International Journal of Research Studies in Educational Technology
2024 Volume 8 Number 2, 63-74

ISSN: 2243-7738
Online ISSN: 2243-7746

OPEN ACCESS

Smart surveillance system using ESP32 and camera-based motion detection with IM technology

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Received: 10 May 2024 **Revised**: 27 June 2024 **Accepted**: 3 July 2024
Available Online: 15 July 2024 **DOI**: 10.5861/ijrset.2024.8012

Abstract

This study aimed to develop a smart surveillance system using ESP32 and Camera-based motion detection with IM Technology to address the general lack of security. Using the quantitative-applied research design, it identified the system as very highly effective, the status of both the smart surveillance system and the traditional CCTV as good, the smart surveillance system for motion detection as somewhat effective, and moderately better for real-time surveillance. The researchers constructed an evaluation checklist with 10 indicators to assess the product performance. The checklist describes the effectiveness of the smart surveillance system using ESP32 as a technique to gather data and maintain the participants' accuracy and unbiased results. Frequencies, percent, and weighted mean were computed to describe the status and effectiveness of the developed product and the traditional CCTV. Furthermore, a t-test was used to examine if differences exist between the smart surveillance system and the traditional CCTV. The smart surveillance system's effectiveness has significantly affected the status of network connectivity, server performance, and location of the camera. Significant differences exist between the smart surveillance system and traditional CCTV in terms of server performance, camera location, and real-time surveillance. The researchers recommend implementing the night vision feature of the ESP32 CAM and conducting tests under low-light conditions for better security and to improve the system's overall performance significantly. Thus, smart surveillance using ESP32 and camera-based motion detection with IM technology is intended to be produced and made available commercially in local and other places.

Keywords: security, smart surveillance system, ESP32, camera-based motion detection, IM technology, closed-circuit television (CCTV)

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1. Introduction

Nearly every surveillance camera in our nation is made or imported from another country; their cost is similarly exorbitant, which is a concern for many Filipino households. Another reason is that, although our country reported a reduced theft and robbery rate this year compared to prior years, we are still dealing with theft cases, and there are only a few houses with security cameras, most of which are not very advanced. Recent research statistics show that the crime rate in the country went down from 6,506 to 5,899 (Caliwan, 2023). The decline in robbery data appears too low, which is supported by the fact that typical closed-circuit television (CCTV) systems that we use now are not as technologically advanced and are also more expensive (Matzcak et al., 2023). The findings of Piza et al. (2019) showed that CCTV is associated with a significant and modest decrease in crime in the United States. As CCTV surveillance continues to expand its reach in both public and private spaces and evolve with new technology, this entails the cost and capability of ordinary families to acquire one. This high cost is also why Filipino families cannot afford standard CCTV systems. Our government took some initiative to address the problem, more importantly, the Philippine National Police (PNP), by heightening the police visibility by patrolling in different areas with cooperation within the community, especially in the urban areas in the Philippines.

The study, which combines a CCTV system with the capability to send images using IM technology when a person is detected, lies in its integration of two distinct technologies to serve a specific purpose and perform as intended. A real-time notification, which is more advanced than traditional CCTV, only records footage for later viewing. The study has instant messaging capabilities through instant messaging (IM) technology to provide real-time notifications and enhanced security. It also offers flexibility and convenience because it enables users to monitor their premises from anywhere as long as they have an internet connection. Additionally, software and hardware development expertise is required to integrate these technologies, making the study unique in its approach. This study is designed to help detect and monitor crimes such as trespassing and robbery, which mostly happen in some small areas. CCTV can prevent crimes, as revealed in the study of Welsh and Farrington (2009), but through other mechanisms. While ordinary CCTV systems would risk the need for real-time monitoring service, this designed system using the ESP32 camera provides a real-time monitoring system. It alerts the house's owner through IM technology.

Statement of the Problem - To address the general lack of security, this study aimed to develop smart surveillance system using ESP32 and Camera-based motion detection with IM Technology. The researchers specifically want to respond to the following questions: (1) What is the status of the smart surveillance system using ESP32 and Camera-based motion detection with IM Technology and traditional CCTV in terms of network connectivity, server performance, and location of the camera? (2) What is the level of effectiveness of the smart surveillance system using ESP32 and Camera-based motion detection with IM Technology and traditional CCTV in terms of motion detection and real-time surveillance? (3) Is the effectiveness of the smart surveillance system using ESP32 and Camera-based motion detection with IM Technology affected by network connectivity, server performance, and location of the camera? (4) Is there a significant difference between the smart surveillance system using ESP32 and Camera-based motion detection with IM Technology and the traditional CCTV camera in terms of network connectivity, server performance, and location of the camera?

