Journal of Electronics and Informatics (ISSN: 2582-3825)
www.irojournals.com/iroei/

Anti-Theft Flooring System using ESP32

Ajmal K[1] , Arun Suresh Muthiyil[2] , Junaidh Haneefa M[3] , Nihal M[4] , Reshmi C S[5]

Jawaharlal college of engineering and technology, India

E-mail: [1]junaidhhaneef.m@gmail.com, [2]arunsuresh3112@gmail.com, [3]ajua62552@gmail.com, [4]nihaalm2001@gmail.com, [5]resmi345@gmail.com

Abstract

The ESP32-powered anti-theft flooring system represents an innovative and cost-effective solution designed to enhance security across various settings, including homes, businesses, and diverse locations. At its core, the system comprises a network of strategically placed pressure sensors concealed beneath a flooring mat, seamlessly integrated with the ESP32 microcontroller featuring built-in Wi-Fi and a camera. When an object exceeding a predetermined weight threshold traverses the mat, the embedded sensors swiftly activate the ESP32, prompting it to capture a photograph of the event. This image is then promptly forwarded to a pre-configured email address, offering real-time visual insights into potential security breaches. Furthermore, the ESP32 can be programmatically configured to activate an audible alarm, providing an additional layer of security and acting as a powerful deterrent. The system's design emphasizes user-friendliness, ease of installation, and adaptability to various environmental needs. Its customization options enable users to tailor the system to specific requirements, ensuring a seamless integration into any given space. Importantly, safety measures have been incorporated to prevent false alarms triggered by smaller entities, as the pressure sensors only respond to objects surpassing a predefined weight. Beyond its primary function of theft prevention, the ESP32 anti-theft flooring system unveils a realm of creative possibilities. Its applications extend to smart home automation, traffic monitoring, and even livestock tracking, showcasing the system's versatility and adaptability in addressing diverse challenges. This multifaceted approach positions the ESP32 system not only as a robust security solution but also as a catalyst for innovation in various technological domains.

DOI: https://doi.org/10.36548/jei.2024.1.004
Received: 07.03.2024, received in revised form: 03.04.2024, accepted: 14.04.2024, published: 29.04.2024

Keywords: ESP32 Microprocessor, AI, Anti-Theft Flooring System, Home Automation.

1. Introduction

In response to the evolving security landscape, the ESP32 anti-theft flooring system emerges as an innovative and budget-friendly solution. This cutting-edge security system integrates discreet pressure sensors beneath common flooring mats, collaborating with the ESP32 microcontroller, equipped with advanced Wi-Fi and a built-in camera [11]. The system’s efficiency lies in its rapid response to potential threats, activating when an object surpasses a predetermined weight threshold [12]. The ESP32 captures a high-resolution photo, sends it to a pre-configured email, and can trigger an audible alarm for added deterrence. Beyond security, the ESP32 system enhances user engagement through advanced Wi-Fi and real-time visual information. Its adaptability extends to setting customization, making it ideal for diverse security scenarios. Cost-effectiveness is a key advantage of utilizing existing flooring infrastructure for seamless integration into residential and commercial spaces. The modular nature of the system positions it as a forward-compatible solution capable of easy updates and expansions to meet emerging security challenges. As a result, the ESP32 anti-theft flooring system represents a durable, budget-friendly, and future-proof investment in the ever-evolving realm of security, aligning with market demands for practical innovation [10].

2. Literature Survey

The realm of anti-theft flooring systems has become a focal point in the evolution of security technologies, with micro-controllers playing a pivotal role in shaping innovative solutions. This literature review delves into the methodologies, technologies, and advancements associated with anti-theft flooring systems, focusing on key microcontrollers such as the ESP32, Raspberry Pi, ESP32-CAM, and Arduino. Each system brings a unique set of features to the table, contributing to the diverse landscape of anti-theft solutions.

