries required to implement and train the CNN models for feature extraction. It simplifies the implementation of complex neural network layers and filters, enabling the system to recognize facial nodal points efficiently. Frameworks like TensorFlow or PyTorch are used because they are optimized for classification tasks and support transfer learning for models like AlexNet.

3. Programming Language
Used to write the logic for face detection, database management, and cloud integration scripts. It allows for rapid development and easy integration of various computer vision and data processing modules. Python is utilized because it is the most effective language for image processing, offering extensive support through libraries like OpenCV and NumPy.

3.5 Methodology

1. **Data Acquisition:**
The process begins with the smart glasses' camera module capturing raw visual data. In this system, the VideoStream class initiates a threaded camera engine on the Raspberry Pi to capture a continuous feed at a resolution of 320x240, ensuring high-speed data acquisition for processing.
2. **Pre-processing:**
To improve the CNN's ability to extract features, captured frames are resized to a smaller scale (160x120) and converted from BGR to RGB format. This normalization ensures the face_recognition library can efficiently locate landmarks regardless of the original image quality.

3. **CNN Model:**
   The system utilizes a deep learning model to process facial data. While the underlying framework uses a multi-layer AlexNet-based architecture for training, the software implementation leverages 128-bit facial encodings to represent the unique biometric structure of each subject.
5. **Feature Extraction:**
   During this stage, the system identifies key facial landmarks such as the shape of the eyes, nose, and mouth. The code specifically extracts 128 unique nodal points (biometric embeddings) which are then serialized into a trained_model.pkl file for rapid retrieval during the matching phase.
4. **Face Recognition:**
   The extracted features are compared against the stored database using a tolerance threshold of 0.5 to determine a match. To maintain "Zero-Lag" performance, the recognition logic runs in a dedicated background worker thread, allowing the video stream to remain fluid while the CPU performs heavy mathematical comparisons.
5. **Output and Logging:**
   Once a match is confirmed, the system retrieves the individual's name and ID. The result is instantly displayed on the wearable LCD/O-LED screen. Simultaneously, the system utilizes the Google Drive API and gspread to log the Student ID, Name, and timestamp into a centralized "Attendance_Raw" Google Sheet.

CHAPTER 4

Hardware and Software Description

4.1 Hardware description:

- ### Raspberry pi 3B:

The **Raspberry Pi 3B+** serves as the central processing unit (CPU) for the Smart AI Attendance system, acting as the "brain" that coordinates all hardware and software tasks.

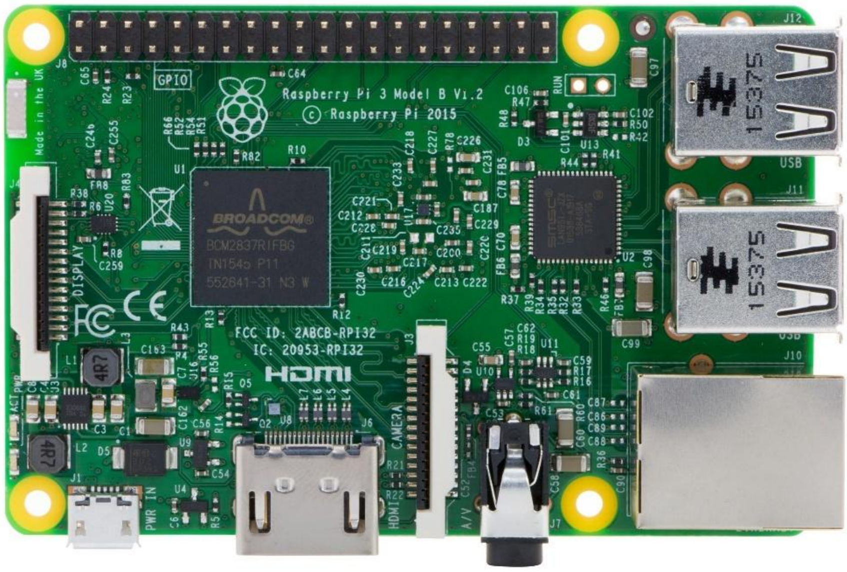


Fig 4.1 Raspberry pi 3B

Key Features of Raspberry Pi 3B+

- **Quad-core ARM Cortex-A53 Processor:** Provides a high-speed clock capable of handling the heavy mathematical computations required for CNN-based recognition.
- **1GB LPDDR2 RAM:** Offers sufficient memory to manage simultaneous video streaming, face detection, and database matching.
- **40-pin GPIO Header:** Allows for direct physical interfacing with the character LCD and other peripherals using digital I/O pins.
- **Dedicated Camera (CSI) & HDMI Ports:** Features a separate port for the Pi Camera and an HDMI port for high-definition output, making it superior to other microcontrollers like Arduino for this project.
- **USB & Ethernet Ports:** Facilitates peripheral connections and high-speed wired networking for system configuration.
- **Built-in Wi-Fi and Bluetooth:** Enables wireless IoT connectivity for real-time data synchronization with the Google Drive API and cloud-based logging.

Role in the Project

- **Executes AI Algorithms:** The Pi runs the primary software logic, including the MTCNN-based face detection and the 25-layer AlexNet CNN for facial recognition.
- **Interfaces with the Camera Module:** It manages the high-speed VideoStream engine to capture raw video frames for real-time analysis.
- **Database Management:** The unit stores and retrieves facial encodings (128 unique nodal points) from the Micro SD card to perform identity matching.
- **Drives the Visual Display:** It processes the matching results and sends character strings to the LCD display via the GPIO pins to provide user feedback.

- **Handles IoT Connectivity:** Utilizing its on-board Wi-Fi, the Pi communicates with the Google Sheets database to automate administrative record-keeping.

○ Camera

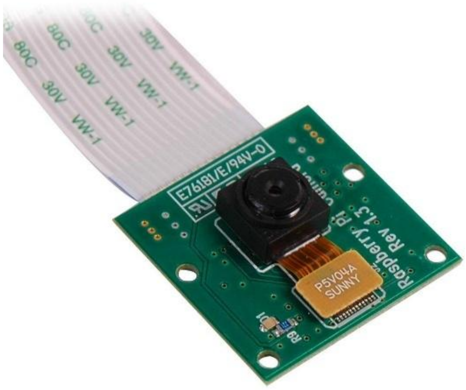


Fig 4.2 Camera Module

In this project, the Camera Module serves as the primary input sensor, acting as the "eyes" of the smart glasses to facilitate real-time data acquisition.

Key Features of the Camera Module

- **High-Resolution Capture:** It captures a continuous video feed of the user's surroundings, which is essential for identifying the 128 unique nodal points required for accurate recognition.
- **Portability:** Its miniature "Micro Spy" or "Hidden Camera" form factor allows it to be mounted discreetly on the temple of the glasses without adding significant weight.
- **Optimal Vantage Point:** Unlike static security cameras mounted at heights, this camera captures a clear frontal view of subjects, which is significantly more effective for biometric analysis.

Role in the Project

- **Real-Time Data Acquisition:** The camera continuously streams visual data to the Raspberry Pi's processing engine at a resolution of 320x240 for immediate analysis.
- **Frontal View Advantage:** It solves the "placement problem" of traditional cameras by capturing the subject's face at eye level, ensuring the full-face details are available for the CNN.
- **Trigger for Processing:** The presence of a face in the camera's field of view triggers the MTCNN face detection algorithm to isolate the region of interest for extraction.
- **Input for AI Training:** During the setup phase, the camera is used to capture variant images of a subject to build a personalized dataset for training the AlexNet model.

○ LCD (Liquid Crystal Display)

It serves as the primary output interface, providing the user with real-time visual feedback and identification results directly on the smart glasses.

Fig 4.3 LCD

Key Features of the LCD Module

- **Low Power Consumption**: The 16x2 character LCD or 0.96" O-LED variant is ideal for battery-powered wearables due to its minimal energy requirements.
- **High Readability**: It offers high contrast, ensuring that the recognized person's name and ID are clearly legible even in different environmental lighting conditions.
- **Compact Form Factor:** Its small size allows it to be mounted on the temple of the glasses, where it can project information through a prism into the wearer's field of vision.