Significance of the Study - This study aims to develop a smart surveillance system using the ESP32 camera and Passive Infra-Red (PIR) motion sensor to determine its effectiveness and accuracy in detecting objects and monitoring the surroundings with a notification system through IM technology. Furthermore, this study holds substantial significance for the following groups: To the community, by assessing the performance of the smart

surveillance system, this study will likely contribute to creating safer living environments. It aims to diminish the risk of theft, trespassers, and other security threats. To the business establishments, the study will help monitor establishments to maintain their security and safety. It will help provide evidence in case an incident happens to the schools. This research will benefit the school by maintaining its safe learning environment and monitoring the students, teachers, and staff's activities inside the campus. To the students, the study's findings hold significant educational value for students in security, technology, and surveillance fields. It will offer real-world insights into the effectiveness of smart surveillance systems, enabling a better understanding of practical applications. The study will provide a valuable reference for future researchers interested in smart surveillance systems. By documenting the methodology, results, and conclusions, it hopes to establish a solid groundwork for further exploration of topics concerning security enhancement and safety through technological advancements. By considering these beneficiaries, the significance of the study may expand across various domains of education, community, and research. It will not only impart practical knowledge but will also foster safety within communities. Additionally, it will be an invaluable resource for researchers seeking to advance existing findings.

Scope and Delimitations of the Study - This study focused on developing a Smart Surveillance System using ESP32 and Camera-Based Motion Detection with IM Technology. This study is also dedicated to the monitoring and notification system for maintaining a secure area such as houses, whether inside or outside, the local store, or any location/area that may need security. The owner or consumer can manipulate the product since the product is easy to program and flexible. With the use of a PIR Motion Sensor and ESP32 Camera module, it would help monitor the user's area or location. The P.I.R. Motion Sensor would provide the ability to detect motion, which is almost often utilized to determine if a person has entered or left the sensor range. The ESP32 Camera, on the other hand, monitors the surroundings for this project. These two components helped the product to be reliable and possible. However, since the sensor is very sensitive, the limitation of this study is that once the device is turned on, every person, animal, and even an object that passes across the sensor is considered an intruder. The product is also affected by the network connectivity, the availability of the internet, and the surveillance camera, which may also affect the performance of the server and when it comes to the location of the camera, it may be affected by the condition of the environment and its surroundings. The researchers started collecting materials and gathering data as the study was conducted at Rizal Municipal Police Station, Occidental Mindoro, during the school year 2023-2024.

2. Methodology

Research Design - The development of this study utilized an applied research design that focuses on using scientific theories and knowledge in developing new technologies. The objective is to design and implement a Smart Surveillance System using ESP32 and Camera-Based Motion Detection with IM Technology. The research design aims to evaluate the effectiveness and efficiency of the system in providing real-time surveillance and timely notifications to the users. This study used quantitative research to obtain precise, objective, and generalizable findings. The researchers collected the data through experiments, measurements, and a self-made evaluation checklist to analyze the performance of the Smart Surveillance System. The data includes factors such as detection accuracy and response time. A controlled environment is set up with predefined scenarios to evaluate detection accuracy and recorded to simulate real-life situations. The recorded photos would be reviewed manually to determine the system's ability to accurately detect and recognize various objects and activities. The metrics that are used in assessing detection accuracy include true positives, false positives, true negatives, and false negatives. To measure response time, the researchers recorded the time the system took to process and analyze the photos, detect suspicious activities, and generate notifications. The response time is then measured from when a suspicious activity occurred to when the notification was sent to the user's device.

Participants of the Study - The product was tested and observed purposively by 23 participants from different government offices and establishments in San Jose, Occidental Mindoro. They were chosen since the researchers aimed to test the device more naturally, which will likely be available in the future. A demonstration of the system's operation was shown to them. Afterward, they gave the evaluation to rate the effectiveness of the product.