Raspberry Pi-based systems harness the computational prowess of single-board computers to efficiently process sensor data and initiate responses. An added feature includes the integration of a camera module for visual documentation. This comprehensive system comprises pressure sensors for weight detection, a Raspberry Pi for data processing, and a camera module for capturing images [1, 2]. Noteworthy for its computational versatility, the system's strength lies in its capability to potentially implement more intricate algorithms [9]. However, it comes with drawbacks such as higher power consumption and a larger footprint when compared to microcontrollers like the ESP32. Despite these limitations, the Raspberry Pi-based approach stands out for its ability to handle diverse sensor data and facilitate more sophisticated processing tasks, presenting a trade-off between computational capabilities and resource efficiency [14].

The ESP32-CAM system represents a cohesive integration of the ESP32 microcontroller with an embedded camera, offering a compact and efficient solution specifically designed for capturing images triggered by weight detection on the mat. This innovative system utilizes the ESP32-CAM for both data processing and capturing images, complemented by the incorporation of pressure sensors for precise weight detection. What sets this system apart is its thoughtfully engineered, compact design, which not only optimizes space but also simplifies the integration of camera functionality into the overall setup. The cohesive nature of the ESP32-CAM system streamlines the implementation process, making it an attractive choice for scenarios where space efficiency and straightforward integration are critical considerations [3, 4].

Arduino-based systems leverage the capabilities of open-source microcontrollers to process sensor data and initiate responses, offering a versatile platform for various applications [5]. This system seamlessly integrates pressure sensors for weight detection, utilizes Arduino for data processing, and provides the option to incorporate camera modules for visual documentation. The widespread adoption of Arduino systems is attributed to their extensive community support, contributing to a wealth of resources, tutorials, and shared knowledge. This collaborative environment fosters accessibility and ease of use, making Arduino an appealing choice for a diverse range of projects. The system's ability to incorporate optional camera modules enhances its functionality, allowing users to include visual documentation in their applications.

The ESP32 anti-theft flooring system is a novel approach to security, employing a network of pressure sensors embedded beneath floor mats and a central ESP32 microcontroller. ESP32 anti-theft flooring system [6]. This microcontroller acts as the brain of the operation, triggered by pressure anomalies on the mats to initiate a series of actions. These actions can include capturing high-resolution images with an integrated camera, sending notifications to pre-configured email addresses, and activating audible alarms to deter potential intruders. The system's design offers several key advantages. The pressure sensors allow for weight detection, ensuring the system only responds to potentially threatening movement. The ESP32 microcontroller is responsible for data processing, enabling the system to analyze anomalies and trigger appropriate responses. Wi-Fi connectivity facilitates communication, allowing for real-time notification and remote monitoring. Finally, the integrated camera captures visual evidence of suspicious activity [13].

Ease of customization is another significant benefit. Users can adjust weight thresholds, sensitivity levels, and alarm settings to tailor the system to their specific needs and environment. This adaptability makes the ESP32 anti-theft flooring system a versatile solution suitable for various applications, from homes and businesses to sensitive areas requiring heightened security. The Table.1 presents the comparison of microprocessors

Table 1. Microprocessor Comparison

Technology	Methods and Techniques	Advantages	Demerits
ESP32 Anti-Theft Flooring	Pressure sensors, ESP32, Wi-Fi, camera	Seamless integration, rapid response, customization	Limited computational power for complex algorithms
Raspberry Pi-Based System	Pressure sensors, Raspberry Pi, camera module	Computational versatility, potential for complexity	Higher power consumption, larger footprint
ESP32-CAM Flooring System	Pressure sensors, ESP32-CAM	Compact design, integrated camera functionality	Limited processing power for complex tasks
Arduino-Based Flooring System	Pressure sensors, Arduino, optional camera modules	Widely used, extensive community support	Limited processing power, may require additional modules

The incorporation of fog computing into anti-theft flooring systems signifies a transformative shift in the realm of security technology. Fog computing, an extension of cloud computing, decentralizes data processing, bringing it closer to the source of generation. This comprehensive literature review explores the burgeoning research and advancements in leveraging fog computing for the enhancement of anti-theft flooring systems. Fundamentally, fog computing offers lower latency, reduced bandwidth usage, and improved data processing capabilities. In the context of anti-theft flooring systems, this proximity to data sources proves invaluable for real-time monitoring, instantaneous detection of unauthorized access, and swift responses to security threats. The integration of edge analytics and machine learning algorithms directly within the system adds a layer of intelligence, enabling on-site analysis and adaptive responses to evolving security challenges. The redundancy and resilience introduced by fog computing contribute to the continuous operation of anti-theft flooring systems, even in the face of network disruptions.