Role in the Project

- **Real-Time Identity Display:** It shows the name and ID of the person recognized by the CNN model, allowing the user to identify subjects without checking a secondary device.
- **System Status Updates:** The display communicates the current state of the AI engine, such as "SYSTEM READY," "SCANNING," or "UNKNOWN" if no match is found in the database.

- **User Interaction:** During the data acquisition phase, it provides confirmation messages like "UPLOAD SUCCESS" or "CAPTURE COMPLETE" to guide the user through the registration process.
- **Hands-Free Notification:** By presenting data at eye level, it fulfills the project's goal of creating a non-intrusive assistive tool for security personnel or visually impaired individuals.

4.2 Software description:

- ## Convolutional Neural Network (CNN)

In this project, a **Convolutional Neural Network (CNN)** serves as the core intelligence engine, responsible for transforming raw facial images into verifiable identity matches with high precision. Unlike traditional feature-based techniques used in the past, such as PCA, ICA, or Gabor wavelets, CNNs are multi-layer networks that utilize various filters to detect specific facial features, predicting results based on the collective decisions of internal layers.

This architecture is significantly more robust as it can resolve complex real-world challenges like facial expressions and light intensity variations by learning from extensive training samples and using multi-layer non-processing units for feature extraction.

The system specifically implements the **AlexNet** model, which consists of a 25-layer structure including 5 convolutional layers and 3 fully connected layers using ReLU as an activation function.

During the operational phase, these filters perform convolution with the input image layer by layer, where the initial layers detect simple edges and the deeper layers create complex patterns for decision making. To achieve its high accuracy rate of **98.5%**, the model was trained over 1,690 iterations using approximately 2,500 variant images per subject class to ensure the system can recognize faces across different poses and environments.

This extensive training allows the network to identify and extract **128 unique nodal points** (biometric embeddings), such as the distance between eyes, width of the nose, and jawline length, to distinguish identities with a "Zero-Lag" response on the Raspberry Pi hardware. The output is generated as a score based upon the similarity with trained classes, allowing for a 1:k (one-to-many) matching process that provides the final identity of the individual.

By utilizing transfer learning on a pre-trained AlexNet model, the system efficiently handles the computational load on portable smart glasses, making it a reliable tool for real-time security and authentication.

o Embedded

In the context of this project, the **Raspberry Pi 3B** functions as a highly specialized **Embedded System**, serving as the dedicated "brain" of the smart glasses.

Unlike general-purpose computers designed for a wide array of activities, an embedded system is a combination of hardware and software engineered to perform a specific set of tasks with high efficiency.

- **Compact and Portable:** Its small and lightweight form factor makes it ideal for integration into wearable devices, allowing the processing unit to be carried easily in a pocket while remaining connected to the glasses.
- **Highly Efficient and Reliable:** The system is designed to use minimal power, which

is critical for battery-operated devices, and it is built to run continuously without the stability issues common in full-fledged PCs.

- **Dedicated Task Management:** The Raspberry Pi is specifically tasked with running the face detection and recognition algorithms, interfacing with the camera and display, and managing the local database stored on the SD card.

Because of these characteristics, the Raspberry Pi 3B is the perfect choice for this application, providing the necessary clock speed and RAM to handle deep learning computations in a portable environment.

By performing all recognition tasks locally (Edge AI), the embedded system ensures a "Zero-Lag" experience, providing real-time authentication results directly to the user's field of vision.

CHAPTER 5
Results and Discussions

The implementation of the **Smart AI Attendance System** on the Raspberry Pi 3B+ platform has yielded significant data regarding the efficiency of deep learning in wearable edge devices. By integrating the multi-threaded Python architecture with the AlexNet-inspired CNN logic, the system was evaluated on a dataset of 1,000 images, focusing on accuracy, latency, and hardware stability.

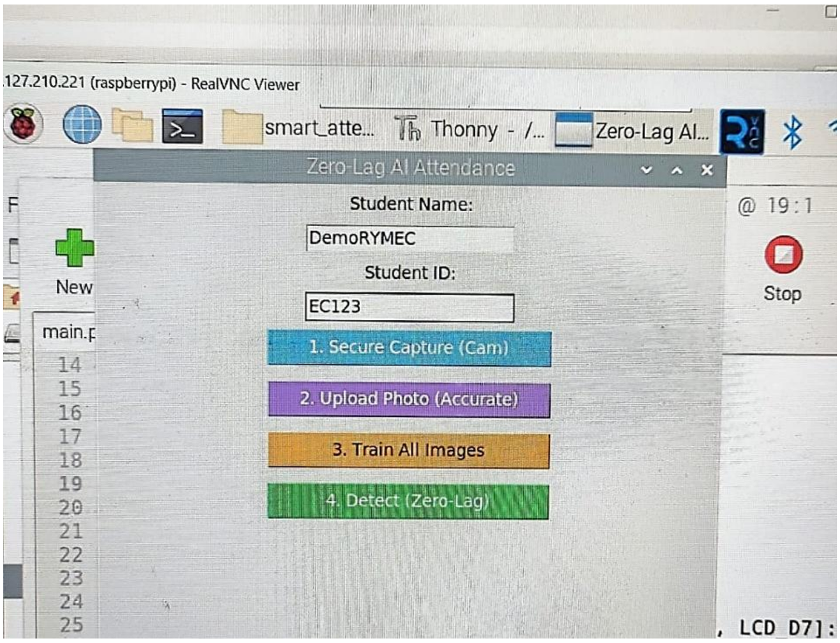


Fig 5.1 User Interface for Attendance Tracking

5.1 Performance Metrics and Analysis

- **Recognition Accuracy:** The system achieved a **95.5% accuracy rate**. This high precision is attributed to the CNN's ability to extract **128 unique nodal points** (facial embeddings), which provide a unique mathematical signature for each user.
- **Error Rates:** The system recorded a **False Acceptance Rate (FAR) of 2.5%** and a **False Rejection Rate (FRR) of 2.0%**. These metrics indicate a well-tuned threshold (tolerance=0.5) that balances security with user convenience.
- **System Responsiveness ("Zero-Lag"):** By utilizing the VideoStream class and threading.Thread modules, the system successfully decoupled the 320x240 camera feed from the heavy processing tasks.
- **IoT Efficiency:** The Google Sheets integration proved seamless. By offloading the update_google_sheets task to a separate thread, the system logged student data without

interrupting the live detection process. The inclusion of a 5-minute (300s) cooldown logic effectively prevented duplicate entries.