Research Instrument - The researcher-made evaluation checklist was constructed to provide the assessment of the smart surveillance. It consists of 10 statements to evaluate the effective performance of the system. Another questionnaire consisting of five items was made to gather responses about the status and effectiveness of the smart surveillance system and the traditional CCTV in terms of network connectivity, server performance, location of the camera, motion detection, and real-time surveillance. The research adviser and experts in Science and Technology at Divine Word College of San Jose checked and validated the evaluation checklist using content and face validation. After thorough analysis, the researchers followed the comments and suggestions from the adviser and experts to refine the evaluation checklist.

Data Gathering Procedure - The researchers constructed an evaluation checklist with 10 indicators to assess the product performance. The checklist describes the effectiveness of the smart surveillance system using ESP32 as a technique to gather data and maintain the participants' accuracy and unbiased results. The criterion set is that the participants have CCTV installed in their homes. The product was tested using the Smart Surveillance System (Independent Variable, which can be manipulated), and it was observed by 23 participants from different government offices and establishments. Before initiating the test and survey, the researchers first need to get a consensus from the participants. They must test the product for themselves and answer the following evaluation questionnaire. The experimentation was conducted for the whole day to gather crucial data and insights from the respondents, which would help the researchers better understand the benefits as well as the disadvantages and drawbacks of the device. The participants tried the product at the respective establishments for the whole day and after testing the product, the participants answered the survey questionnaire. After testing and answering the validated survey, the researchers organized and analyzed the results gathered from the respondents.

Research Process; Stage 1 Preparation and Gathering of Materials - This product requires researchers with highly technical materials to improve the product. Researchers were required to use the following materials, which they have selected from affordably priced materials and credible sources:

- Developing the product: ESP32 Camera, PIR Motion Sensor, TTL Programmer, Breadboard, Jumper Wires, and Female Header Pin.
- Crafting the case: Craft board, Acrylic glass, 10000 mah powerbank and Spray paint

The researchers purchased all the materials online. The total budget is two thousand five hundred (2,500 PHP).

Stage 2: Building and Development of the Project - The researcher's primary purpose in conducting this study is to develop a smart surveillance camera that uses motion detection and IM Technology to address the general lack of security. By utilizing the used parts and making a smart surveillance camera, the researchers aim to make all owners of houses and establishments aware of all intruders who will try to take their valuable things away. The researchers allotted 39 days (Feb.11-March 21,2024) in the application called Arduino IDE for the coding, 3 days for making the device, and 2 days in making the final product. Thus, the product was developed in 44 days. In this experiment, the researchers utilized the PIR motion sensor to have the capability to detect incoming intruders through its motion and heat waves. It will send an alert if there are unwelcome guests who will come in and break through your house or establishments. Property owners will be promptly alerted to any unauthorized entry attempts into their residence, and with the help of Instant Messaging, they will be notified as soon as possible. It will help house owners if there is an ongoing robbery. The researchers finished the stimulated surveillance through the codes and programming. The researchers used jumper wires to make connections between all the components used. They will utilize instant messaging (IM) technology, which notifies the house owners quickly. After the composition of the product, the surveillance camera and its instant messaging feature still have room for improvement, which researchers may improve in the future.

Figure 1. Actual Product of Smart Surveillance System Using ESP32 and Camera-Based Motion Detection with IM Technology

Stage 3: Experimental Stage, Observation and Data Recording - To determine whether the product is functional, the researcher assembled the product, and for the coding, the researcher used the application called Arduino IDE for the coding and testing of the product. The other components required were purchased through an online store, while the main components were already bought. The materials were completed to finalize the product. The PIR sensor, ESP32 CAM, female header pin, and the TTL programmer are plugged into the breadboard. The application Arduino IDE is used to alert and monitor the system whenever the sensor is triggered. To ensure the effectiveness and reliability of the product, the researchers would let the participants use the product that has traditional CCTV in their houses and/or buildings to see which is more reliable and if the product is a success. The experiment and observation were done for almost a week. The Surveillance Camera was installed in certain areas, such as near the doors, on top of a cabinet or shelf, or outside the house or an establishment that will need security. It would begin to trigger the sensor's alarm by making such motion or movement in the range of the sensor. When the sensor's alarm is triggered, it will alarm one of the participant's telegram notifications in their phone. Following the trial, the researchers distributed a survey form to the participants to get their opinions about the product's effectiveness.

