AI-Based Home Security Surveillance System

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ABSTRACT- The rising security threats in smart home environments highlight the need for intelligent, automated protection systems, and this project introduces an AI-driven Home Security Surveillance System that integrates IoT sensors with machine learning models to deliver real-time monitoring and threat detection. Using technologies such as Python, OpenCV, Arduino, and GSM modules, the system incorporates facial recognition, gas and fire sensors, LDRs, and surveillance cameras to detect intrusions and immediately alert homeowners. Algorithms like Haar Cascade, LightGBM, and XGBoost enable accurate face detection and efficient intrusion classification, while features such as live video streaming, face database matching, SMS notifications, and remote control enhance usability and responsiveness. Built on a layered architecture that supports authentication, data logging, and intelligent decision-making, the platform offers a scalable, low-cost, and energy-efficient security solution that advances traditional home surveillance through automation, anomaly detection, and user-specific insights.

KEYWORDS- Computer Vision Architecture, Deep Learning Detection Mechanism, Automated Threat Recognition Models, Secure Data Encryption Protocols, Decentralised Surveillance Network Systems, Real-Time Intrusion Monitoring and Alert Processing.

I. INTRODUCTION

The "AI-Based Home Security Surveillance System" is an advanced security platform that integrates artificial intelligence, IoT technologies, and real-time monitoring to strengthen home protection. It enhances traditional surveillance by combining smart sensors, facial recognition, and machine learning to detect intrusions accurately with minimal human involvement. Utilizing a live camera feed and Python-based facial recognition through OpenCV and the Haar Cascade algorithm, the system identifies authorized users and flags unfamiliar faces. Whenever a potential threat is detected, it immediately notifies the homeowner via GSM-based SMS and call alerts, ensuring rapid awareness and response. Machine learning models such as LightGBM and XGBoost further improve intrusion classification and significantly reduce false alarms. A centralized control interface manages user authentication, facial image storage, and alert configurations, while a finite-state logic structure supports reliable decision-making and event tracking. The system also offers remote monitoring capabilities and a modular design, allowing future upgrades like cloud storage or predictive AI for enhanced security and adaptability.

II .RELATED WORK

The paper titled *"Design of an Intrusion Detection Model for IoT-Enabled Smart Home"* (2023) [1] by Deepti Rani and colleagues presents a specialized intrusion detection system for smart homes using IoT devices. The authors apply machine learning methods to monitor network activity and identify unusual behavior. Their study compares different classifiers to determine which provides the best accuracy and lowest false alarm rate. The results show that the proposed model performs effectively in detecting threats in real time. The work underscores the importance of secure IoT networks in modern smart homes. It demonstrates how combining IoT sensors with machine learning strengthens overall system security. The research ultimately offers a strong framework for defending smart homes against cyberattacks.

In the paper *"Proposed LGB-IDS Intrusion Detection Model"* (2020) [2] S.H. Twe, Y.M. Thant, and M.M.S. Thwin present an intrusion detection system built using Light Gradient Boosting. Their model applies machine learning to detect network security threats quickly and effectively. The authors show that LGB-IDS outperforms many traditional methods in both accuracy and processing speed. The study's findings are particularly relevant to AI-driven home security solutions, as they demonstrate how gradient boosting techniques can enhance intrusion detection within IoT-based environments

The paper *"Real-Time Automation System Using Arduino"* (2022) [3] by S. Aravindhu, N. Siddarth, N. Manjula, and K. Rogan presents an automation setup that uses Arduino-based hardware with various sensors to perform real-time monitoring and control. Their system is designed to track environmental conditions and collect data efficiently, enabling quick responses to changing situations. With components such as fire and gas sensors, the setup can detect hazards and trigger immediate action. This study is useful for understanding smart home security applications, as it illustrates how Arduino platforms can support continuous monitoring and reliable system automation.