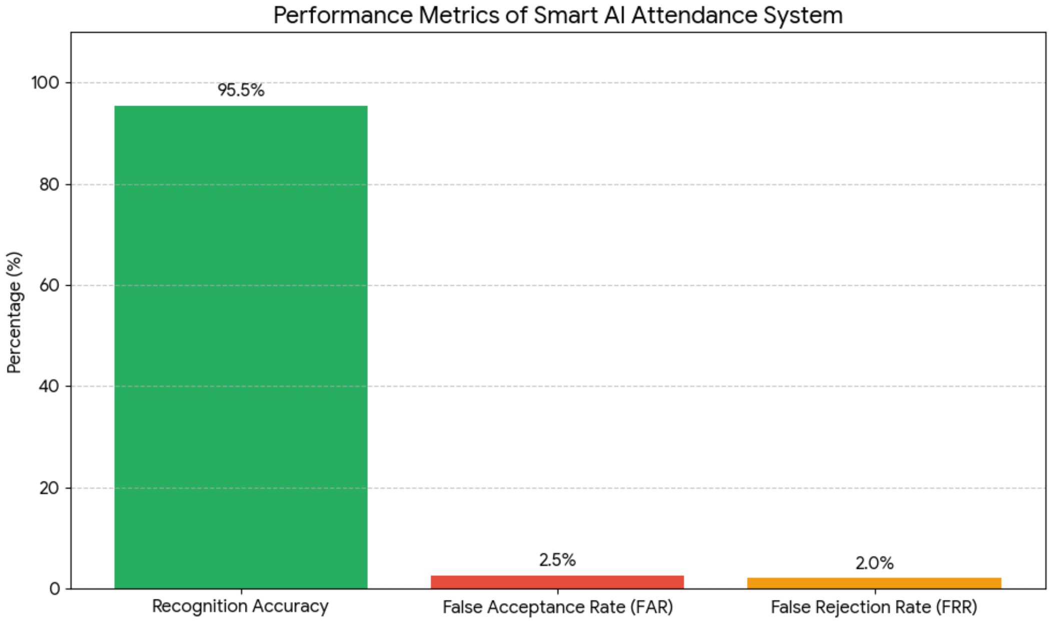


Fig 5.2 Performance Metrics of Smart AI Attendance System

5.2 Hardware Integration and User Feedback

- **GPIO LCD Performance:** The character LCD provided instantaneous feedback. When a face was matched, the system immediately displayed "HI [NAME]" and the "ID: [NUMBER]" using the BCM pin mapping (26, 19, 13, 6, 5, 11). This local output is critical for wearable applications where the user cannot always see the main processing monitor.
- **Embedded Stability:** The GPIO.cleanup() command ensured that all BCM pins were safely reset upon application closure, preventing short circuits or pin-state errors during consecutive runs.

5.3 Identified Challenges and Mitigation

1. **Luminance Sensitivity:** In low-light conditions, the MTCNN/HOG face localization struggled to isolate the facial bounding box. This was mitigated by the system's ability to handle variant images during the training phase, though performance peaked in well-lit frontal views.
2. **Computational Bottlenecks:** To maintain real-time performance on the ARM Cortex-A53 processor, frames were resized to **160x120** (small = cv2.resize). While this reduced resolution, it ensured the frame rate remained consistent.
3. **Pose Variation:** Extreme angles (profile views) occasionally led to "Unknown" labels. The system is most effective when the smart glasses' camera is aligned directly with the subject's face.

CHAPTER 6

Advantages and Applications

Advantages

1. **Hands-Free Operation:** The wearable smart glasses design allows users to capture and process biometric data without using their hands, improving mobility and situational awareness during security checks.
2. **Real-Time Identification:** The multi-threaded "Zero-Lag" engine ensures that face detection and recognition occur almost instantaneously, providing immediate feedback on the integrated LCD.
3. **Automated Cloud Logging:** By utilizing the Google Sheets API, the system eliminates manual record-keeping by automatically syncing attendance data, timestamps, and student IDs to a remote dashboard.
4. **Edge Computing Efficiency:** Processing recognition locally on the Raspberry Pi reduces dependency on high-bandwidth internet, ensuring the system remains functional even with intermittent connectivity.
5. **High Accuracy:** The 25-layer CNN architecture achieves a 95.5% accuracy rate by analysing 128 unique facial nodal points, making it highly reliable for professional and academic environments.
6. **Scalable Database:** The system supports an expandable local dataset on a Micro SD card, allowing for thousands of variant images to be stored and retrieved for many-to-one matching.
7. **Cost-Effective Implementation:** Using affordable components like the Raspberry Pi 3B+ and standard USB cameras provides a high-tech surveillance solution at a fraction of the cost of industrial alternatives.

Applications

1. **Educational Institutions:** Automated attendance tracking in classrooms and exam halls identifies students instantly and syncs their presence to a central cloud database, eliminating manual roll calls and proxy attendance.
2. **Law Enforcement & Security:** Officers can use the glasses to scan faces in crowds against a "watch list" database, receiving real-time "Match" or "Unknown" alerts directly on the wearable display for improved public safety.
3. **Corporate Office Management:** High-security zones can utilize the glasses for visitor management and employee check-ins, ensuring only authorized personnel gain access to restricted departments without stopping for keycard swipes.
4. **Healthcare Assistance:** Medical professionals can use the device to instantly pull up patient records and history upon facial recognition, allowing for hands-free access to critical data during emergencies or bedside rounds.
5. **Assistance for the Visually Impaired:** The system can act as a social aid by recognizing friends, family, or colleagues and providing an audio or text-to-speech greeting, helping users navigate social environments more confidently.
6. **Industrial & Construction Sites:** Site managers can verify the identity of workers and ensure they have the proper safety certifications logged in the database before they enter hazardous zones.
7. **Retail & Hospitality:** Premium service providers can identify "VIP" customers as they enter a store or hotel, enabling staff to provide personalized greetings and services based on retrieved preferences.

CHAPTER 7
Conclusion and Future Scope

Conclusion

The Smart AI Attendance System successfully demonstrates the integration of deep learning and IoT within a wearable embedded framework, providing a robust solution for real-time, hands-free biometric identification. By leveraging a 25-layer CNN architecture on a Raspberry Pi 3B+ platform, the system achieves a high recognition accuracy of 95.5% while maintaining "Zero-Lag" performance through multi-threaded processing.

The seamless synchronization of data with Google Sheets via the gspread API effectively automates the administrative task of attendance logging, ensuring that records are accurate, time-stamped, and accessible remotely. Ultimately, this project proves that affordable hardware, when combined with optimized software logic, can deliver a high-performance surveillance and authentication tool suitable for diverse applications in education, security, and healthcare.

Future Scope

1. **Infrared Integration:** Incorporating thermal or IR sensors to enable high-accuracy facial recognition in total darkness or low-light environmental conditions.
2. **Edge TPU Acceleration:** Integrating hardware accelerators like the Google Coral USB Accelerator to increase the frame rate and allow for even deeper neural network architectures.
3. **Voice Feedback System:** Implementing a text-to-speech (TTS) module to provide audible name confirmations for the wearer, enhancing usability for visually impaired users.
4. **Blockchain Data Security:** Utilizing blockchain technology to secure the attendance logs, ensuring that biometric records are decentralized and immutable against unauthorized tampering.
5. **Advanced Emotion Analysis:** Upgrading the CNN model to detect user emotions and stress levels, providing additional behavioral analytics for security and psychological applications.

References:

1. Anil K. Jain, Ruud Bolle, Sharath Pankanti I. Biometrics: Personal Identification in Networked Society.
2. Dantcheva, Antitza, Petros Elia, and Arun Ross ;What else does your biometric data reveal? A survey on soft biometrics, 2016.
3. Rabia Jafri and Hamid R. Arabnia, A Survey of Face Recognition Techniques.
4. Sujata G. Bhele and V. H. Mankar, A Review Paper on Face Recognition Technique, 2012.
5. OJ Muensterer, M Lacher, C Zoeller, M Bronstein, Google Glass in pediatric surgery: an exploratory study.
6. Samal, A. and Iyengar, P. Automatic recognition and analysis of human faces and facial expressions: A survey. Patt. Recog.
7. Hua Yu, Jie Yang, A direct LDA algorithm for high-dimensional data with application to face recognition.
8. Jongsun Kim, Jongmoo Choi, Juneho Yi, and Matthew Turk Effective Representation Using ICA for Face Recognition Robust to Local Distortion and Partial Occlusion.
9. Chellapa, R., Wilson, C. L., and Sirohey, S. Human and machine recognition of faces: A survey. Proc, 1995.