To test the effectiveness of this device, the researchers turned on the camera and kept an eye on the alarm system. Every time the device was used or tested, they checked the camera's functionality by walking past it and seeing if the device would alert the user when it detected motion. The researchers also highlighted the shortcomings of the Smart Surveillance camera that could hinder its performance in an attempt to improve the aforementioned device. The findings were interpreted by the researchers to assess and improve the product's capabilities.

Statistical Treatment of the Data - To describe the status of the smart surveillance system using ESP32 and camera-based motion detection with IM Technology and the traditional CCTV and the level of effectiveness of the two systems, frequencies, percent, and weighted mean were computed. The data were presented graphically to facilitate easy understanding of the results. To find out if the effectiveness of the smart surveillance system can be affected by network connectivity, server performance and location of the camera, correlation analysis was used. The t-test was used to examine if differences exist between the smart surveillance system and the traditional CCTV. The result generates a p-value, which represents the likelihood of getting the observed results if there's no difference between the two groups being compared. A p-value smaller than 0.05 indicates that the observed difference is statistically significant, suggesting a true performance gap between traditional CCTV and smart surveillance systems.

3. Results and Discussions

Table 1 shows the extent of effectiveness of smart surveillance systems using ESP32 and camera-based

motion detection with IM technology. A very high extent of effectiveness, with means 3.57 to 3.67, is given to prompt sending of notification done by ESP32 camera (3.57), functioning PIR motion (3.57), and ESP32 camera according to its purpose (3.57), effectiveness in giving an alert (3.57), and the product is highly recommended for implementation in facilities of the area (3.67). Participants also describe the effectiveness of the product to a high extent based on the features such as it providing high-resolution photos to the telegram (3.14), being effective in monitoring and maintaining a secure area or facilities (3.19), sending real-time surveillance to the owner (3.19) and detecting anyone attempting to steal or break in the house (3.19). Weighted means for these descriptions ranged from 3.14 to 3.19. Since the indicators were rated at a high to very high extent, the smart surveillance system using ESP32 and camera-based motion detection with IM technology is found to be effective based on its intended functions of alerting, detecting, sending notifications, and monitoring. The results reveal that the product can be used according to its purpose. The very high extent of the system's effectiveness appears to conform to the purpose of the technology, as revealed by Cahyono et al. (2022), which stated that surveillance technology provides security device features for homes in the modern day.

Table 1

Mean Extent of Effectiveness of Smart Surveillance System using ESP32 and Camera-based Motion Detection with IM Technology

Indicators	**Weighted Mean**	**Descriptive Rating**
1. The P.I.R. Motion Sensor is effective whenever it detects any attempt of stealing.	3.19	High
2. The PIR Motion and ESP32 Camera are functioning and can detect any attempts of theft.	3.57	Very High
3. The ESP32 Camera effectively sends real-time surveillance to the owner through telegram.	3.19	High
4. The ESP32 Camera promptly sends a notification when someone is detected.	3.62	Very High
5. The ESP32 Camera provides high-resolution photos to telegram.	3.14	High
6. The product can effectively detect anyone attempting to steal or break into the house.	3.19	High
7. The product is effective when it comes to alerting, compared to traditional camera.	3.57	Very High
8. The product is effective in monitoring and maintaining a secure area/facility wherever I place it.	3.19	High
9. The overall product is functioning according to its purpose.	3.57	Very High
10. I would recommend this product to be implemented in facilities in my area.	3.67	Very High
Overall Mean	**3.39**	**Very High**

Legend: * 3.25-4.00 Very High; 2.50-3.24 High; 1.75-2.49 Moderate; 1.0-1.74 Low

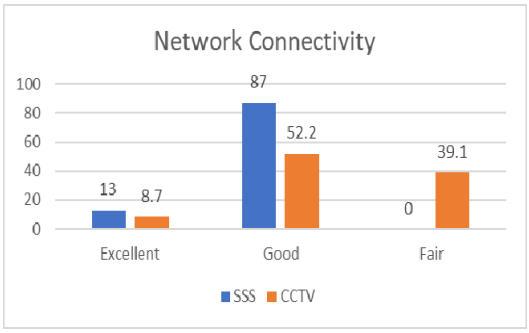

Figure 2. Status of Network Connectivity of Smart Surveillance System (SSS) and Traditional CCTV