This decentralized approach ensures that the system remains effective across various operational conditions. The seamless integration of fog computing with cloud computing optimizes both real-time responsiveness and long-term analytics, creating a hybrid architecture that maximizes the strengths of each. Energy efficiency is another notable advantage, as fog computing minimizes the need for transmitting large volumes of data to centralized cloud servers. By processing data at the edge, the system conserves energy, making it suitable for environments with limited power resources. Additionally, the reviewed literature underscores the importance of addressing security and privacy concerns in fog computing for antitheft flooring systems. Secure communication protocols, encryption mechanisms, and access control measures are crucial components to ensure the integrity and confidentiality of processed data at the edge [7].

OpenCV, or Open-Source Computer Vision, has evolved into a pivotal force in computer vision. Its journey from an open-source library to a robust framework includes essential concepts like image processing, feature detection, and transformation. OpenCV finds wide-ranging applications, from facial recognition and object detection to 3D computer vision and real-time processing, making it a versatile tool.The integration of OpenCV with machine learning, particularly deep learning frameworks, enhances its capabilities in image classification and neural network training. Real-time applications, such as surveillance and human-computer interaction, highlight OpenCV’s significance. However, challenges persist, requiring optimization for speed and robustness in varied conditions [8].

3. System Development

3.1 System Architecture

The architecture devised for image processing entails a comprehensive amalgamation of both hardware and software components, providing a versatile and robust framework adaptable to a diverse array of applications. In the hardware realm, the foundational elements include the ESP32 microcontroller, a camera for visual input, a piezo sensor translating mechanical vibrations into electrical signals, a GSM module facilitating SMS communication, an email/message module for more detailed notifications, a buzzer for auditory alerts, and a power source tailored to the specific requirements of the application. Additionally, an optional AI module can be integrated to augment processing power and introduce machine learning capabilities, refining object recognition and image classification tasks. Figure .1 depicts the system architecture

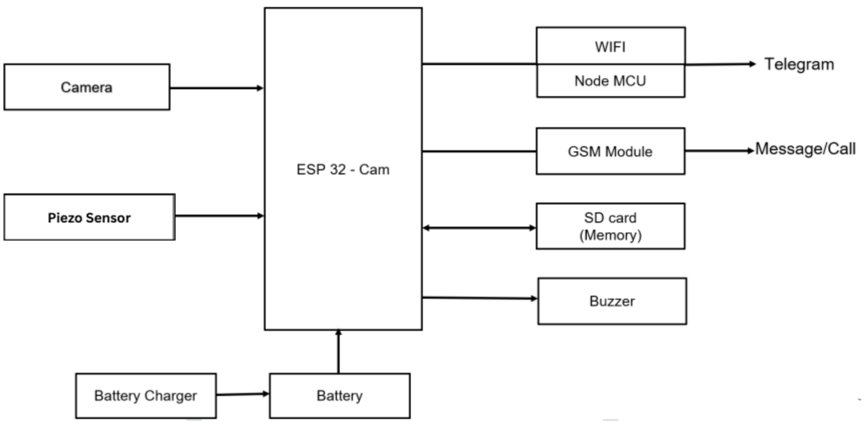

Figure 1. System Architecture

The software domain is equally instrumental in the system's functionality. The firmware layer, operating at a lower level, takes charge of initializing the hardware, establishing a basic operating environment, and facilitating communication with the application layer. The application layer, situated at a higher level, embodies the core functionality of the system. It engages in processing images captured by the camera, detecting objects and events, and subsequently transmitting alerts to users or other connected devices. Optionally, a user interface layer can be incorporated, providing an interactive medium for users through web, mobile, or desktop applications.