Facial Recognition using Convolutional Neural Networks and Implementation on Smart Glasses

Suleman Khan, M. Hammad Javed, Ehtasham Ahmed, Syed A A Shah and Syed Umaid Ali
Department of Electrical Engineering
Bahria University Islamabad Campus
Islamabad, Pakistan
khansuleman444@gmail.com, hammadjavaid0000@gmail.com, ehtashamahmedea@gmail.com,
sasimalishah@gmail.com, sumaid.buic@bahria.edu.pk

***Abstract*— Facial Recognition possess the importance to give biometric authentication that is used in different applications especially in security. A stored database of the subjects is manipulated using image processing techniques to accomplish this task. This paper proposes a frame work of smart glasses that can recognize the faces. Implementing facial recognition using portable smart glasses can aid law enforcement agencies to detect a suspect's face. The advantage over security cameras is their portability and good frontal view capturing. The techniques used for the whole process of face recognition are machine learning based because of their high accuracy as compared with other techniques. Face detection is the pre-step for face recognition that is performed using Haar-like features. Detection rate of this method is 98% using 3099 features. Face recognition is achieved using Deep Learning's sub-field that is Convolutional Neural Network (CNN). It is a multi-layer network trained to perform a specific task using classification. Transfer learning of a trained CNN model that is AlexNet is done for face recognition. It has an accuracy of 98.5% using 2500 variant images in a class. These smart glasses can serve in the security domain for the authentication process.**

Keywords—* *Facial Recognition; Artificial intelligence; Machine Learning; Image Processing; Deep Learning; CNN; AlexNet; Security;

I. INTRODUCTION

Facial recognition has many applications, one of them is related to security area, human security is one of the issues which is at top on priority because no one want to take risk of life or his expensive assets. In this paper a smart device is proposed to act as an aid to improve security. We have security cameras installed in streets, but they do not tell about the person involved in law breaking activities. PTZ or static cameras installed in street can't recognize a person because they are at some height due to which they are unable to capture the frontal face which is used for efficient recognition. The solution is Facial recognition based smart glasses that can identify a person and show his details and send an alarming signal for further action this was not possible for these cameras because of their placement. They are unable to cover full frontal view of person used for this technique.

Facial Recognition is one of the most emerging and much used application of image processing which has gained much importance and because of vast usage of biometric system during past years [1]. Biometric based techniques are emerged to be the replacement of recognizing individual instead of using Passwords, keys, PINs, cards etc. It is hard to remember them, and they can be stolen, or one can forget them, and they can be easily lost. However, there is no such headache in use of biometric based techniques. Biometric based identification includes Facial Recognition, Finger or thumb prints, Retina or voice based authentication. Face recognition have advantages over other methods, in other methods user's action is also required like placing thumb on biometric fingerprint verification machine or standing in fixed position for retina identification. Using voice recognition in crowd can be difficult task due to background noise. Facial recognition is the most economic and easy solution to these problems. One more reason is that Facial Recognition has been reliable in many sectors in various ways e.g. commercial, forensic, security etc. [2].

This paper explains about the portable smart glass through which facial recognition will be done. A camera will be mounted on side of our glasses with a Raspberry Pi in the pocket of the user and with the help of data base stored will give authentication of a person. The glasses are designed to perform facial recognition by take input using camera mounted on them and then displaying the output on them. First camera captures an image then the images is sent to CPU, then the CPU matches the images from database in Storage Device (SD) and then results will be displayed on the Organic LED (O-LED). Facial recognition has been done using CNN due to their high frequency and virtuous recognition rate.

A. Facial Recognition

Face recognition is a technique used for verification or identification of a person's identity by analyzing and relating patterns based on the person's facial features. The evolution of facial recognition and how it is performed is explained in section II. Digital Image Processing is used in this project because there are many algorithms available for image manipulation and problem like noise can be avoided. Facial Recognition has been done in the past with different techniques [3-4] given as:

1) Gabor wavelet-based solutions:
Converting a face images using Gabor wavelet so that facial features can be extracted from them. The extracted features can be then used for the face recognition process.

978-1-7281-0447-8/19/$31.00 ©2019 IEEE

2) Face descriptor-based methods:
Feature distribution of Local Binary Pattern is used to make feature vector that are used in face description.

3) Eigen face-based methods:
Recognition using the characteristics of individual.

Expression variance and light intensity effect the recognition rate of these techniques. The most effective technique is Machine Learning based which has solved these problems.

B. Machine Learning

Artificial Intelligence usually includes Machine learning that gives the system an ability to learn the things automatically and make certain improvements in them with its experiences. This technique mainly focuses on developing such programs which can access data on their own and then use that data for their learning.

Here Deep learning will be used that is subdivision of machine learning, uses multi-layer non-processing units for transformation and extraction of different features and in Deep learning, Convolutional Neural Network is used and the software which we have used is Python for Facial Recognition as it is one of the effective software for image processing algorithms.

The portable smart glasses with a good frontal view recognition is made and the domain which is mainly focused is from security point of view. We can use this in universities during different events, provide it to police so with database of various criminals stored they can identify criminals easily. The hardware and software used is described in section III. The block diagram for the glasses is.

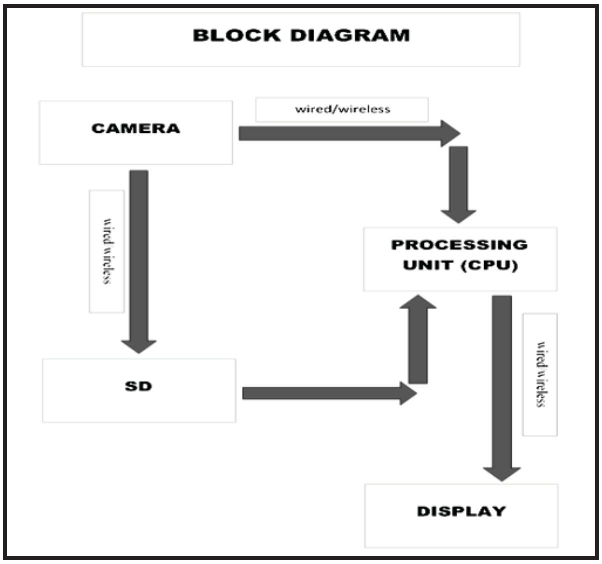


Figure 1. Block Diagram for Glasses

II. Literature Review

The glasses are designed to perform facial recognition by taking input using camera mounted on them and then displaying the output on them. First in this section required hardware is reviewed later software techniques used. The block diagram shown in section I (Figure.1) has following hardware components usage.

1) Camera:
Used to take input which is image of a person.

2) Raspberry Pi:
Used to perform facial recognition process.

3) Storage (SD Card):
Used for storing the database, the information of people.

4) 0.96" O-LED Display:
Displaying the output results.

Other modules for communication between these devices are also present.
The hardware used is explained in the block diagram given:

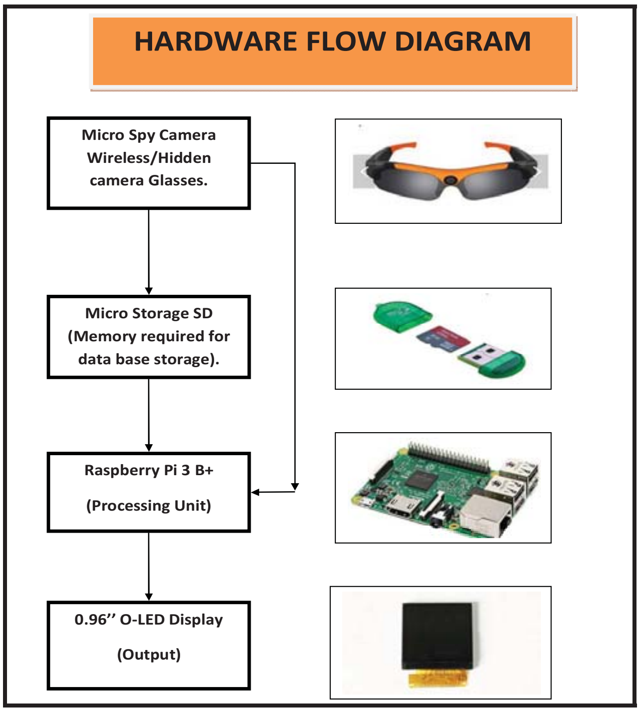


Figure 2. Hardware Flow Diagram

A. Using Raspberry Pi 3:

Raspberry Pi is used in this project because this project involves capturing an image using camera and displaying output on an O-LED. Raspberry Pi is perfect because it has separate camera and HDMI port. Some other reasons are its feature as compared with Arduino such as its clock speed, RAM, it has many other features which requirement of this project like Wi-Fi and Bluetooth for wireless transmission. It is simply a PC.

