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ADVANCED SECURITY SYSTEM UTILIZING ESP32 CAMERA FOR SMART FEATURES

A MINOR PROJECT-III REPORT

Submitted by

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BACHELOR OF ENGINEERING

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

M.KUMARASAMY COLLEGE OF ENGINEERING

(Autonomous)

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BONAFIDE CERTIFICATE

Certified that this **18ECP105L-Minor Project III** report **"ADVANCED SECURITY SYSTEM UTILIZING ESP32 CAMERA FOR SMART FEATURES"** is the bonafide work of **DEEPAN.S(927622BEC028), GIRIVASAN.M.V(927622BEC054),GURUKARTHIKEYAN.M(927622BEC062),HARIRAJAN.M(927622BEC066)** who carried out the project work under my supervision in the academic year **2024-2025 ODD.**

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PROJECT COORDINATOR

INSTITUTION VISION AND MISSION

Vision

To emerge as a leader among the top institutions in the field of technical education.

Mission

M1: Produce smart technocrats with empirical knowledge who can surmount the global challenges.

M2: Create a diverse, fully -engaged, learner -centric campus environment to provide quality education to the students.

M3: Maintain mutually beneficial partnerships with our alumni, industry and professional associations

DEPARTMENT VISION, MISSION, PEO, PO AND PSO

Vision

To empower the Electronics and Communication Engineering students with emerging technologies, professionalism, innovative research and social responsibility.

Mission

M1: Attain the academic excellence through innovative teaching learning process, research areas & laboratories and Consultancy projects.

M2: Inculcate the students in problem solving and lifelong learning ability.

M3: Provide entrepreneurial skills and leadership qualities.

M4: Render the technical knowledge and skills of faculty members.

Program Educational Objectives

PEO1: **Core Competence:** Graduates will have a successful career in academia or industry associated with Electronics and Communication Engineering

PEO2: **Professionalism:** Graduates will provide feasible solutions for the challenging problems through comprehensive research and innovation in the allied areas of Electronics and Communication Engineering.

PEO3: **Lifelong Learning:** Graduates will contribute to the social needs through lifelong learning, practicing professional ethics and leadership quality

Program Outcomes

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 Specific Outcomes

PSO1: Applying knowledge in various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of Engineering application.

PSO2: Able to solve complex problems in Electronics and Communication Engineering with analytical and managerial skills either independently or in team using latest hardware and software tools to fulfil the industrial expectations.

Abstract	**Matching with POs,PSOs**
ESP32-CAM, Real-time video monitoring, Se-cure data transmission, IoT integration.	**PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2**

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We would like to thank our **Minor Project Co-ordinator**, **Mrs.D.PUSHPALATHA, M.E., Assistant Professor**, Department of Electronics and Communication Engineering for her kind cooperation and culminating in the successful completion of this project work. We are glad to thank all **the Faculty Members** of the **Department of Electronics and Communication Engineering** for extending a warm helping hand and valuable suggestions throughout the project. Words are boundless to thank our Parents and Friends for their motivation to complete this project successfully.

ABSTRACT

This paper introduces an advanced smart security system designed for bike and home locks, utilizing the ESP32- CAM WiFi Bluetooth Development Board with OV2640 Camera Module. The system combines real-time video monitoring, motion detection, and face recognition to enhance traditional locking mechanisms with smart features. Leveraging the ESP32-CAM's WiFi and Bluetooth connectivity, the solution enables remote access, real-time alerts, and secure unlocking via authorized facial identification or mobile app controls. The OV2640 camera mod- ule ensures high-quality image capture for reliable recognition, while the system's compact and energy-efficient design makes it ideal for portable and stationary security applications. This IoT-enabled approach redefines lock systems, offering enhanced security, convenience, and scalability for personal and residential use.

Keywords - ESP32-CAM, Real-time video monitoring, Secure data transmission, IoT integration.

