CYPHER: Implementation of an IoT-based Smart Security Camera System with Image Detection and Email alert using Raspberry Pi

Patric Ian Cortez, Bruce Mendoza, Emdrey Quijano
College of Computer Studies
Angeles University Foundation
Angeles City, Philippines
cortez.patrician@auf.edu.ph, mendoza.bruce@auf.edu.ph, quijano.emdrey@auf.edu.ph

Jonilo C. Mababa
College of Computer Studies, Faculty
Angeles University Foundation
Angeles City, Philippines
jonilo,mababa@auf.edu.ph

Abstract

The Philippines is ranked as the least peaceful Asian country in accordance with common crimes like burglary, theft, and kidnapping. Additionally, 60.5% of these criminals enter a property violently by smashing through a window or a doorway. That's why it is essential to have a security camera system because the mere sight of a security camera can signal the presence of the law and deter criminals. The study proposed by the researchers is to develop and install an IOT-based Smart Security Camera System to monitor and detect any disturbances inside the XVLOZADA Hardware at Fil-Am Friendship Hwy, Angeles City. The smart security camera system is built using Raspberry pi 3b with camera and IR led, the researchers used OpenCV and Python Flask to launch the web server of the security system. The smart security system is packed with smart features like Image recognition, Email notification alert, Cloud storage, Video Recorder, and Account management. Whenever the system detects a human within its line of sight, it will use object detection to capture and notify the client immediately. In addition, the images captured by the system will be stored in the cloud which can be accessed anytime using the web application. The purpose of this study is to guarantee the wellbeing and security for the client, because present day business surely requires a smart system which is low-cost and requires little or less human exertion.

Keywords
Security camera, IOT, Object detection, Low-cost, Cloud storage

1. Introduction
According to (Statista Research Department 2021) the most frequent record of crime in the Philippines is robbery and theft. In 2020, there were nearly thousand instances of theft and robbery reported in the Philippines. On top of that, 60.5% of these criminals are using brute force to enter a property. Criminals are using force like breaking windows, lock-picking, kicking in entryways and more to enter a property (Sofroniou 2020). In addition, when it comes to typical crimes like burglary, theft, and kidnapping which is why the Philippines is also considered to be the least peaceful country in Asia (DataLeads Asia News 2022) Luckily, Security Camera Systems are becoming more relevant especially for Retail stores and businesses. Having a security camera system is important because seeing a security camera alone lays out the presence of the law and can act as a deterrent for criminals. In fact, clients entering a store who realize they are being recorded are less likely to steal (Vigderman and Turner 2021). In addition, security cameras make life safer and simpler for property owners and business managers because this helps them distinguish any individual who has carried out wrongdoing in their office or home. Security cameras additionally help to prevent theft by workers, particularly in retail and office setup (Bennett 2018).

Today, there are a wide range of Smart Security System accessible on the lookout. However, they are over the top expensive. Clients should consider four things when installing a home security camera: Hardware cost, Monthly fees, Installation, and Activation fees (Perry and Allen 2022). That's why researchers come up with ideas utilizing The Internet of Things (IoT) which introduces the Internet by empowering simple access and collaboration with a broad assortment of gadgets like Computer, Camera, Sensors, etc. The IoT enables all devices and appliances to be connected to the internet and monitored remotely.

The IoT deals with the improvement of various applications that use hardware and data to execute further convenience to many people (Sri et al. 2021). Furthermore, this project explains the plan and execution of an IoT-based security camera system called CYPHER that would be utilized by the XVLOZADA hardware store owner at Fil-Am Friendship Hwy, Angeles City which has been a victim of burglary. By using raspberry pi board and Night Vision camera module as its main hardware components. The features include Live Camera feed, Night Vision Capabilities, Cloud data storage, Image Recognition, and Email Alert. It is notable that the impact of present-day innovation has arrived at its pinnacle, with the appearance of computerized and wireless advancements, security frameworks become smarter (Sruthy et al. 2020).