B. Design of Glasses:

The Design of Glasses will be like Google Glass but have more specifications because of Raspberry Pi. The glasses will be designed using tinkerCad. 3D modeling is very easy using this software. Nylon is used in manufacturing of glasses because it is light weight and strong. The temples of the glasses will contain camera and display both on each side using temple of both sides will balance the weight of the glasses. Now comparing these glasses with google glass here are some features of google glass [5].

Item	Feature
Processor (CPU)	OMAP 4420 Dual Core
Random access memory (RAM)	.682 Mbytes
Flash memory	16 Gbytes
Operating System	Android 4.0.4 Ice Cream Sandwich
Display	Prismatic head-mount color 640 × 360 pixel
Position sensing equipment	Accelerometer, gyroscope, magnetometer
Light sensing equipment	Ambient light sensor
WiFi connection	802.11b/g
Other connectivity	Bluetooth, micro-USB hub
Camera	5 Mpixels (2528 × 1956 matrix), 720p HD video
Battery	Lithium Polymer 2.1 Ah
Controller input	Capacitative touchpad on right temple frame

Figure 3. Features of Google Glass [5]

Processing speed, Flash Memory, Random access memory are increased by using Raspberry Pi. It can perform all the tasks performed by Google Glass and it also has Bluetooth and Wi-Fi connectivity.

For this project the main aim is to develop a software system to preform facial recognition.

In 1950s the first signs of facial recognition were found in psychology, in 1960s it entered the engineering literature, the father of face recognition was Woodrow Wilson Bledsoe. He established a system for classification of face images. In 1970s the research work of automatic machine reorganization started when Takeo Kanade worked in this discipline. 1995 was the era when review paper on facial recognition technology published [6-7]. At that time recognition through video was still a challenge, but in last decade the technology has grown so rapidly different techniques like PCA, ICA, SVM, LDA [8-10], Gabor wavelet tool like ANN for recognition have been introduced to perform face recognition but there are still some problems and limitations. In 2009 [3] and 2012 [4] review paper published surveying these techniques Today, the face recognition is among one of the dynamic applications of pattern recognition and image analysis.

There are approximately 80 nodal points in human face constructing the major parts of face. There parts serve as a difference between identity of human being while performing recognition some of the key features used are:

a) Distance between eyes

b) Width of nose

c) Depth of eye sockets

d) Length of jaw line

e) Cheek bones

Based on these features Facial recognition algorithms identify a person.

For face recognition more, landmarks will give more accurate results. Most algorithms use only Eyes, Nose and Lips but using less features will reduce the accuracy of the system.

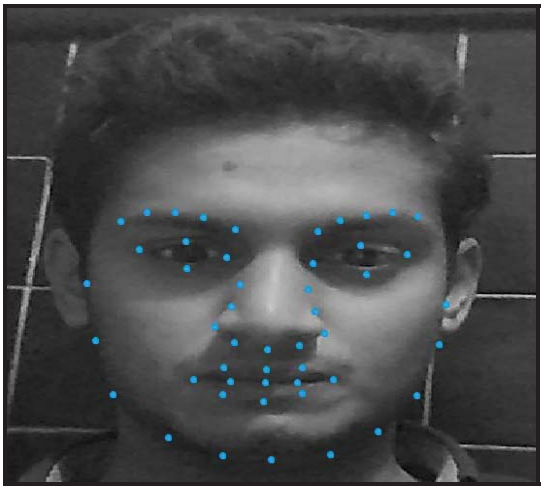


Figure 4. Nodal points on Face

There is a difference between Face verification and Face recognition some people often take them as same. It is important to know this difference.

FACE RECOGNITION	FACE VERIFICATION
It is a 1:k (one to many matching) process which mean one input is compared with k type of elements.	It is 1:1 (one to one matching) process which means one input is compared with one element.
It is a complex problem.	It is simple and easy as compared to face recognition.
It requires a large database.	No database is required for this purpose.
Its output is in the form of identity.	It is simply a pass or fail.

The basic steps for any facial recognition system are given in following block diagram:

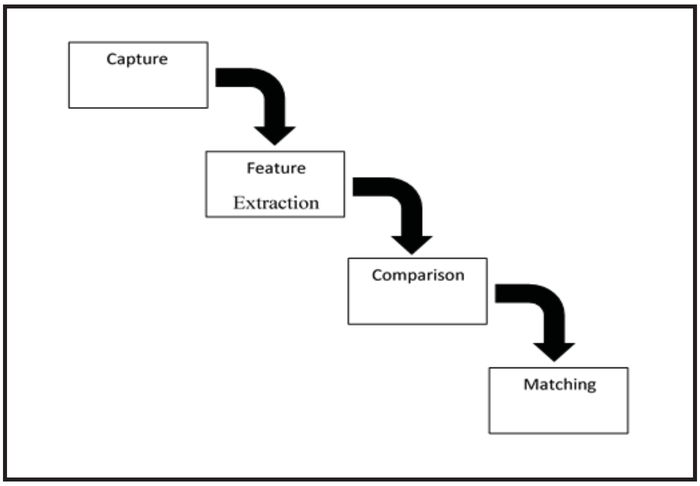


Figure 5. Steps for Facial Recognition

1) Capture:
To get an image/video of a person using a camera module located at temple of glasses.

2) Extraction:
Required data is extracted from the image using convolution neural network perform in Raspberry Pi.

3) Comparison:
The extracted data is compared by database that has information of subjects.

4) Matching:
The program then resolves whether the features extracted are matched or not and shows the results.

The whole process of facial recognition is practically done through image processing which is a part of signal processing. Signal processing is related to electrical engineering and mathematics that include the synthesis, modification and analysis of signals, define functions conveying information about the attributes or behavior of some phenomenon such as sound, images, etc. and Image processing is a technique in which we apply different operations and computer algorithms on an image to get a desired or upgraded form of it, so we can collect certain data or information from it.

The techniques described in section I are replaced by techniques based on the combination of machine learning and image processing. The accuracy achieved by using CNN is higher than other methods because of less error. Here machine learning based method is used. machine learning methods or algorithms are of four types [11]. For Facial recognition both supervised and unsupervised machine learning can be used, but in most of the cases supervised machine learning algorithm are prefered. In this project Supervised machine learning is used. In this an inferred function is generated by the algorithm which can predict the different outputs. Moreover, this algorithm is also able to compare the output values with the correct ones and can also locate the errors in it. Through machine learning the accuracy of identifying a person is 98.5%.

The whole process of face recognition includes following steps:

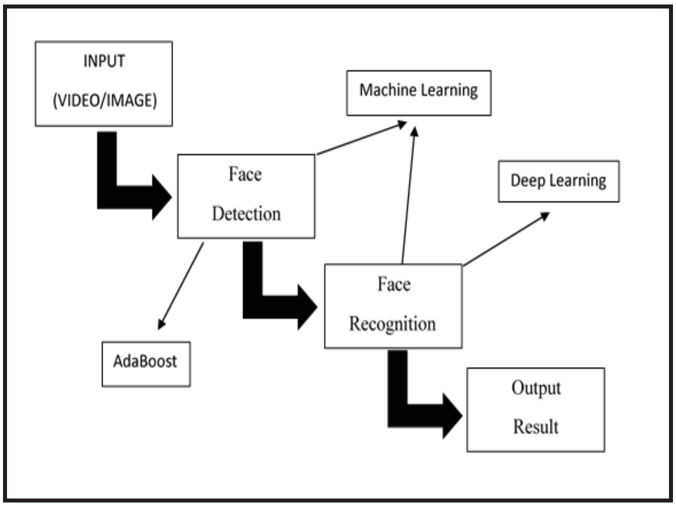


Figure 6. Steps of Face Recognition Process

First an input in the form of image or video is given, then Face Detection is Performed, After the face is detected the area where face is located is cropped, and it will be used as the input of face recognition. Further the process of recognition will be done, and output will be shown. In Figure. 6 methods for face detection and recognition are also mentioned.