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LIST OF ABBREVIATIONS

ACRONYM		ABBREVIATION
ESP32	-	Espressif Systems Chip 32
MQTT	-	Message Queuing Telemetry Transport
IoT	-	Internet of Things
AES	-	Advanced Encryption Standard
SSL	-	Secure Sockets Layer

CHAPTER 1

INTRODUCTION

1.1 Objective

The main objective of the Advanced Security System utilizing the ESP32-CAM for Smart Features is to create an affordable, efficient, and scalable smart security solution that enhances safety through real-time video surveillance, motion detection, facial recognition, and cloud storage. The system aims to provide a seamless integration of these advanced features into a single platform, enabling remote monitoring and automation for homes and businesses.

By leveraging the ESP32-CAM module, the project seeks to deliver a cost-effective and user-friendly solution that improves security, facilitates access control, and integrates easily with smart home automation systems, ensuring real-time alerts, convenient remote access, and secure data storage.

1.2 Importance

The importance of the Advanced Security System utilizing the ESP32-CAM for Smart Features lies in its ability to significantly enhance security, convenience, and cost-efficiency in both residential and commercial environments[2]. Key points of importance include:

1.2.1 Enhanced Security:

- The system improves the safety of homes and businesses by providing real-time surveillance, motion detection, and facial recognition, making it easier to monitor premises and detect unauthorized activities or intruders.

1.2.2 Cost-Effectiveness:

- By using the ESP32-CAM, an affordable and powerful module, this system offers a low-cost alternative to traditional, expensive security solutions, making it accessible for a wide range of users, from homeowners to small businesses.

1.2.3 Remote Monitoring and Control:

- The system enables users to remotely monitor their property via smartphones or PCs, ensuring they can keep an eye on their premises even when they are not physically present. This flexibility adds an extra layer of security and peace of mind.

CHAPTER 2

LITERATURE SURVEY

2.1 Paper: "Privacy Concerns and Security in IoT Surveillance Systems"
Key Findings: This paper highlights privacy and security issues in surveillance systems based on devices like the ESP32-CAM. The study examines potential vulnerabilities, such as unauthorized access to live feeds, data interception, and privacy violations, and proposes strategies like encryption, secure Wi-Fi networks, and user authentication. Many existing works focus on incorporating features like motion detection, video streaming, and face recognition into surveillance systems. For instance, algorithms for motion detection often rely on frame difference techniques or back- ground subtraction to identify suspicious activity.
Technologies: AES encryption, SSL/TLS, MQTT over TLS, two-factor authentication.

2.2 Paper: "Privacy Concerns and Security in IoT Surveillance Systems"
Key Findings: This paper highlights privacy and security issues in surveillance systems based on devices like the ESP32-CAM. The study examines potential vulnerabilities, such as unauthorized access to live feeds, data interception, and privacy violations, and proposes strategies like encryption, secure Wi-Fi networks, and user authentication. The development of smart security systems has gained significant attention in recent years, driven by advancements in IoT, artificial intelligence, and embedded systems. Several studies have explored the integration of IoT devices for real- time surveillance.
Technologies: AES encryption, SSL/TLS, MQTT over TLS, two-factor authentication**.**

CHAPTER 3

EXISTING SYSTEM`

3.1 ESP32-CAM Facial Recognition System

Overview: This project leverages the ESP32-CAM for facial recognition as part of an advanced security system for access control. The system uses pre-trained models to recognize authorized faces and unlock doors or grant access to certain areas. Unauthorized faces can trigger alarms or send alerts to the user. Pre-trained models (such as Haar cascades or deep learning models) are used to detect and recognize faces from a database of known faces. If a match is found, the system grants access or triggers a specific action. The system is typically used for access control in secure areas like homes, offices, or restricted zones. If the face recognized matches an authorized entry, the system can trigger actions like unlocking doors or granting entry.

3.2 ESP32-CAM Smart Home Surveillance System

Overview: A smart home security system utilizing the ESP32-CAM to create a comprehensive surveillance network with real-time monitoring, motion detection, and cloud storage. The system integrates with a home automation platform, allowing users to view live streams, receive alerts, and even control other devices (e.g., lights, locks). The system includes motion detection capabilities, which can detect movement in the camera's field of view. When motion is detected, the system triggers an action such as capturing an image, recording a video, or sending an alert. Captured images and videos are stored in the cloud, ensuring that footage is saved securely and can be accessed remotely, even if the local device is compromised.