The graph in Figure 2 presents the network connectivity status of the smart surveillance system using ESP32 and camera-based motion detection with IM Technology and traditional CCTV. The majority of the participants rated the network connectivity for both the smart surveillance system and traditional CCTV as good, with 87% and 52.2%. Traditional CCTV was rated fair with 39.1%. An excellent network connectivity is given by 13% using the smart surveillance system and 8.7% for traditional CCTV. Overall, the network connectivity falls to the acceptable level for both systems. The good status of the network connectivity confirms its importance in providing uninterrupted functioning of the system, according to Bary & Crowley (2012). Since most security cameras nowadays are connected to the internet, however, in the event that there is no connectivity, the system will not be able to send a notification when it detects motion, to check the footage, or to turn on and off the camera remotely.

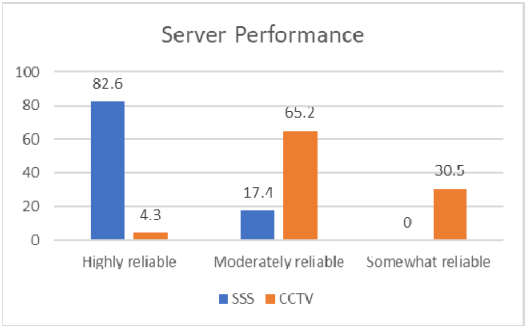

Figure 3. Status of Server Performance of Smart Surveillance System (SSS) and Traditional CCTV

The server performance of the system, as shown in Figure 3, is described by how well a server works, and it depends on the operating system and resources like CPU, memory, and disk space. A good performance means the server can process requests quickly and handle many requests at once. Out of the 23 participants, 82.6% rated the server performance of the smart surveillance system as highly reliable. With traditional CCTV, the server performance is rated moderately reliable by 15 or 65.2% of the participants. However, 4.3% rated it highly reliable, and 30.5% said the server's performance is somewhat reliable. A moderately reliable rating for smart surveillance systems is given at 17.4%. Based on their ratings on the reliability of the server performance, there is a higher rating given to the smart surveillance system than to the traditional CCTV. The high reliability of the smart surveillance system, as viewed by the participants, conforms with the contention that servers are the backbone of an organization's data center since it does everything for the operation, as stated by Nagothu et al. (2020). Hence, the ideal server performance requires proactive monitoring of physical and virtual servers and the components that constitute server health with a server performance monitor.

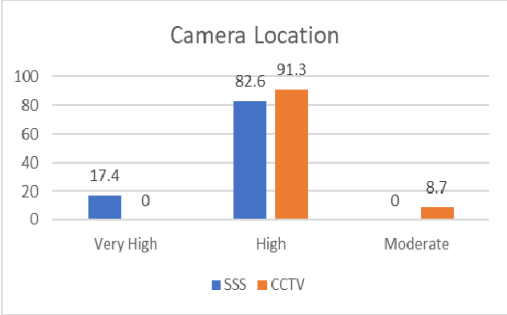

Figure 4. Status of Optimal Camera Location for Surveillance of Smart Surveillance Camera and Traditional CCTV

When the participants were asked whether the camera's location is optimal for surveillance purposes, the majority gave a high agreement for both the smart surveillance system (19 or 82.6%) and traditional CCTV (21 or 91.3%). Using the smart surveillance system, 17.4% agreed with the optimal camera location for surveillance. Only two, or 8.7%, rated on a moderate level considering the optimal camera location using the traditional CCTV. Generally, the optimal camera location is given a higher agreement in favor of the smart surveillance system than the traditional CCTV. Given the perceived high status of the camera's location, this finding agrees with Habas' (2023) article, which concluded that strategic placement and appropriate angles are essential for achieving optimal surveillance coverage.