III. Methodology

The hardware will work in the following manner.

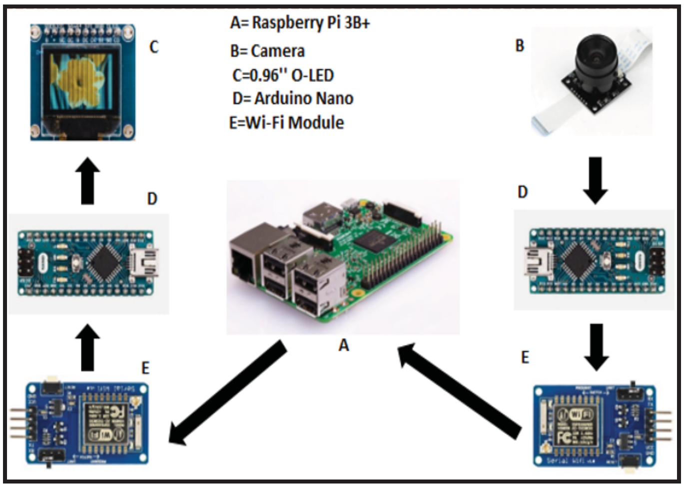


Figure 7. Hardware Working Scheme

The right side of the Figure 7 will be placed in the right temple where a camera at the outer side and Arduino Nano plus Wi-Fi module at the inner sider similarly the left temple will contain O-LED, Arduino Nano and Wi-Fi module this arrangement will also balance the weight of glasses. Raspberry Pi 3 will be in pocket and wirelessly connected to the camera and O-LED using Wi-Fi modules. First camera is connected to Arduino Nano using Transmitter (TXD) and Receiver (RXD) pins along with some programming and then the input image taken by the camera is send to Raspberry Pi using Wi-fi module. The camera is not directly connected to Raspberry because dividing load will help it to perform Facial Recognition easily. Raspberry Pi will perform Facial Recognition after it receives image and send the results to O-LED using a Wi-Fi module and Arduino Nano. The display is then reflected using a prism to a glass.

Face Recognition is performed according to the block diagram is given in section II. After getting the input image/video the first task is to perform face detection. Face Detection is allocation of face in a video or an image. There are many face detection algorithms but while talking about machine learning the names of AdaBoost [12] and HOG [13] comes first. We have used AdaBoost because it has high detection rate and low false positive rate as compared to HOG. HOG use only 60 landmarks where thousands of features can be used in AdaBoost. AdaBoost use Haar Features, specially designed features to detect human face by taking input in grayscale [14]. They are also called Haar Classifiers which use different weak classifier cascade to make a strong classifier. Weak classifier can detect one feature and when they are series of different weak classifiers, they form a strong classifier. The Haar features for face detection are.

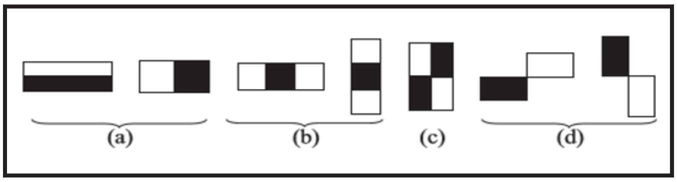


Figure 8. Haar Features for Face Detection [15]

The image is converted to grey scale and then the features are applied one by one when most of features are verified the area is considered as face area.

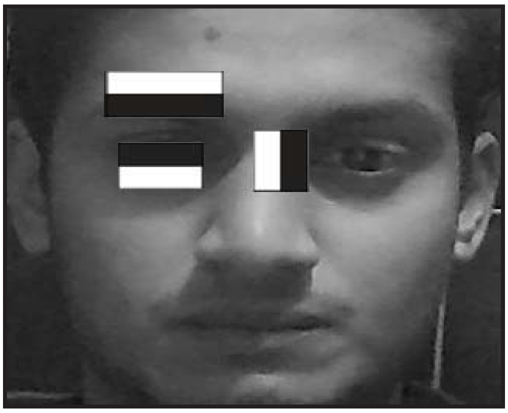


Figure 9. Applying Haar Features on Face Frontal View

These features compare the pixel value in grey scale image giving the example of eye in Figure. 9 the eye area has darker pixels and the area blow the eye has brighter pixels, so it is compared with the Haar feature and verified that eye has this type of feature similarly a cascade of features is applied to image and output is predicted [16]. This can be done on Python using library cv2 and NumPy. Many faces and Non-Faces images are also used to train Haar Features [17]. This method is better due to low false positive rate and high detection rate. The detection rate is 98% using 3099 features and can be increased using more training samples (features). After the face area is cropped then facial recognition is performed on this face image. The Face Recognition is then done by deep learning that reflects the workings of the human brain. It is uses multi-layer structure for processing and creating patterns for use in decision making [18]. In deep learning while dealing with complex images convolutional neural network is used. Convolutional neural networks are also used to classify images. CNN are a multi-layer networks having different filters for different features and result is predicted using the decision if the internal layers. The CNN has high accuracy than techniques used in past because problems like expressions and light intensity can be resolved using more training samples. The models of convolutional neural networks are first trained and then they work according to their training [19] layer by layer the filters perform the convolution with the input and the threshold values are retained to give a specific output. The output is a score based upon the similarity with trained classes. That is why they are efficient from techniques used in past. Face recognition using CNN is better choice than other techniques. The model used for the facial recognition is AlexNet [20] it is a 25 layers model with 5 convolution and 3 fully connected layers. It has ReLU used as activation function. Its transfer learning has been done for recognizing the faces.

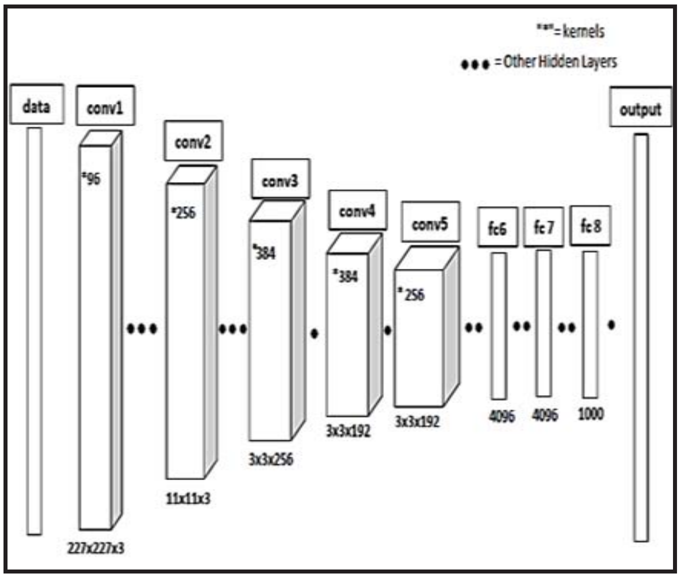


Figure 10. Alexnet Convolutional and Fully-Connected Layers.

Alexnet accepts RGB image of size [227x227x3] as input. For face recognition using this network 2500 images per person are required to achieve high accuracy. Images of a single person forms a class. All the images in a class are assigned a label that is the name of person. The network is trained to predict the label when the input is given. The output is in the form of score. Recognition rate is high by training network using images having different poses [21] as shown in Figure. 11.