CHAPTER 4

PROPOSED SYSTEM

The Advanced Security System utilizing the ESP32-CAM is a robust solution designed to provide comprehensive home and office security features through the integration of real-time video surveillance, motion detection, facial recognition, cloud storage, and smart home automation. Powered by the ESP32-CAM module, this system allows users to monitor their premises remotely via live video streams, while motion detection sensors automatically trigger alerts and store footage upon detecting movement. The facial recognition component enhances security by granting or denying access based on a pre-configured database of authorized individuals, making it an ideal tool for access control. The cloud storage integration ensures that all captured footage and event logs are securely stored and easily accessible from anywhere, reducing the risk of data loss in case of device theft. Moreover, the system can be seamlessly integrated with smart home platforms, enabling users to automate actions like turning on lights or unlocking doors based on security events. This combination of advanced features provides an affordable yet highly effective solution for creating a smart, secure environment with minimal hardware requirements.[4]This project leverages the ESP32-CAM for facial recognition as part of an advanced security system for access control. The system uses pre-trained models to recognize authorized faces and unlock doors or grant access to certain areas. Unauthorized faces can trigger alarms or send alerts to the user.

The rapid advancement of technology in the Internet of Things (IoT) and artificial intelligence (AI) has revolutionized security and surveillance systems. Traditional surveillance systems often face limitations in cost, scalability, and advanced features such as intelligent decision-making and remote accessibility. To address these challenges, this paper introduces an advanced security system utilizing the ESP32-CAM module, a compact and cost-effective microcontroller with integrated camera capabilities, Wi-Fi, and Bluetooth connectivity.

The proposed system integrates smart surveillance features, including real-time video streaming, motion detection, and face recognition, making it a versatile solution for residential, commercial, and industrial applications. By leveraging the processing power of the ESP32-CAM, the system ensures efficient image capture, data handling, and secure transmission to cloud or local servers. Its compatibility with IoT ecosystems allows seamless integration with existing smart devices, enabling remote monitoring and control through mobile or web applications.

This project emphasizes energy efficiency and low-cost design, addressing the growing demand for sustainable and affordable security solutions. Optimized image processing algorithms ensure low latency and high performance, while secure data transmission protocols protect sensitive information. The main objective of the Advanced Security System utilizing the ESP32-CAM for Smart Features is to create an affordable, efficient, and scalable smart security solution that enhances safety through real-time video surveillance, motion detection, facial recognition, and cloud storage. The system aims to provide a seamless integration of these advanced features into a single platform, enabling remote monitoring and automation for homes and businesses.

CHAPTER 5

SYSTEM DESIGN

The Advanced Security System utilizing the ESP32-CAM is designed to be a modular, scalable, and flexible solution that incorporates several key features like real-time video surveillance, motion detection, facial recognition, cloud storage, and smart home automation.

5.1 COMPONENTS

A.ESP32-CAM WiFi Bluetooth Development Board withOV2640 Camera Module

The ESP32-CAM serves as the primary processing and surveillance unit. It captures high-quality images and streams real-time video while providing wireless connectivity through WiFi and Bluetooth. The module is equipped to execute smart features such as motion detection and face recognition, forming the core of the security system's intelligence.

Fig.1 ESP32

B.FT232RL USB to TTL 3.3V 5V Serial Adapter Module

This module is essential during the development phase,allowing firmware to be uploaded to the ESP32-CAM and facilitating debugging. It ensures compatibility with both 3.3V and 5V devices, providing a versatile and reliable interface for programming

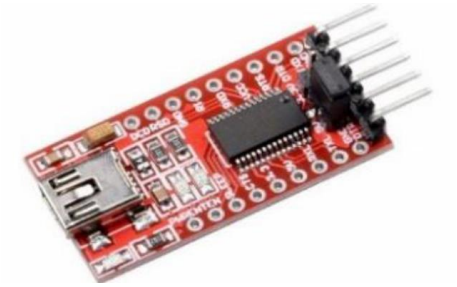

Fig.2 FT232RL

C.12V Electronic Door Lock Assembly Solenoid

The solenoid lock mechanism provides physical security,locking and unlocking doors or bike systems based on user authentication. This component is designed for low power consumption, ensuring energy efficiency, and is activated by signals from the relay module upon user authorization

Fig.3 Solenoid Lock

D.5V Single Channel Relay Module

The relay module acts as a bridge between the low-powerESP32-CAM GPIO outputs and the high-power solenoid lock. It safely switches the 12V power needed to operate the lock, ensuring reliable and secure operation without overloading the ESP32-CAM.