Jogdand, S. and Karanjkar, M. introduces an automated door access system based on facial recognition. The system uses cameras and facial recognition algorithms to verify users, ensuring secure and convenient access management. Machine

The paper *"Implementation of Automated Door Accessing System with Face Design and Recognition"* (2015) [4] by learning techniques, including the Haar Cascade algorithm, are employed to achieve accurate and reliable face detection. This research is particularly relevant to AI-driven home security systems, as it demonstrates how facial recognition can be effectively integrated for secure access control in smart homes.

The paper *"IoT-Based Monitoring and Control System for Home Automation"* (2015) [5] by D. Pavithra and R. Balakrishnan presents a home automation system using IoT connectivity. It combines sensors for environmental monitoring with actuators to control appliances efficiently. The system provides real-time alerts to enhance security and automation. This study is relevant to AI-based surveillance, showing how IoT sensors can support comprehensive home monitoring.

The paper *"Android-Based Home Automation System Using Bluetooth and Voice Command"* (2016) [6] by B. Pandya, M. Mehat, and N. Jain presents a home automation system controlled through an Android app using Bluetooth and voice commands. It enables users to manage appliances and monitor security remotely. The study emphasizes the convenience of mobile-based control. This approach is relevant to AI-driven surveillance systems, as it supports user-friendly interfaces for efficient home security management.

The paper *"Smart Home Automation System Using Ethernet Technology"* (2017) [7] by Prity N. Adhagale and R.J. Magar presents a smart home system using Ethernet connectivity. It integrates sensors and actuators to monitor and control home environments, promoting energy efficiency and security. The study highlights the scalability and reliability of Ethernet-based solutions. These features are relevant to AI-based surveillance systems, providing robust network communication for smart homes.

The paper *"Smart Home Automation Using IoT"* (2016) [8] by Dhakad Kunal, Dhake Tushar, Undegaonkar Pooja, Zope Vaibhav, and Vinay Lodha presents a smart home system based on IoT. It uses sensors for environmental monitoring and actuators for automation, enhancing both security and convenience. The study highlights how IoT enables seamless connectivity and real-time monitoring. These features are essential for AI-based home surveillance systems, supporting efficient and responsive home security.

The paper *"Smart Home-Control and Monitoring System Using Smart Phone"* (2013) [9] by Rajeev Piyare and Seong Ro Lee presents a smartphone-based system for monitoring and controlling smart homes. Using IoT connectivity, it allows remote access to home devices and security alerts. The study emphasizes the importance of mobile interfaces for user interaction. This approach is relevant to AI-based surveillance systems, providing homeowners with convenient and accessible control.

The paper *"Home Appliance Controlling Using Zigbee on ATMEGA128 Hardware Platform"* (2014) [10] by Manish Kumar and Ramandeep Singh presents a home automation system using Zigbee communication on the ATMEGA128 platform. It allows wireless control of appliances and monitoring of environmental conditions. The study highlights the effectiveness of wireless communication for smart home management. This work is relevant to AI-based surveillance systems, demonstrating efficient remote

The paper *"Implementing Smart Homes with Open Source Solutions*" [11], Hsien Tang Lin (2013) explores how platforms like Arduino and Raspberry Pi can be used to create low-cost, flexible, and scalable smart home systems. The study shows that open-source technologies support customizable automation and security features, making them suitable for AI-based surveillance solutions. Lin emphasizes the benefits of modular hardware, easy integration of new sensors or AI modules, and greater user control and transparency. Overall, the research highlights the value of open-source ecosystems in building affordable and innovative smart home security systemsmonitoring and control.

the paper "*An Embedded Platform for Image Capture Within an Embedded System Using a Laptop Arduino Board*" [12], K. Gopalakrishnan and V. Sathish Kumar present an embedded framework for capturing images using a Laptop Arduino board and evaluate its ability to handle basic image recognition and continuous data flow. Their work demonstrates the feasibility of using compact, low-cost hardware for real-time visual processing, making it relevant to AI-based surveillance systems. The study highlights the importance of efficient data handling in continuous imaging tasks and shows that such embedded platforms can support on-device analysis and potentially integrate with advanced AI models for improved threat detection in resource-limited environments.