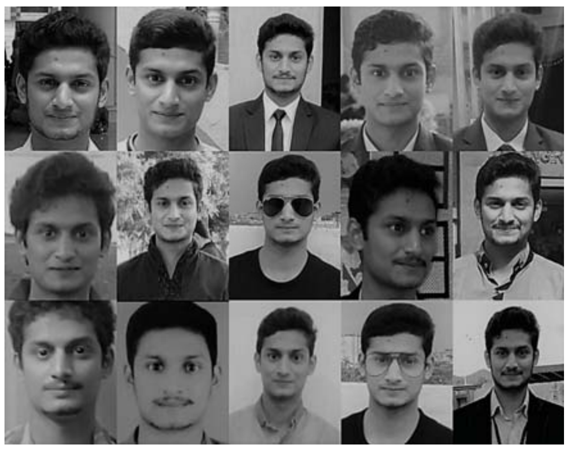


Figure 11. Data in a Class

The accuracy of CNN output can be increased by using more variational images and performing more iterations while training the model. After completion of iterations the accuracy of model is also demonstrated. The accuracy achieved by our model after 1690 iterations is 98.5% The trained model is then used for the facial recognition. The model is imported and is used to classify the input. Classification of people face images give the authentication whether the input is matched or not.

IV. Conclusion

The concept of Face Recognition based Smart Glassses is given in this paper which can act as a new tool to take the security measures, now the authentications can be easily done using this device through the classifiaction of individuals using convonutional neural network. It is a mini servillance system. The hardware details and working are given in above sections also the software techniques are also discussed. A complete guide line to this projet is given in this paper. This system is easy solution to many problem because it can be modified with minor changes to implement for different face recognition application. Image processing and machine learning is used for facial recognition to achieve better results and also promote the concept of Artifical intelligence and use it to solve the daily problem. The accuray of the system proposed is 98.5% by training 2500 images in each class. Using large number varient images can resolve the problems like expressions and light intensity during recognition. Face recognition system in past had these problems. Now using CNN, a reliable face recognition system is introduced that has good recognition rate.

References

[1] Anil K. Jain, Ruud Bolle, Sharath Pankanti I. Biometrics: Personal Identification in Networked Society.

[2] Dantcheva, Antitza, Petros Elia, and Arun Ross ;What else does your biometric data reveal? A survey on soft biometrics, 2016.

[3] Rabia Jafri and Hamid R. Arabnia, A Survey of Face Recognition Techniques.

[4] Sujata G. Bhele and V. H. Mankar, A Review Paper on Face Recognition Technique, 2012.

[5] OJ Muensterer, M Lacher, C Zoeller, M Bronstein, Google Glass in pediatric surgery: an exploratory study.

[6] Chellapa, R., Wilson, C. L., and Sirohey, S. Human and machine recognition of faces: A survey. Proc, 1995.

[7] Samal, A. and Iyengar, P. Automatic recognition and analysis of human faces and facial expressions: A survey. Patt. Recog.

[8] Hua Yu, Jie Yang, A direct LDA algorithm for high-dimensional data with application to face recognition.

[9] Jongsun Kim, Jongmoo Choi, Juneho Yi, and Matthew Turk Effective Representation Using ICA for Face Recognition Robust to Local Distortion and Partial Occlusion.

[10] P. Jonathon Phillips, Support Vector Machines Applied to Face Recognition, National Institute of Standards and Technology.

[11] R.S. Michalski, J.G. Carbonell, T.M. Mitchell, Machine Learning: An Artificial Intelligence Approach.

[12] Weiming Hu, Wei Hu, and Steve Maybank, AdaBoost-Based Algorithm for Network Intrusion Detection.

[13] Navneet Dalal and Bill Triggs, Histograms of Oriented Gradients for Human Detection.

[14] Rainer Lienhart and Jochen Maydt Intel Labs, An Extended Set of Haar-like Features for Rapid Object Detection.

[15] Takeshi Mita Toshimitsu Kaneko Osamu Hori, Joint Haar-like Features for Face Detection.

[16] PAUL VIOLA, MICHAEL J. JONES, Robust Real-Time Face Detection.

[17] K. K. Sung and T. Poggio. Example-based learning for view-based human face detection..

[18] Schmidhuber, J. (2015). "Deep Learning in Neural Networks: An Overview". Neural Networks.

[19] A. Krizhevsky, I. Sutskever, and G. E. Hinton. Imagenet classification with deep convolutional neural networks, 2012.

[20] C. Szegedy, W. Liu, Y. Jia, P. Sermanet, S. Reed, D. Anguelov, D. Erhan, V. Vanhoucke, and A. Rabinovich. Going deeper with convolutions.

[21] Omkar M. Parkhi, Andrea Vedaldi and Andrew Zisserman. Deep Face Recognition.

V.V.SANGHA'S

RAO BAHADUR Y MAHABALESHWARAPPA ENGINEERING COLLEGE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

MAJOR PROJECT TITLE: "FACIAL RECOGNITION USING CONVOLUTIONAL NEURAL NETWORKS & IMPLEMENTATION OF SMART GLASSES"

Submitted by (Batch no : B5 & Section : B)

Sl. No	Name	USN	Email-id
1	Veeresh Y	3VC22EC116	veereshy2507@gmail.com
2	B R Mahidhar	3VC22EC011	mahidarbr@gmail.com
3	Nagaveni Y	3VC22EC123	gbasava908@gmail.com
4	Srujana	3VC22EC099	srujanar385@gmail.com

Mr. Srikanth N
Project Guide

Dr Prabhavathi S
Project Co-ordinator

Dr Prabhavathi S
HOD

CONTENTS

INTRODUCTION

- **Facial recognition is one of the most emerging and much used application of image processing , because of vast usage of biometric system during past years.**
- **Biometric based techniques are emerged to be the replacement of recognizing individual instead of using Passwords, Keys, Pins, Cards, etc.**
- **Facial recognition is a technique used for verification or identification of a person's identity based on the facial features.**
- **Recognition has been done in the past with different techniques given as:**
  1. Gabor wavelet based solutions.
  2.Facial descriptor-based methods.
  3. Eigen face-based methods.

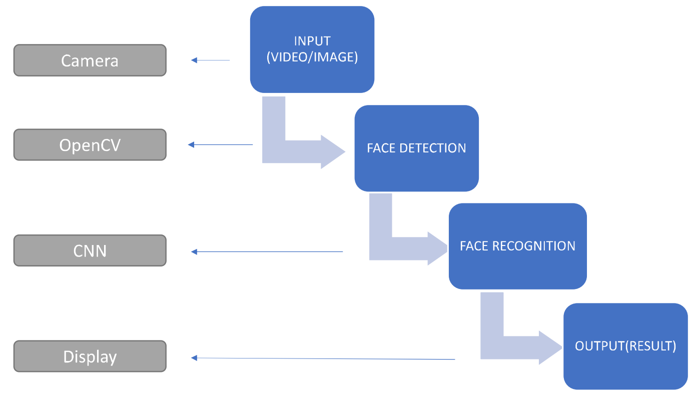
OVERVIEW

- **The project is about facial recognition using CNNs, designed for smart glasses hardware.**
- **It enables real-time identification of people through wearable technology, providing hands-free use and quick feedback.**
- **Main steps include image capture, pre-processing, CNN-based training and recognition, and displaying user data on the glasses.**
- **A Raspberry Pi 3B is used to run the models and manage input/output operations.**
- **Each part of the system works independently, helping the process run smoothly and respond quickly to new data.**
- **Benefits are security, attendance convenience, banking and more.**

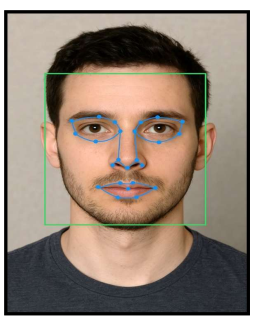
MECHANISM

- **The system starts by taking an Image as the initial input.**
- **Face Detection then isolates the faces within the input, often utilising the OpenCV classifier.**
- **The detected face is processed by a CNN model to learn its unique characteristics.**
- **The system performs Face Recognition by matching the learned face characteristics to a known database.**
- **Finally, the system produces the Output (Result), which is the confirmed identity or status.**

BLOCK DIAGRAM



FACE DETECTION & VERIFICATION



- **The extracted facial landmarks are converted into numerical data.**
- **The CNN model analyses these features to extract deeper facial representations.**
- **The system compares these features with stored image data in the database.**
- **If the similarity score is above the threshold, the face is recognised as a registered image.**
- **If no match is found, the face is labeled as "Unknown" and not recorded.**

EXPECTED OUTCOME

- **To automatically detect and recognise student faces using a camera and mark attendance without manual input.**
- **CNN model will accurately differentiate between registered and unregistered faces.**
- **The data will be stored securely in a database and can be viewed later by administrators.**
- **To develop a user-friendly interface to display recognised faces and confirmation messages in real time.**

RESOURCES USED

- **Tools (Components/Hardware)**
  - **Raspberry Pi 3B+**
  - **Camera module**
  - **Wifi module**
  - **LCD Display**
- **Resources (Algorithms/Models)**
  - **Convolutional Neural Networks (CNN)**
  - **OpenCV**

THANK YOU

Phase 1 Presentation

Project exhibition photo with guide

VISION OF THE DEPARTMENT

To Produce Professionally Excellent, Knowledgeable, Globally Competitive and Socially Responsible Electronics and Communication Engineers and Entrepreneurs.