1.1 Objectives
The purpose of this study is to develop a Smart Security System which is cost-efficient and packed with features like Image Recognition, Night Vision Capability, Real-time Email alert, live security feed with web application, and Cloud storage for the images and video.

1. To develop a Smart Security Camera System with Image Recognition and Real-Time Email alert
2. To develop a Smart Security Camera System with free cloud-based storage using Google Drive
3. To develop a Smart Security Camera System using Raspberry pi and IoT to take out any added cost and monthly fees for the system.

2. Literature Review
IoT simply refers to a combination of gadgets that are connected to the internet. IOT is developing at a quick rate as a lot of gadgets and articles are focusing on the internet. Security is an exceptionally helpful utilization of IoT using this to make a cost-efficient security framework for homes and businesses (Ranger 2020). In addition, another groundbreaking discovery of the IoT is the ascent of the Maker. The Maker culture empowers specialists and experts to make their own gadgets as well as play around with the existing ones to track down answers into a particular issue. According to (Rosebrock 2019), the Pi surveillance camera is a good fit to create an IoT, making it possible for the Raspberry Pi to send txt or Email message alerts, pictures, and video footage when the surveillance camera is set off.

As stated by (Tholen Celeste 2021), security systems are a combination of electronic gadgets with a main control board to protect against criminals and other expected home invaders. Home security is a vital part of a home automated system. As stated by the main goal of the study called "A review advancement of security alarm system using IoT" (Çavaş and Ahmad 2019), the plan is to create a prototype security system which can alarm the user and others if ever an intruder has been detected by sending a message through the user's phones. Some notable features of the system proposed are the capacity of the sensors to inform the property owner when the door is opened by sending an alert through SMS. Furthermore, the hardware that is used in this study is also affordable, which makes the project a more viable option. The beneficial thing about this framework is it can likewise be upgraded to add additional security highlights like cameras for future research study.

Home security is becoming important these days as the potential outcomes of intruders and criminals are expanding each day (Sisavath and Yu 2021), The utilization of IOT inside the homes or businesses permits the user to control almost everything from a single device, this allows the user to control their home security to add comfort and satisfaction (Grant 2020). Furthermore, it also draws comparison in the paper cited for PSNR. Setiadi's article also cites a finding that SSIM, in comparison, can be sensitive to the loss of quality that happens with JPEG format compressions.

3. Methods

The developed system helped the client to detect any unwanted guest inside the hardware store during closed hours. Furthermore, as shown in the figure below, the system will send a real-time notification alert whenever the system detects a person and a live feed security feed to verify if there is a burglar inside the hardware store. In addition, in case of internet interruption, the system also has a backup functionality which will save all the video recordings into the local drive. Afterward, if the internet is up, the system will upload all the video into the cloud. The developed system will help the hardware store to automate their security needs inside the store.
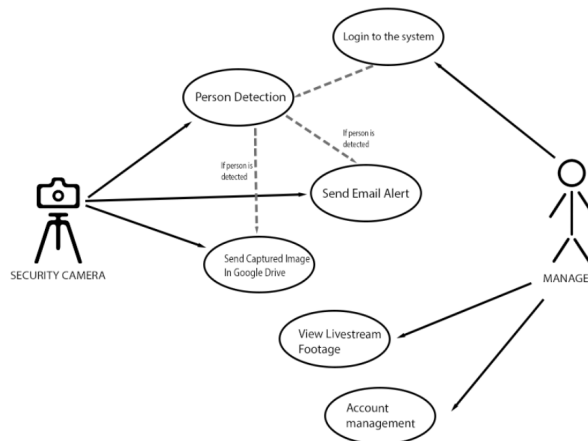
Figure 1. Use case diagram