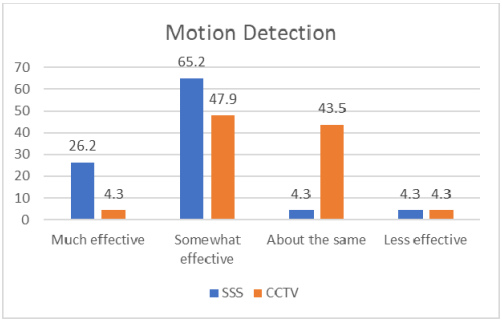

Figure 5. Level of Effectiveness of Smart Surveillance System using ESP32 and Camera-based Motion Detection with IM Technology and Traditional CCTV in Terms of Motion Detection

The effectiveness of the smart surveillance system and the traditional CCTV were rated by the participants according to motion detection. The motion detection of the smart surveillance system is rated as somewhat effective by 65.2%, while only 47.9% rated the same on traditional CCTV. Motion detection is much effective using the smart surveillance system, as rated by 26.2% and 4.3% in using traditional CCTV. Motion detection is seen as less effective by 4.3% when using both systems. Using traditional CCTV, 43.5% of them revealed the same effectiveness. As described by the participants, the level of effectiveness in motion detection is generally effective using smart surveillance. With the findings of a moderate level of effectiveness of both systems based on motion detection features, its importance is emphasized in CCTVSG.NET (2023), stating that, video motion detection cameras can be prone to false alarms depending on where you set them up. So, to prevent unnecessary alarms and/or recordings, the camera must be kept away from areas where heat levels can change rapidly, such as windows or heating vents.

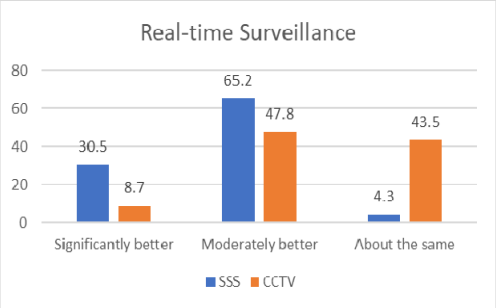

Figure 6. Level of Effectiveness of Smart Surveillance System using ESP32 and Camera-based Motion Detection with IM Technology and Traditional CCTV
In terms of Real-time Surveillance

The real-time surveillance feature of the smart surveillance system shows a moderately better level of effectiveness, according to 65.2% of the respondents. Seven, or 30.5% of them, disclosed that smart surveillance systems are significantly better in real-time surveillance. There is moderately better real-time surveillance with the use of traditional CCTV, according to 47.8% of the respondents. It is about the same effectiveness for 43.5% using the traditional camera and 4.3% using the smart surveillance system. There is generally a good level of effectiveness in terms of real-time surveillance. As the participants observed, the smart surveillance system has a clear edge over traditional CCTV. Findings also reveal that in terms of real-time surveillance, according to Iqbal et al. (2021), it can provide an advanced security solution with real-time data and direct integration with user systems.

Table 2

*Correlation Analysis on the Status of the Smart Surveillance System and Its Level of Effectiv*eness

Dependent Variable	Independent Variable	R-value	p-value*	Interpretation
Motion Detection	Server Performance	0.419	0.047	Significant
Real-time Surveillance	Server Performance	0.641	0.001	Significant

Legend: P-value ≤ 0.05 Significant; reject H0.

The correlation analysis is used to test whether the effectiveness of the smart surveillance system using ESP32 and Camera-based motion detection with IM Technology in terms of motion detection and real-time surveillance can be affected by network connectivity, server performance, and location of the camera. The R-value represents the correlation coefficient, and the p-value represents the significance level of the correlation between the variables. The result shows that among the three factors describing the smart surveillance system, the server performance status can significantly affect motion detection at a positive, moderate level (R=0.419). The significance of the effect is given by a 0.047 p-value. The p-value should be lower than 0.05 for the correlation to be significant. The server performance status can also moderately affect the real-time surveillance effectiveness as shown by the positive R-value of 0.641 and is significant at 0.001 p-value. A consistently good performance of the system server can positively affect the smart surveillance system in detecting motion and real-time surveillance. Network connectivity and the geographic location of the camera did not reveal any effect on the effectiveness of the smart surveillance system using ESP32 and Camera-based motion detection with IM

Technology. Therefore, the server's performance should be maintained under good conditions to ensure the consistent effectiveness of motion detection and the system's real-time surveillance. Furthermore, Chong et al. (2023) confirmed that smart surveillance systems can integrate multiple types of sensors and electrical appliances, such as motion sensors, humidity sensors, and temperature sensors, making it possible to send alerts to users in case of robbery. This alerts the user and allows them to take immediate action. This particular system is easily customizable, and users can implement it with an app or interface that enables them to control and monitor connected devices remotely, making it highly adaptable to individual requirements and enabling efficient monitoring and control from a distance.