In the operational sequence, the initiation of the ESP32 micro-controller serves as the catalyst for the system's commencement. The firmware layer, subsequently activated, undertakes the configuration of hardware settings and the initiation of the application layer. This higher-tier application layer is designed to process images, monitor vibrations from the piezo sensor, and, upon the detection of objects or events, dispatch alerts through the GSM or email modules. Importantly, users possess the autonomy to engage with the system through the optional user interface layer, allowing for the review of system status and the adjustment of settings according to individual preferences.

3.2 Hardware Data Diagram

The intricately designed dataflow chart show in Figure .2 encapsulates a sophisticated system geared towards capturing, identifying, and notifying users about the presence or absence of relatives in the submitted photos. Let's delve deeper into each stage of this seamless process to gain a comprehensive understanding of its functionality and significance. Upon initiation by the camera activation, the system embarks on a journey that commences with the capture of a relative's photo. This image is swiftly transmitted to the image processing module, where a series of operations unfold. The photo undergoes meticulous preprocessing tasks, such as resizing and grayscale conversion, to optimize its compatibility with subsequent stages in the pipeline. This thoughtful preprocessing ensures that the AI model receives well-formatted input, enhancing the accuracy and efficiency of the identification process.

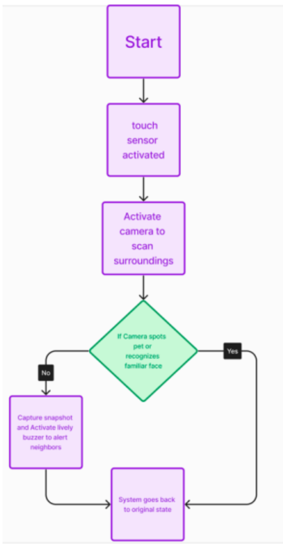

Figure 2. Data Flow Diagram

The heartbeat of this system lies in the AI model, a powerful component that performs the crucial task of identifying the person in the submitted photo. Leveraging advanced algorithms and deep learning techniques, the AI model is capable of discerning intricate facial features, enabling precise identification. The results are then communicated back to the application layer, which acts as the orchestrator of the entire process. The application layer, serving as the nerve center of the system, plays a pivotal role in cross-referencing the identified person with the OpenCV AI database. This database serves as a comprehensive repository for the housing profiles of known individuals. The comparison results determine whether a match exists. In the event of a non-match, an intricate and prompt response mechanism is triggered. The responsiveness of the system is exemplified by the swift initiation of an email notification process. Configured with pre-defined parameters, the application layer promptly sends out an email notification to a pre-configured address. This notification includes the photo in question, allowing the user to visually confirm the potential unidentified individual. This proactive approach not only enhances security but also provides users with real-time information about any discrepancies.

The design of the dataflow incorporates key elements of efficiency and scalability. By enabling parallel processing of the image processing module and the AI model, the system maximizes its throughput, ensuring a rapid and effective photo processing pipeline. Furthermore, the OpenCV AI database, designed as a central repository, is architected to scale seamlessly. This scalability feature allows the system to accommodate a substantial volume of photos and person profiles, making it robust and adaptable to growing datasets. In conclusion, this well-orchestrated dataflow framework serves as a fundamental and indispensable component within the broader system architecture. It not only ensures the seamless processing of data but also reflects a thoughtful and strategic sequence of steps, from photo capture to potential email notification, underpinning the system's overall functionality and performance.

3.3 Software Data Diagram

The software dataflow within the proposed project shown in Figure.3 orchestrates a streamlined process aimed at efficiently recognizing and verifying individuals captured in photographs. Commencing with the user capturing an image of their relative using the camera, the dataflow unfolds in a sequence of well-defined steps.