III PROBLEM STATEMENT

Despite the growing need for effective home security due to rising cyber and physical threats, many IoT-enabled smart homes remain vulnerable because current surveillance systems are fragmented, inefficient, and lack intelligence. Homeowners and security personnel often struggle with real-time monitoring, threat detection, and automated response, as traditional setups rely heavily on manual supervision, leading to delayed alerts, false alarms, and poor coordination between devices. Existing systems rarely leverage artificial intelligence to predict or respond to evolving threat patterns, and disconnected sensors, cameras, and communication modules further limit actionable insights. Energy inefficiency, absence of anomaly detection, inadequate logging of security events, and restricted remote monitoring reduce operational effectiveness and adaptability. Homeowners are often forced to manage multiple platforms, complicating surveillance and weakening protection. These gaps underscore the need for integrated, AI-driven home security solutions that combine real-time monitoring, intelligent decision-making, remote control, and predictive threat analysis to ensure proactive, reliable, and efficient protection in modern smart homes.

A. Objectives of the Proposed System

The following are the Objectives of the proposed project, each of which is aimed at addressing the current challenges and the existing gaps in the AI-Based Home Security Surveillance System.

- **To strengthen Smart Home Safety through Advanced Monitoring:** The proposed AI-driven home security surveillance system aims to provide instant threat detection, timely alerts, and continuous automated monitoring, helping homeowners safeguard their properties more effectively. This enhancement reduces security risks, minimizes dependence on traditional surveillance methods, and ensures uninterrupted protection even when residents are away. By learning household patterns over time, the system becomes increasingly accurate, intelligently identifying unusual activities with improved precision.

- **Enhance Accessibility for Users and Security Systems:** The system enhances user accessibility and overall security by integrating AI algorithms—such as Haar Cascade for facial recognition and LGBM for intrusion detection—along with IoT connectivity to streamline monitoring. This combination allows users to easily access real-time surveillance data while minimizing operational complexity, ensuring a smoother, more efficient security experience.

- **Streamline Surveillance Processes:** AI analyzes both environmental and intrusion-related data to identify potential threats, while IoT integration supports real-time monitoring and communication. Together, they enable a more structured and automated response to security incidents, ensuring faster and more coordinated protection.

- **Promote Safety and System Efficiency :**AI-driven threat optimization helps reduce false alarms by accurately distinguishing real risks from normal activity, while IoT connectivity provides consistent, real-time monitoring. Combined, these technologies strengthen home safety and boost operational efficiency within smart home environments.

IV. METHODOLOGY

The system collects sensor and camera data, processes it for accuracy, and uses AI for facial recognition, object detection, and intrusion detection, sending real-time alerts, triggering automated actions, and continuously improving performance.

1. Requirement Analysis & System Design: The project identified stakeholders and defined roles, then built a modular system with IoT sensors, AI threat detection, and user interfaces—using UML and state models to map out workflows like motion detection and face recognition, providing a scalable development foundation.

2. Data Collection: Synthetic datasets were generated to simulate smart home scenarios, capturing events like motion detection, facial recognition, alerts, and related details such as type, severity, and location. They also included user roles, device associations, and facial data, supporting AI training and system validation.

3.Frontend Development: The frontend, built with React.js, offers a responsive interface with live feeds, alerts, system settings, and secure, user-friendly controls for homeowners and security staff.

4. Backend Development: The backend, built with Node.js and Express.js, provides a robust RESTful API for authentication, sensor data processing, and alerts, with MongoDB managing user profiles, event logs, and device configurations. Flask was optionally used to run AI models for real-time threat analysis.

5. Data Processing & Logic Layer:A Finite State Machine (FSM) managed surveillance events, moving through states like Motion Detected, Face Analyzed, Threat Confirmed, and Alert Sent. Face detection was handled using the Haar Cascade algorithm, facial recognition with LBP, and intrusion detection with LGBM analyzing sensor data. This logic layer ensured precise and context-aware threat detection.