3.1 Hardware utilization

The researchers produced various inexpensive hardware like Raspberry pi 3b, RPI Camera Night Vision Module IR sensor, and SD card as shown in the figure below. Additionally, to avoid the possibility of the system overheating, the researchers incorporated a heatsink, which helps dissipate heat, a fan, which helps with the airflow and aids in cooling, and an aluminum case, which is known for its heat-conducting properties into the system. These additions work together to regulate the temperature and ensure the system functions optimally.
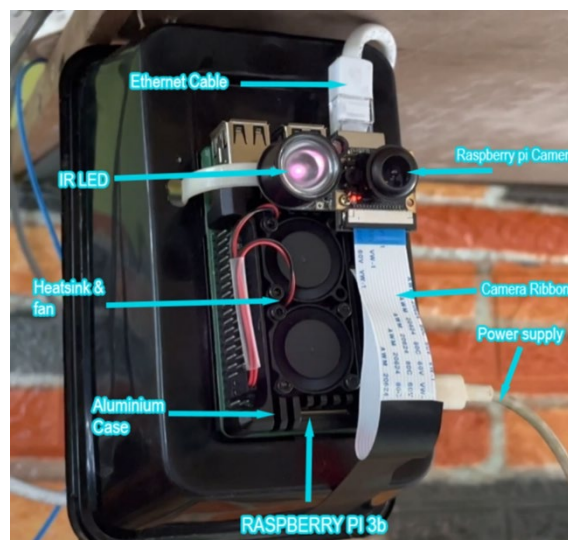
Figure 2. System hardware

3.2 Object detection

For the Object Detection, the researchers used OpenCV. OpenCV contains a lot of pre-configured classifiers that can be utilized to recognize and detect if there is a person. Individuals can use any of these classifiers to recognize the object according to what the user desires. The method that the researchers used to detect a human is the HAAR cascade. The OpenCV library deals with a repository containing all well-known HAAR cascade that can be utilized for human body detection. This is beneficial for the researchers because this prevents false alarms like; pets who are crossing the field of view of the camera, or so that other objects in general which are moving won't trigger the alert feature.

The researchers used python to implement features like Image Recognition alert in transforming a Raspberry Pi with a camera into a security camera framework.

3.3 System account management

The system's web server is built using Flask and can be accessed through any web browser. To reach the admin's home page, users are prompted to enter their username and password on the login page.

Once you have logged in, you will be directed to the main landing page. This page includes the live security feed and the video recorder of the system. Additionally, as indicated in the figures below, it features a navigation bar that provides access to various sections, such as home, add user, users, and settings.
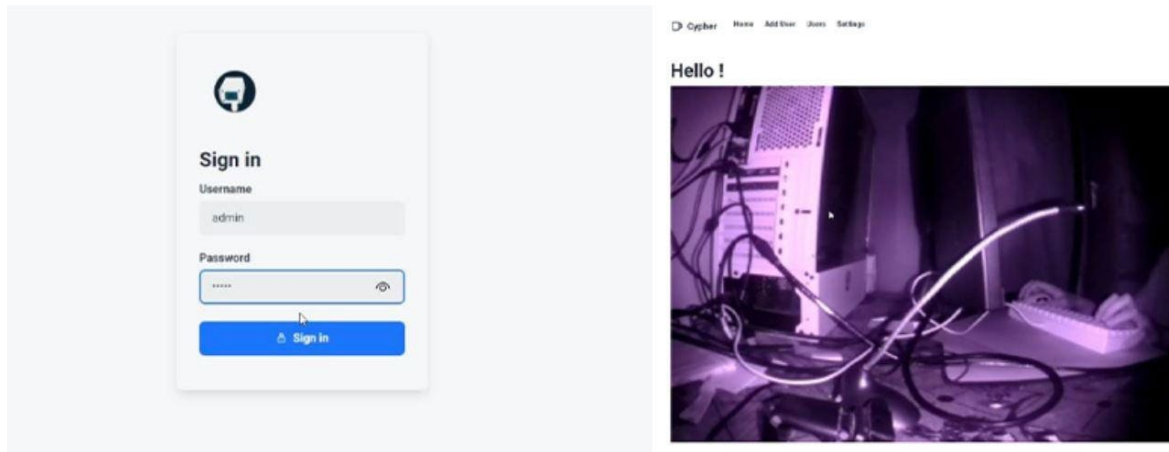

Figure 3. Login page and home page

Within the database, an administrator has the privilege to modify and remove user information, whereas a regular user can only observe the live stream and does not possess the authority to alter or erase other user data.