Fig.4 Relay Module

5.2 Block Diagram

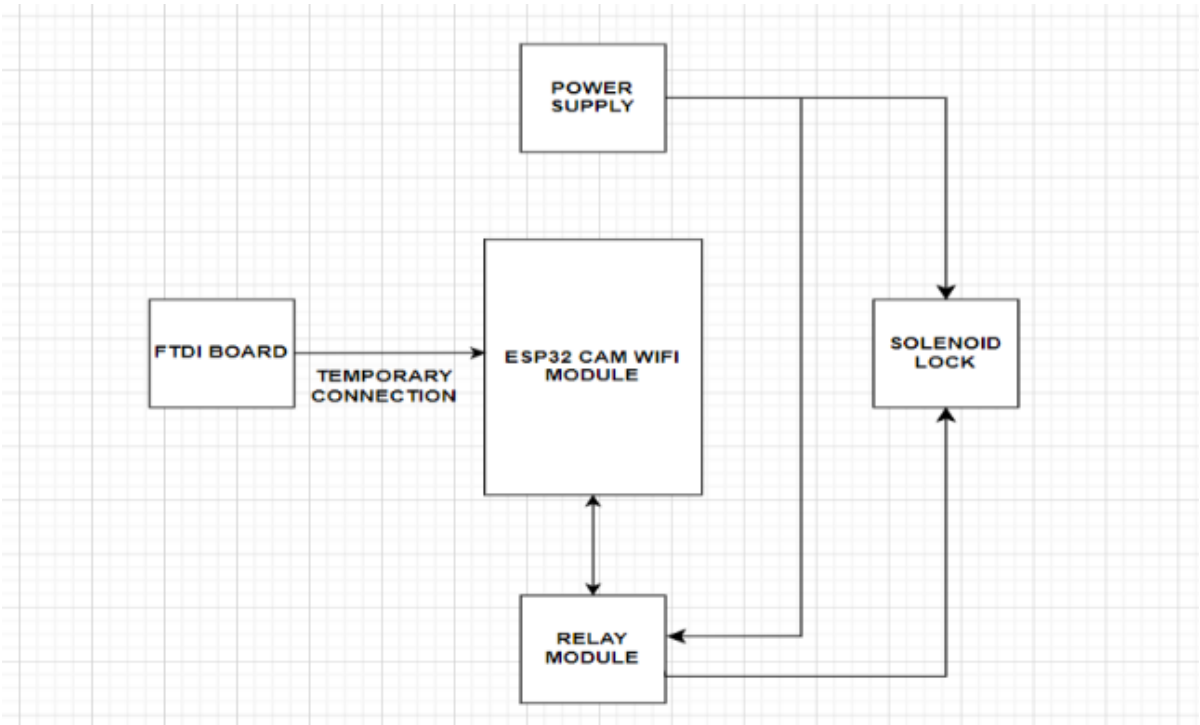

Fig.5 Block Diagram

5.3 Circuit Diagram

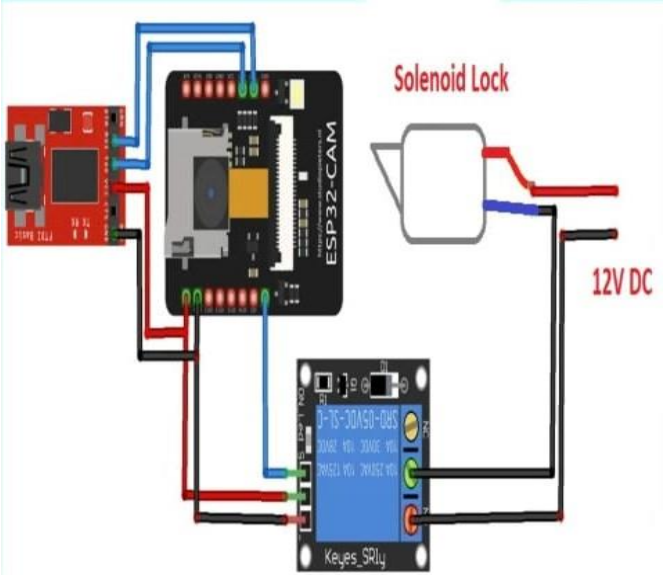

Fig.6 Circuit Diagram

5.4 Prototype

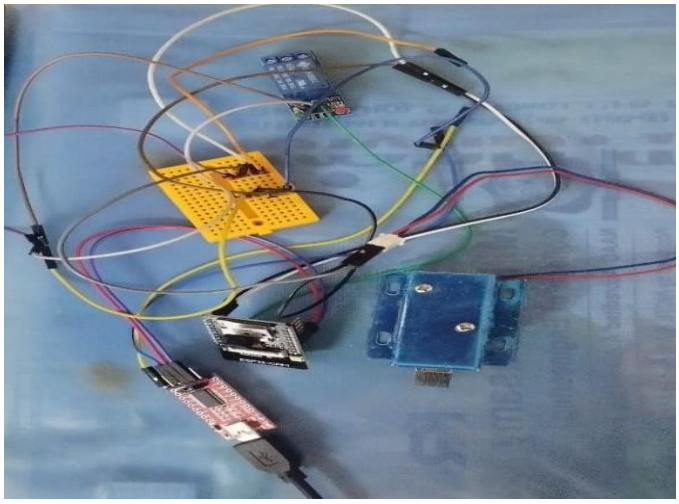

Fig.7 Prototype

CHAPTER 6

RESULT AND DISCUSSION

The Advanced Security System Utilizing ESP32-CAM offers a powerful, affordable, and flexible solution for enhancing security through real-time video surveillance, motion detection, and facial recognition. By leveraging the capabilities of the ESP32-CAM, the system provides an excellent way to monitor and protect homes, businesses, and other sensitive environments. While there are challenges to address, particularly in processing power, network dependency, and environmental factors, the potential benefits of such a system—combined with its ease of integration with existing smart home ecosystems—make it a promising security solution for a wide range of users. With the right optimizations and enhancements, this system can provide both security and peace of mind in an increasingly connected world.

The proposed advanced security system using the ESP32- CAM offers an affordable, efficient, and intelligent surveillance solution. It integrates real-time video streaming, motion detection, face recognition, and instant notifications to address modern security needs for homes and businesses. The system balances cost-effectiveness with advanced features, offering local and cloud storage, offline functionality, and energy-efficient operation, making it ideal for remote or low-power setups. Its scalability supports multiple cameras, while its integration with external devices like alarms and smart locks enhances access control and overall security. By combining affordability, flexibility, and cutting-edge functionality, this project provides a comprehensive, user- friendly, and customizable security solution suitable for a wide range of environments. It bridges the gap between expensive commercial systems and basic DIY setups, paving the way for future smart security innovations.

CHAPTER 7

CONCLUSION

The development of an advanced security system utilizing the ESP32 camera presents a modern, cost-effective solution to meet the increasing demand for smarter surveillance. The ESP32 camera, with its compact design, wireless connectivity, and robust processing capabilities, serves as the backbone of this system, enabling features such as motion detection, real-time video streaming, facial recognition, and remote monitoring.

This innovative approach bridges the gap between traditional security systems and contemporary smart solutions. By incorporating AI-powered features like facial and object recognition, the system not only enhances security but also improves user convenience, enabling automated alerts and seamless integration with mobile or web applications for real-time monitoring.

Additionally, the system's affordability and low power consumption make it accessible to a wide range of users, from homeowners to businesses. The flexibility of the ESP32 platform allows for scalability and customization, paving the way for further enhancements such as IoT integration and cloud-based analytics, which can significantly boost its functionality and adaptability to diverse environments.

In conclusion, the ESP32 camera-based security system is a significant step forward in making smart security accessible, efficient, and reliable. It addresses the challenges of modern security requirements with its advanced features and sets the stage for future innovations in the field.

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