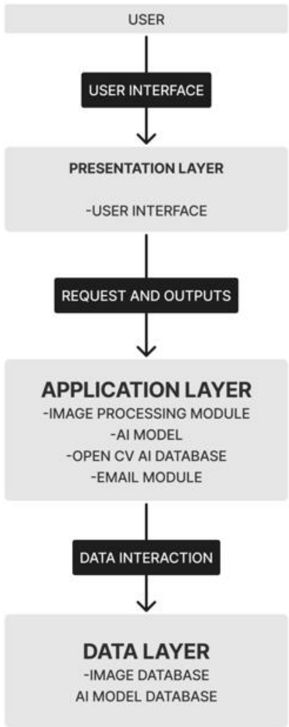

Figure 3. Software Data Flow Diagram

Upon capture, the photograph embarks on a journey through the software ecosystem. It first traverses to the image processing module, where crucial preprocessing steps unfold. These may include resizing and converting the image to grayscale and optimizing it for subsequent analysis. Subsequently, the preprocessed photo embarks on a dual path, one leading to the image processing module and the other to the AI model. In the realm of image processing, the module tackles essential tasks in parallel with the AI model's analysis. While the image processing module fine-tunes the photo, the AI model delves into the intricacies of person identification. The AI model, armed with sophisticated algorithms, processes the preprocessed image and swiftly delivers its findings to the application layer. At the heart of the system, the application layer plays a pivotal role in decision-making. It consults the OpenCV AI database, a repository of person profiles and reference data. If the AI model successfully identifies the person in the photo and a match is found in the database, the application layer seamlessly progresses, awaiting the next interaction. However, in the absence of a match, the application layer promptly takes corrective action. It dispatches an email containing the photo to a preconfigured email address, notifying relevant stakeholders of the attempted identification.

The versatility and scalability of the dataflow design are evident in its parallel processing capabilities. The image processing module and the AI model operate concurrently, ensuring swift and efficient handling of photos. Moreover, the OpenCV AI database, a linchpin in the verification process, is designed to accommodate a vast array of person profiles and images, facilitating scalability. Beyond its technical prowess, the dataflow architecture aligns seamlessly with the broader project objectives. It not only ensures the accuracy and efficiency of person identification but also showcases a user-centric approach. The user's experience, from capturing the photo to potential notifications, is thoughtfully considered, contributing to the overall success of the system.

3.4 Requirements

3.4.1 Piezo Sensor

Figure 4. Piezo Sensor

A piezo sensor in Figure.4 is a compact and highly sensitive electronic device that operates on the piezoelectric effect. This effect allows the sensor to generate an electrical charge in response to applied mechanical stress or pressure on piezoelectric materials. Commonly used in industrial settings, these sensors detect vibrations, shocks, and acoustic signals, aiding in machinery monitoring. They are also integral to electronic musical instruments and medical devices, offering rapid response times and durability. With no moving parts and resistance to environmental factors, piezo sensors are versatile components, converting mechanical stimuli into electrical signals for various applications.

3.4.2 ESP32 Microprocessor

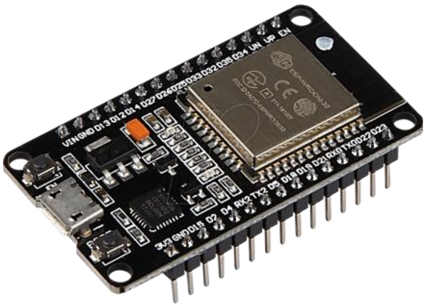

Figure 5. ESP32 Microcontroller

The ESP32 microcontroller, shown in Figure. 5 developed by Espressif Systems, is a versatile and widely used embedded system component. Known for its dual-core architecture, integrated Wi-Fi, and Bluetooth capabilities, the ESP32 is ideal for IoT applications. With features like GPIO pins, SPI, I2C, UART interfaces, and built-in sensors, it offers adaptability to various projects. Its compact size, power efficiency, and compatibility with the Arduino IDE make it popular among hobbyists and professionals for diverse applications in smart devices and industrial automation.

3.4.3 Camera Module

Figure 6. Camera Module

The camera module shown in Figure.6 is a compact and sophisticated electronic component designed for image capture and processing. This module, crucial to the system's functionality, possesses the capability to capture high-resolution photographs when triggered by the pressure sensors embedded within the flooring. The camera's advanced features enable it to swiftly respond to potential threats, providing visual documentation of detected anomalies. Its seamless integration with the ESP32 microcontroller ensures efficient communication and

ISSN: 2582-3825

coordination within the security system. As a pivotal element in the anti-theft solution, the camera module contributes to enhancing surveillance, enabling real-time monitoring, and bolstering the overall security infrastructure.