Figure 4. User manager

3.4 System Backup Functionality

In addition, in order to prevent the system from occupying the cloud storage, the researchers will use the Cron job, this will carry out a functionality in the proposed system which will save the video recorded locally before sending it to the cloud. As indicated in the figure below.
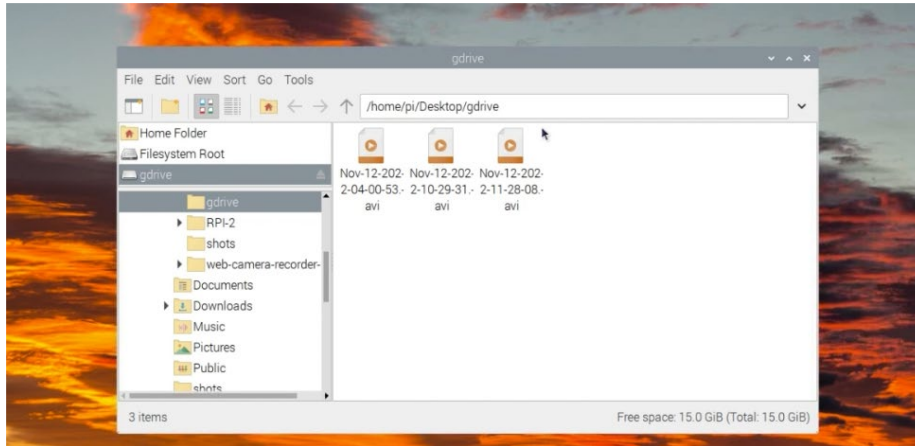

Figure 5. Rclone storage

Afterwards, as shown in the Flowchart figure below, the researchers will also create Crontab scheduler to delete the individually saved videos inside local file every after 7 days or 1 week every 10:30 PM Sunday.
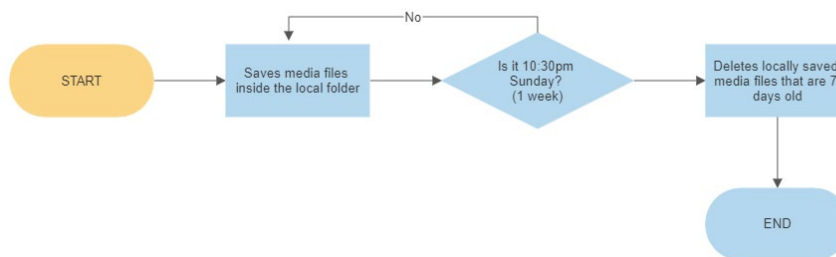

Figure 6. Deletion process flowchart

Lastly, the researchers also added a setting that automatically starts all the Python Scripts including the webserver when the system boots up, this is to enable the user/manager from running the system independently without configuring the system using mouse and keyboard.

4. Results and Discussion

4.1 Hardware temperature assessment

While the system was operational, the researchers conducted a test on the Raspberry Pi. The outcome revealed in the figure below that the temperature ranged between 43°C to 44°C after running the system for several hour, which is considered satisfactory because the Raspberry Pi's maximum temperature is 85°C.