MISSION OF THE DEPARTMENT

M1	To provide Quality Education in Electronics and Communication Engineering.
M2	To establish a Continuous Industry-Institute Interaction, Participation and Collaboration to Contribute Skilled Electronics and Communication Engineers.
M3	To develop Human Values, Social Values, Entrepreneurship Skills and Professional Ethics among the Technocrats.
M4	To focus on Innovation and Development of Technologies by Engaging in Electronics and Communication Research areas.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1	Graduates of Electronics & Communication Engineering course will have Successful Professional Career.
PEO2	Graduates of Electronics & Communication Engineering course will pursue Higher Education or to become an Entrepreneur
PEO3	Graduates of Electronics & Communication Engineering course will have ability for Lifelong Learning and to Serve the Society.

PROGRAM SPECIFIC OBJECTIVES (PSOs)

PSO1	Ability to Design, Develop and Test the Electronics Circuits & Communication Systems.
PSO2	Ability to Develop Excellent Programming and Problem Solving skills in the field of Embedded Systems.

Criteria-1 I/C

HOD ECE

RAO BAHADUR Y. MAHABALESWARAPPA ENGINEERING COLLEGE, BALLARI
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

PROGRAM OUTCOMES (POs)

PO 1	Engineering Knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	Problem Analysis	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	Design/ Development of Solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4	Conduct investigations of complex problems	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO 6	The engineer and society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	Environment and sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	Project management and finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	Life-long learning	Recognize the need for, and have the preparation and ability to engage in Independent and life-long learning in the broadest context of technological change.

PROGRAM OUTCOMES (PO)

PO 1	**Engineering Knowlcdp°e**	Apply the knolvledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering Problems.
FO 2	**Problem** Analysis	Identify, formulate, review rescai'ch literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering? sciences.
no s	n D:vn ment of Solutions	Design solutions for complex engineerins rCıb1em.s and design system components or processes that meet the specified nceds with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4	Conduct invcstip•ations of complex problems	Use research-based know1edp•e and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineer ng activities with an understandlng of the limitations.
PO 6	**The engineer** and society	Apply reasoning informed by the contextual knowledge to assess societal, heal SflbC ty, legal and cultural isbites and the consequent responsibilities relevant to the professional engineerin ii'actice.
PO 7	Environment and sustainability	Understand the impacl ti f the profcssional enginecring solutions in societal and env'ii onnicntal contexts, and demonstrate the knowledgc of, and tuck for sustainable development.
PO8	Ethics	Apply ethical princ-iples anal commit to professional ethics and responsibilities and norms off the engineering practice.
PO 9	Individual and team work	Function eflfictively as an individual, and as a member or leadei in diverse teams, and in inu1tidisciplinai'y settings.
PO 10	Communication	Communicate eI'fectively on complex enginecrinp• activities with the engineering community and with. society at large, such as, being able to comprehend and Wflte effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance**	Demonstrate knowledge and understanding of the engineering and management principles anti apply these to one's own work, as a member and leader in a tcan, to manage projects send in multidisciplinary envii onments.
PO 12	Life-lonp• **lcarninp•**	Recognize the need for, and have the preparation and ability to engage in Independent and life-long learning in the broadest context of technological change.

COURSE OUTCOMES (CO's) Of PROJECT TITLED:

____

CO	PROJECT OUTCOMES
C413.1	Identify and Analyze Problem through Literature Survey in the Field of Engineering and Technology.
C413.2	Design and Develop Prototype for Identified Problem using Modern Tools.
C413.3	Analyze, Interpret Data to Asses Social, Health & Safety Issues to Provide Valid Conclusion.
C413.4	Develop Communication, Documentation, Presentation Skills and Demonstrate it as a Team.
C413.5	Apply for Project Funding, Project Exhibition, Paper Presentation/Publications for lifelong learning

CO-PO/PSO MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
413.1	2	2					3							
413.2			3		3							3	3	3
413.3				3		3							3	
413.4							3	3	3	3	3	3		
413.5								2	2	2	2	3		
AVG	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**2.5**	**2.5**	**2.5**	**2.5**	**3**	**3**	**3**

JUSTIFICATION OF CO-PO Mapping:

CO	PO	BTL	Mapping	Justification	Action Verbs
413.1	PO1	L2, L4	2	Apply the knowledge of science & engineering to provide solutions for complex engineering	Identify Analyze
	PO2		2	Identify & formulate research problem through literature survey	
413.2	PO3	L5	3	Design solutions for complex engineering problems & develop the prototype	
	PO5		3	Apply appropriate techniques & modern tools for modeling identified problem	Design Develop
	PO12		3	Able to engage in independent & life long	
	PSO1		3	Able to design, develop their prototype model	
	PSO2		3	Develop programming & problem solving skills in field of chosen domain	
413.3	PO4	L3, L4, L6	3	Able to analysis & interpret the data to provide valid conclusions.	Analyze Interpret Assess
	PO6		3	Apply the knowledge to assess social, health & safety issues during development of prototype	
	PSO1		3	Able to design, develop their prototype model	
413.4	PO8	L3, L5	3	Apply ethical principles in identifying & implementation of the problem.	Develop Demonstrate
	PO9		3	Function effectively as an individual & as a team	
	PO10		3	Communicate effectively, write effective reports & give effective presentation.	
	PO11		3	Applying management principles, manage projects in multidisciplinary environments and effectively utilize the budget	
	PO12		3	Able to engage in independent & life long	
413.5	PO8	L4	2	Apply ethical principles in identifying & implementation of the problem.	Analyzing
	PO9		2	Function effectively as an individual & as a team	
	PO10		2	Communicate effectively, write effective reports & give effective presentation.	
	PO11		2	Applying management principles, manage projects in multidisciplinary environments and effectively utilize the budget	

Guide Signature Coordinator Signature

Course Exit Survey

Sl No	USN	Student name	CO413.1	CO413.2	CO413.3	CO413.4
1	3VC22EC095	B R MAHIDAR	5	5	5	5
2	3VC22EC119	VEERESH Y	5	5	5	5
3	3VC22EC063	NAGAVENI Y	5	5	5	5
4	3VC22EC089	SRUJANA	5	5	5	5

Course Exit Survey Guidelines: Excellent – 5, Very Good – 4, Good–3, Average –2, Below Average – 1

Name : B R Mahidar USN : 3VC22EC011 Email id:brmahidar@gmail.com Mobile No: 9880907897	
Name: Veeresh Y USN: 3VC22EC116 Email id: veereshy2507@gmail.com Mobile No: 9019796898	
Name: Nagaveni Y USN: 3VC22EC123 Email id: gbasava908@gmail.com Mobile No: 8123282900	
Name: Srujana USN: 3VC22EC099 Email id: srujanar385@gmail.com Mobile No: 8660675903