3.4.4 Buzzer

Figure 7. Buzzer

The buzzer shown in Figure.7 is a compact acoustic signaling device designed to enhance the system's security features. When triggered by the ESP32 microcontroller in response to detected anomalies, the buzzer emits audible alerts, serving as an additional layer of deterrence. Its role extends beyond silent notifications, providing a noticeable auditory signal to deter potential intruders and alerting occupants or security personnel to the presence of suspicious activity. Compact and efficient, the buzzer contributes to the system's comprehensive approach to preventing theft and enhancing security in diverse environments.

3.4.5 Python

Python serves as the programming language backbone for the anti-theft flooring system integrated with ESP32, providing a versatile and powerful platform for system control and data processing. Leveraging Python's simplicity and readability, the system's software is designed for efficient communication between the ESP32 microcontroller and various components. Python's extensive library support facilitates seamless integration of image processing, data analysis, and communication protocols, contributing to the system's robust functionality. Its adaptability and broad community support make Python an ideal choice for implementing intelligent algorithms, enabling the anti-theft flooring system to respond effectively to potential threats and enhance overall security measures.

4. Methodology

The proposed anti-theft flooring system is designed to provide a comprehensive security solution by integrating key hardware components. Pressure sensors, strategically placed to detect breaches within a predefined weight threshold, work in tandem with the ESP32 microcontroller. This central processing unit is responsible for interpreting signals, capturing images, and managing the overall system. An optional alarm system adds an extra layer of security, acting as a deterrent against potential intruders. The working principle of the system is efficient and precise. When pressure sensors identify a weight threshold breach, the ESP32 responds by capturing and promptly sending an image to a pre-configured email address. Users have the option to activate the alarm system for enhanced security. The installation process is user-friendly, with sensors discreetly placed beneath the flooring for seamless integration.

Safety features are integral to the system's design. Sensors are calibrated to ignore objects below a specified weight, ensuring the safety of small animals and preventing unnecessary alerts. Customizable sensitivity settings further optimize the system's responsiveness, minimizing the risk of false alarms. To implement the system, users follow a straightforward process. They create a database by storing images of authorized individuals for recognition, typically relatives. The AI model undergoes training using these stored images to enhance person identification accuracy. During testing, the anti-theft mat is strategically placed in front of the camera, activating only when pressure above the fixed threshold is applied. The system's efficacy is demonstrated through rigorous testing. The AI model crosschecks captured images against the user database, ensuring immediate recognition of authorized individuals. Unrecognized individuals trigger responses, including the transmission of their photo to a preset email address and the activation of an audible alarm for heightened security. The usage instructions are user-friendly. Users initiate the system by uploading images of authorized individuals and training the AI model. Mat placement is straightforward, and the system remains inactive until a weight above the specified threshold is detected. Testing procedures ensure the system's responsiveness, allowing users to fine-tune sensitivity settings to prevent false alarms.

The proposed anti-theft flooring system offers a robust and customizable security solution, seamlessly integrating innovative hardware components and artificial intelligence.

Users can tailor the system to their specific security needs, providing effective protection against unauthorized access.

5. Conclusion

In this culminating chapter, we delve into the development of an anti-theft flooring system utilizing state-of-the-art ESP32-CAM microcontrollers. This significant milestone prompts a thorough synthesis of our objectives, an exploration of key findings, and an emphasis on the broader project's significance. The current phase of the research focuses on a brief literature survey with the proposed architecture; additionally, the components to be used are also decided in the current phase. Further system design, prototype development, testing, field application, and deployment are to be carried out in future development. Notably, the evolution of the project is marked by the transition from conventional touch sensors to more responsive piezo sensors, augmenting the system's accuracy. The integration of an audible alert mechanism through an integrated buzzer serves both as a deterrent to potential intruders and an immediate indication of unauthorized presence. Artificial intelligence undergoes intensive training for enhanced facial and object recognition, accompanied by the expansion of the dataset to refine accuracy. The fine-tuning process entails meticulous adjustments to thresholds and sensor parameters, aiming for a delicate balance between precision and responsiveness. As the project advances, the ambitious goal of real-time deployment in diverse environments becomes a focal point, testing adaptability and providing insights for potential refinements. This evolutionary journey underscores our holistic commitment to innovation, precision, and real-world effectiveness in modern security systems, positioning our project as a testament to a proactive approach in addressing security challenges through a fusion of advanced sensor technologies, artificial intelligence integration, and a dedication to continuous improvement.