6. Admin Management Logic : Administrators managed IoT devices, user roles, and system settings like motion sensitivity and alert thresholds, while the FSM tracked event states and admins verified AI-flagged threats, updating statuses to ensure reliable operation.

7. Tracking & Analytics: Administrators could manage IoT devices, user access, and system settings, including roles and alert thresholds. The FSM ensured consistent tracking of surveillance events. They also validated AI-detected threats and updated event statuses to maintain reliable system operation.

8. Testing & Validation : The system was rigorously tested through unit and integration tests, focusing on sensor and AI accuracy, alert response, and usability, with user feedback used to optimize performance.

V. SYSTEM DESIGN

Figure 1 presents the system architecture of the proposed AI-Based Home Security Surveillance System. The figure presents a face recognition system architecture detailing the steps from an Input Image through Pre-Processing, Features Extraction (including Eigenfaces and PCA), Classification, and a Decision Algorithm to output the Identified Person.

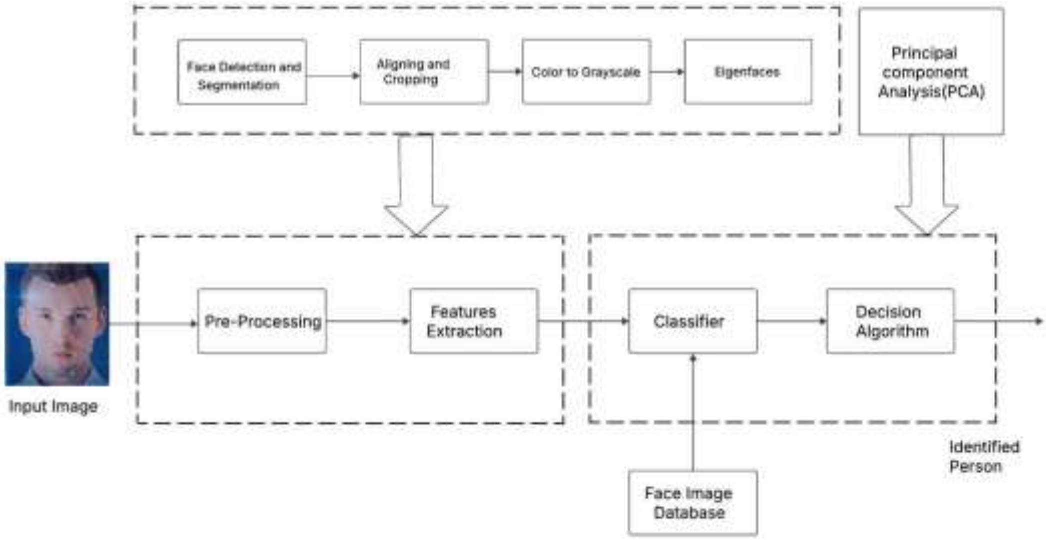

Figure 1: System Architecture of AI-Based Home Security Surveillance System

• **Face Detection and Segmentation:** Face detection is a modern computational technique used to locate and identify human faces in digital images, and it also describes the natural human ability to notice and focus on faces in a visual scene. In image segmentation, an image is divided into groups of pixels based on similarities such as color, depth, or texture, allowing the region of interest (ROI) to be isolated and helping to clearly identify and distinguish objects or boundaries within the image.

• **Aligning and Cropping:** Face alignment is a computer vision technique used to determine the geometric structure of a face in an image by automatically identifying key features such as the eyes and nose once the face's position is detected. Cropping refers to trimming unwanted parts of an image to retain only the necessary section, and the cropped result can also be used as a background or for social media purposes.

• **Color to Grayscale:** A grayscale (or gray-level) image is one in which the only colors are shades of gray. The primary reason for distinguishing such images from other color images is that less data needs to be processed for each pixel.

• **Eigen Faces**: An eigenface refers to a set of eigenvectors used in computer vision for recognizing human faces. It is based on Principal Component Analysis (PCA), an unsupervised dimensionality-reduction method that transforms high-dimensional image data into a simpler, more manageable representation.