Figure 7. Hardware temperature

4. 2 Object detection assessment

During the testing process, one of the researchers will act as the test subject by walking towards the camera. Upon entering the camera's range, the researchers will initiate the timer and begin counting the seconds until the system detects the test subject, at which point the researchers will stop the timer. After conducting 10 trials, the researchers will test the system's detection rates in a different environment by comparing its performance in a well-lit room and a poorly lit room.
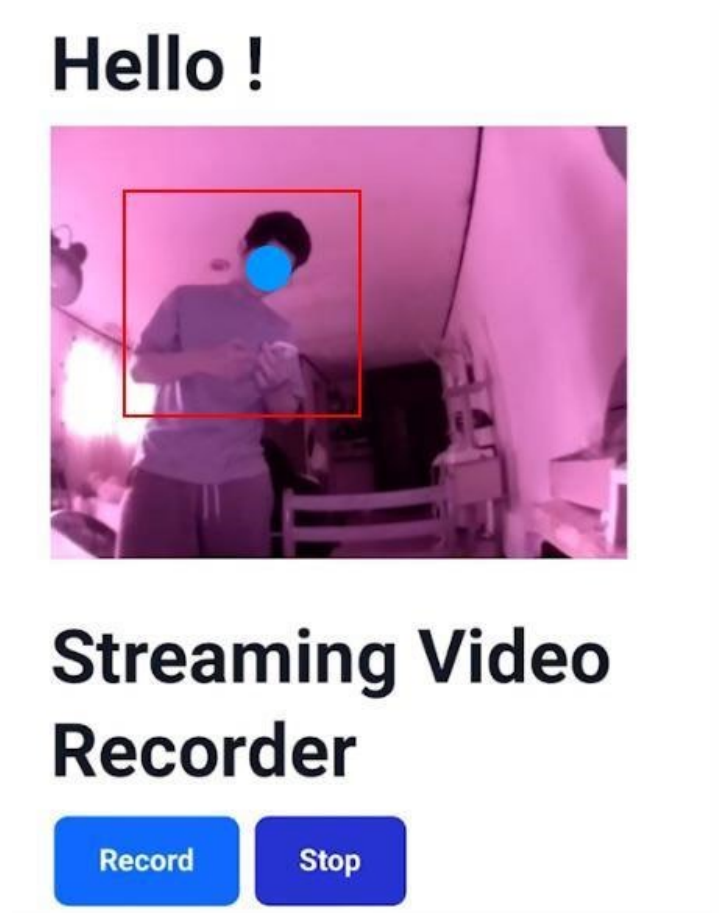

Figure 8. System livestream screenshot

Tables 1 and 2 display the results of trials conducted with and without lighting. The research findings indicate that there is a slight delay in detection time during nighttime conditions, but this does not significantly impact the overall performance of the system and the system remains effective.

0.1 – 2.0 sec = 4 points (very fast)
2.1 – 3.0 sec = 3 points (fast)
3.1 – 4.0 sec =2 points (slow)
4.1 – 5.0 sec = 1 point (very slow)

Table 1. Lights on Trial

LIGHTS ON TRIAL	Detection time (Per second)	Did the system detects a person?
Trial 1	1.4	YES
Trial 2	1.3	YES
Trial 3	2.2	YES
Trial 4	1.9	YES
Trial 5	1.9	YES
Trial 6	2.3	YES
Trial 7	2.1	YES
Trial 8	1.4	YES
Trial 9	1.6	YES
Trial 10	1.7	YES

Table 2. Lights off Trial

LIGHTS OFF TRIAL	Detection time (Per second)	Did the system detects a person?
Trial 1	2.4	YES
Trial 2	2.5	YES
Trial 3	2.1	YES
Trial 4	2.4	YES
Trial 5	2.1	YES
Trial 6	1.9	YES
Trial 7	2.4	YES
Trial 8	2.2	YES
Trial 9	2.5	YES
Trial 10	2.1	YES

Based on the information presented in the table, it can be concluded that the system's detection accuracy is fast and functioning as expected

Table 3. Detection accuracy

TRIAL	AVERAGE DETECTION (per second)	DETECTION ACCURACY
DAYTIME	1.78 per.sec	Very fast
NIGHTTIME	2.26 per sec	fast