Table 3

Difference Between Smart Surveillance System and Traditional CCTV

Indicators	**t-value**	**p-value***	**Interpretation**
Network Connectivity	1.817	0.083	Not Significant
Server Performance	2.152	0.043	Significant
Camera Location	2.152	0.043	Significant
Motion Detection	0.901	0.377	Not Significant
Real-time Surveillance	2.313	0.030	Significant

Legend: P-value ≤ 0.05 Significant; reject H_0.

The comparison between the smart surveillance system and the traditional CCTV has been made using the t-test with five features considered. As revealed in Table 3, significant differences are found in server performance, camera location, and real-time surveillance. This has been proven by the results of the t-values 2.152 and 2.313. The t-values are acceptable if these are greater than +2 or less than -2. These t values indicate a difference between the smart surveillance system and the traditional CCTV. The significance of the differences is given by the p-values of 0.043 in server performance and camera location and 0.030 in real-time surveillance. However, it was found that the smart surveillance system and the traditional CCTV do not significantly differ regarding network connectivity and motion detection since the t-values of 1.817 and 0.901 are low. This indicates the comparability of the two systems considering network connectivity and motion detection.

The results show that the smart surveillance system using ESP32 and camera-based motion detection with IM Technology differs from the traditional camera in server performance, camera location, and real-time surveillance. As Maina (2013) emphasized, “Instant Messaging (IM) has completely revolutionized the way we socialize and communicate with each other. It has made communication much easier and quicker and more convenient.” The utilization of the instant messaging method in disseminating information with the most desirable features opened up doors for achieving much more convenient ways of passing data, which is crucial within the contemporary period since the demands of current citizens of communities are mostly subjected to various instantaneous entities. The urge to acquire a highly responsive tool for the proposed project made the researchers include the Instant Messaging technologies available to craft the product that could potentially accomplish the aims of the perpetrators of the project.

According to Fielding (2023), while continuous recording and infrared night vision are features that CCTV cameras offer, their image quality and storage options may be limited. Furthermore, as stated by Muts (2023), one can identify indications such as rapid bursts of flames, suspicious persons, movement and behavior patterns, item features, and face recognition. Real-time surveillance can prevent illicit activity before it starts. The results show that the smart surveillance system using ESP32 and camera-based motion detection with IM Technology differs from the traditional camera in server performance, camera location, and real-time surveillance.

4. Conclusions

Based on the findings given, the following conclusions are presented: The smart surveillance system using ESP32 and Camera-based motion detection with IM Technology is very highly effective in prompt sending of notification, functioning PIR motion and ESP32 camera, effective in giving an alert, and the product is highly recommended for implementation in facilities of the area. The network connectivity is good for the smart surveillance system and traditional CCTV. The server performance of the smart surveillance system is highly reliable, and the traditional CCTV is moderately reliable. The camera's location is optimal for surveillance purposes for both smart surveillance systems and traditional CCTV. The smart surveillance system is somewhat effective in motion detection and has a moderately better level of effectiveness in real-time surveillance. The effectiveness of the smart surveillance system using ESP32 and Camera-based motion detection with IM Technology in terms of motion detection and real-time surveillance is affected by the server performance. Significant differences exist between the smart surveillance system and traditional CCTV in terms of server performance, camera location, and real-time surveillance.

4.1 Recommendation

From the findings presented, the following recommendations are offered: Based on the effectiveness of smart surveillance using ESP32 and Camera-based motion detection with IM Technology, this system may be produced and made available commercially in the locality and in other places. Investors, businessmen from the locality, and other interested entities may support this enhanced technology that will help the local community's safety. For prospective users, it is recommended that the product be installed with a good signal for more accurate and faster data sending to the Telegram application than the regular CCTV. It is advisable to implement the night vision feature of the ESP32 CAM and to conduct tests under low-light conditions for better security and to improve the system's overall performance. Future researchers may explore additional features by sending a video using ESP32 through the IM technology.

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