• **Pre-Processing:** The images are analyzed using the proposed algorithm, and pre-processing is performed as the first stage of the face recognition system. A new pre-processing approach is introduced to enhance face recognition performance under uncontrolled and challenging lighting conditions.

• **Classifier:** Face recognition performance is assessed using multiple PCA-based classification techniques, where three distance measures—Euclidean distance, squared Euclidean distance, and city block (Manhattan) distance—are employed to compute the recognition scores and compare the similarity between facial feature vectors.

• **Face Image Database**: Face databases are image datasets used for testing face processing algorithms. In the context of biometrics, face databases are collected and utilized to assess the performance of face recognition biometric systems.

• **Principal Component Analysis (PCA):** Principal Component Analysis (PCA) is a dimensionality reduction technique often used to decrease the dimensionality of large datasets. It transforms a large set of variables into a smaller one that still retains most of the important information.

• **Decision Algorithm:** The decision algorithm belongs to the family of supervised learning algorithms. The goal of using a decision tree is to create a training model that can predict the class or value of the target variable by learning simple decision rules inferred from previous data (training data).

A. Algorithms Used

• **Haar Cascade Classifier :** The Haar Cascade Classifier is a machine learning–based approach used for object and face detection. It uses a set of positive and negative images to train the classifier. The algorithm detects faces by scanning the image at multiple scales and identifying patterns using Haar like features. The detection process follows a cascade structure, where simpler classifiers eliminate unlikely face regions early, improving speed and efficiency.

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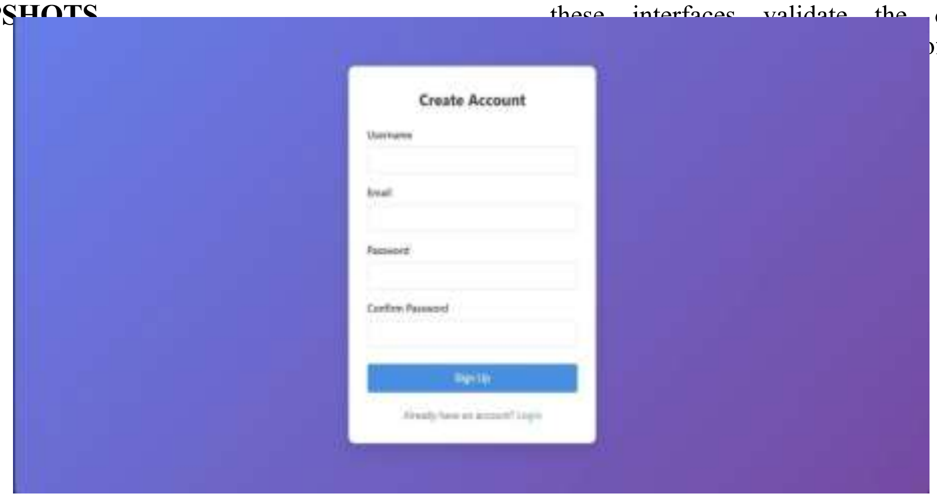
• **AdaBoost Algorithm :** AdaBoost (Adaptive Boosting) is used to improve the performance of the Haar Cascade Classifier. It combines multiple weak classifiers into one strong classifier by focusing on the misclassified instances in each iteration. In the context of face detection, AdaBoost selects the most important features from a large set and builds a strong classifier, making the detection process more accurate and reliable.

• **Local Binary Patterns (LBP) :** LBP is a texture-based feature extraction technique used for face recognition. It works by comparing each pixel with its neighboring pixels to generate a binary pattern, which is then used to describe the texture of the face. LBP is robust to lighting variations and facial expressions, making it highly effective for recognizing faces in varying conditions. It is lightweight and suitable for real-time applications on embedded devices.