4. 3 Statistical Evaluation

Total results of three (3) IT professionals who answered the survey using ISO 25010 survey in order to measure and evaluate the system's product quality. For a total of 32 question, 81.4% of the 3 IT experts answered excellent, and the rest of the 15.16% answered very good as indicated in the Statistical evaluation bar graph.
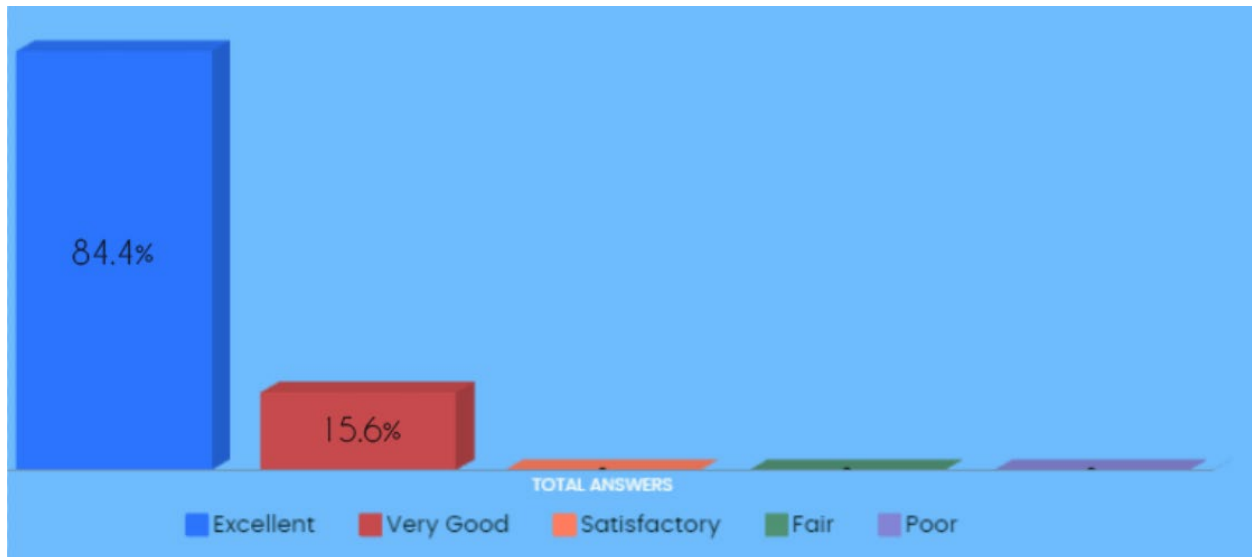

Figure 9. Statistical evaluation bar graph

5. Conclusion

According to the data that's been gathered, the XVLozada hardware store has been a previous victim of burglary during night time, reason for them to install CCTV cameras around the store to prevent those kinds of events from happening. However, the manager of the store discovered some inconvenience while using their current security system, which includes some added fees from installing the security system, high power consumption, and inaccurate or misleading motion detection. With that said, the researchers proposed a smart security system which will allow the store manager to detect person and be notified whenever a person has been detection through Gmail alert, The system also includes a video recorder which will record and save all of the media file from the local media file to the cloud using google drive, lastly, the security camera system also includes a IR led which will help the camera to detect objects even in dark areas.

The proposed Smart security camera system implemented for the XVLozada hardware store enhances and improves the hardware store's security because of the added features from the system. The manager can now rest assured that the system will not give false alerts since the smart security system only detects and sends email whenever it detects a person. The manager also does not need to worry about maintaining storage capacity since all of the recorded videos and screenshots are stored using cloud storage for free.

Future researchers may consider the following suggestions/recommendations for enhancing the current security camera system:

- Using better and latest hardware like Raspberry pi 4 to get better overall performance of the system.
- Purchasing or preferably 3D printing a custom for the Raspberry pi in order to mount the system properly.
- Future researchers may also consider using a pan tilt camera to get a better viewing angle from the security system.

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Biographies

Patric Ian Cortez is a student from Angeles University Foundation, taking up B.S. in Information technology under the specialization of IT Infrastructure. His research interest encompasses all the fields included in the thesis paper.

Bruce Mendoza is a student from Angeles University Foundation, taking up B.S. in Information technology under the specialization of IT Infrastructure.

Emdrey Quijano is a student from Angeles University Foundation, taking up B.S. in Information technology under the specialization of IT Infrastructure.

Jonilo Mababa is an instructor at the College of Computer Studies at Angeles University Foundation, Angeles City. He holds the positions of Program Chair and Internship Coordinator in the CCS Department, as well as the role of President in PSITE Central Luzon.