References

[1] Kumari, Sushma, Shashi Kant Singh, Akash Tyagi, Rupesh Kumar Sharma, and Ms Mona Devi. "IOT BASED ANTI-THEFT FLOORING MAT SYSTEM USING RASPBERRY PI." International Research Journal of Modernization in Engineering Technology and Science 5(2) 2023 . 1759 -1764

[2] Teja, P. Amith, A. Anne Frank Joe, and V. Kalist. "Home security system using raspberry PI with IOT." In 2021 International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), pp. 450-453. IEEE, 2021.

[3] Dinakarasu, S., M. Baskar, C. Balaji, and M. Gawtham. "REAL TIME FACE DETECTING UNAUTHORIZED HUMAN MOVEMENT USING ESP 32 CAM MODULE." International Research Journal of Engineering and Technology (IRJET) 9(6) (2022). 981-985

[4] Nagamani, T., W. H. Beniga, K. S. Dhanish, and A. Sherine Benitta. “Anti-Theft Monitoring for a Smart Home.” In 2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT), pp. 76-82. IEEE, 2022.

[5] Shah, Vaibhav, Sahil Shah, Jay Shah, and Prithvish Mamtora. "Anti-Theft Home Security System." International Journal of Electronics and Communication Engineering (IJECE) 2, no. IV (2013): 113-118.

[6] Alreshidi, Eissa Jaber. “Introducing fog computing (FC) technology to internet of things (IoT) cloud-based anti-theft vehicles solutions.” International Journal of System Dynamics Applications (IJSDA) 11, no. 3 (2022): 1-21.

[7] Muhammad, Nauval, Endro Ariyanto, and Yogi Anggun Saloko Yudo. "IMPROVED FACE DETECTION ACCURACY USING HAAR CASCADE CLASSIFIER METHOD AND ESP32-CAM FOR IOT-BASED HOME DOOR SECURITY." JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika) 8, no. 1 (2023): 154-161.

[8] Sirisha, U., D. PoojaSri, N. Gayathri, K. Heshma, and G. Raja Sekhar. "IOT BASED ANTI THEFT DETECTION AND ALERTING SYSTEM USING RASPBERRY PI." International Research Journal of Engineering and Technology (IRJET) 7, no. 03 (2020). 1650 -1655

[9] Tressler, James F., Sedat Alkoy, and Robert E. Newnham. "Piezoelectric sensors and sensor materials." Journal of electroceramics 2 (1998): 257-272.

[10] Binti Ramli, Rusyaizila, Nur Dini Afrina binti Nazri, Omar Ismael Al-Sanjary, and Nabilah Rozzani. “The Development of Weight Detection System using IOT Flooring.”

In 2021 IEEE 11th IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), pp. 250-255. IEEE, 2021.

[11] Pandya, Sharnil, Hemant Ghayvat, Ketan Kotecha, Mohammed Awais, Saeed Akbarzadeh, Prosanta Gope, Subhas Chandra Mukhopadhyay, and Wei Chen. "Smart home anti-theft system: a novel approach for near real-time monitoring and smart home security for wellness protocol." Applied System Innovation 1, no. 4 (2018): 42. 1-22

[12] Rai, Pertab, and Murk Rehman. “ESP32 based smart surveillance system.” In 2019 2nd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), pp. 1-3. IEEE, 2019.

[13] Maier, Alexander, Andrew Sharp, and Yuriy Vagapov. "Comparative analysis and practical implementation of the ESP32 microcontroller module for the internet of things." In 2017 Internet Technologies and Applications (ITA), pp. 143-148. IEEE, 2017.

[14] Fazil, P. Mohammed, N. Prasad, B. Ranjitha, and Sneha S. Nair. "Anti Theft Security System with Image Feedback using Raspberry PI and IoT." i-Manager's Journal on Electronics Engineering 10, no. 3 (2020): 8-17.