VI. SYSTEM IMPLEMENTATION SNAPSHOTS

The following section provides snapshots (Figure 2 to Figure 9) of the developed AI-based Home Security Surveillance System prototype, which demonstrates the essential functional modules supporting intelligent monitoring, secure user interaction, and automated threat detection. Specifically, Figure 2 displays the account creation interface for new user registration, while Figure 3 presents the login page used for authenticated system access. Figure 4 illustrates the system's Home Page, offering centralized navigation to surveillance features and real-time monitoring utilities. Figures 5 and 6 capture the user registration workflow and successful registration confirmation, respectively, highlighting the onboarding process. Figure 7 showcases the automated email notification module responsible for sending security alerts and system updates to registered users. Figure 8 demonstrates the AI-powered face detection interface that identifies individuals and retrieves their names from the trained dataset. Finally, Figure 9 presents the live camera streaming interface, reflecting continuous real-time surveillance of the monitored environment. Collectively, these interfaces validate the operational feasibility, ...of the proposed AI-based ... architectural model.



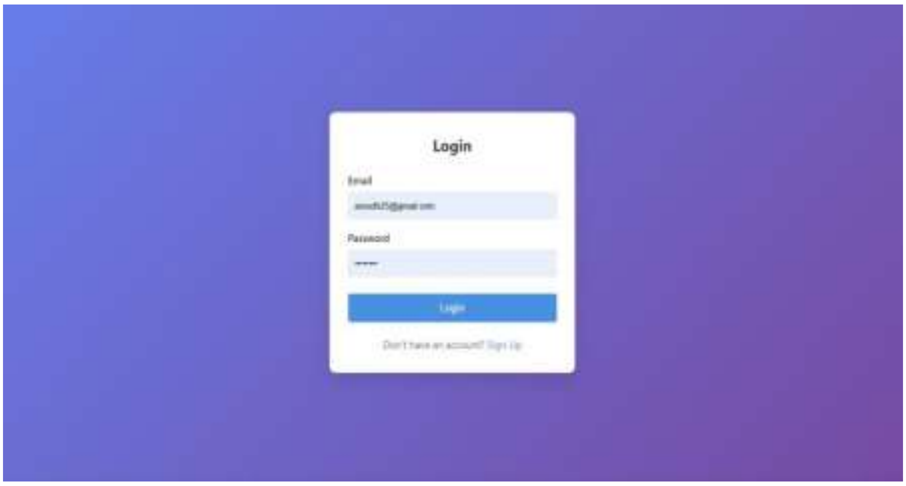


Fig-3: Login Page by user to this application

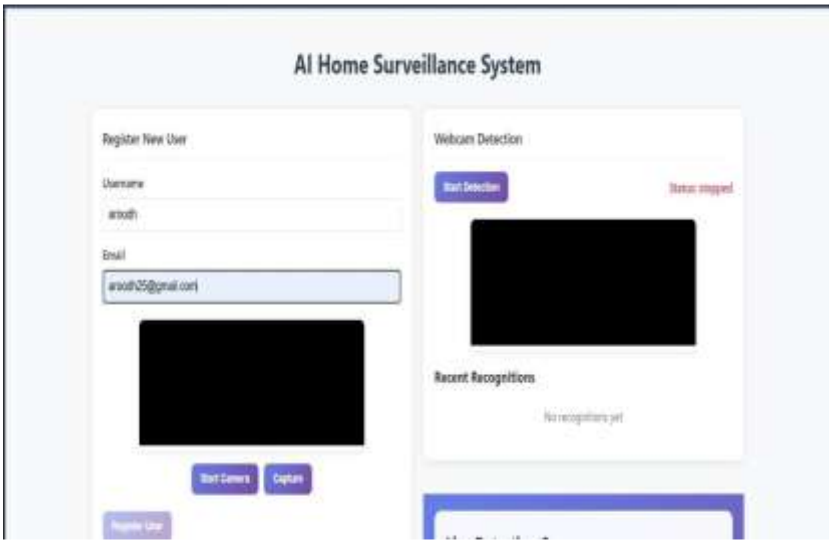


Figure 4: Main Page of AI Home surveillance system application

Figure 5: New User Registration Page to this application

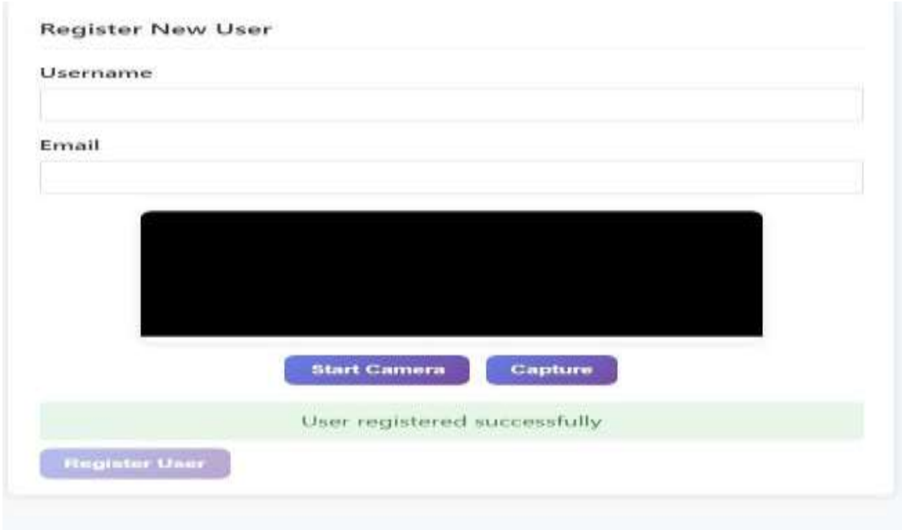


Figure 6: Registration which get successfull

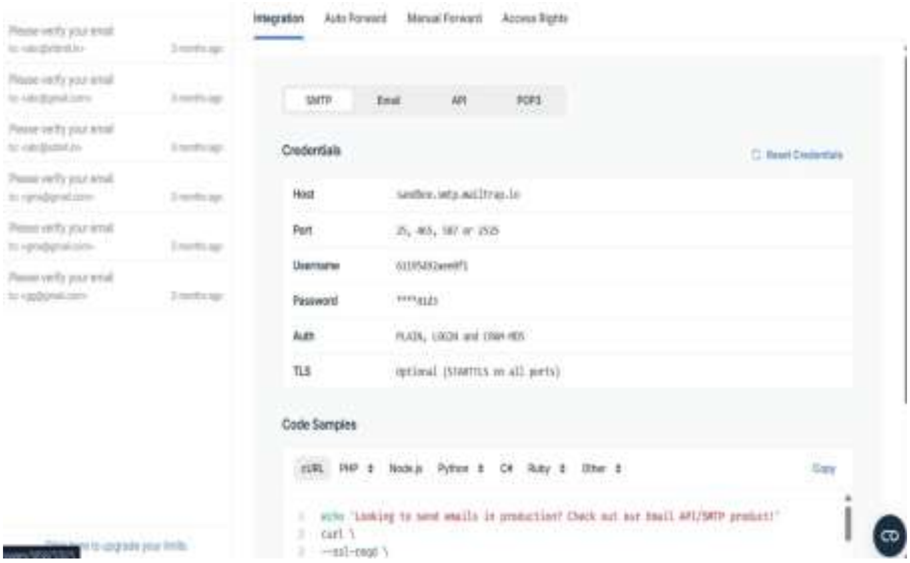


Figure 7: Email Notification to the user after detection

Figure 8: Face detection with registred name

Figure 9: Live Streaming camera

IV. CONCLUSIONS

The AI-Based Home Surveillance System offers a modern, efficient, and intelligent approach to residential security by combining real-time video monitoring with advanced computer vision techniques like Haar Cascade-based face detection and PCA-driven facial recognition. It accurately identifies familiar individuals, alerts homeowners to intruders, and automates continuous monitoring and recording without requiring constant supervision. With its user-friendly interface, reliable performance, and scalable architecture, the system can be easily expanded to include IoT integration, cloud storage, and advanced AI models. Overall, it enhances home safety, streamlines threat response, and provides greater peace of mind in today's smart home environments.

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