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Security Intruder Detection System Using IoT

Zhi Xuan Lee, Mohd Rushdi Idrus

School of Computing, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia
*Corresponding Author: rushdi@uum.edu.my

Abstract: This paper aims to design and develop a Security Intruder Detection System using the Internet of Things (IoT). IoT is a system with interconnected computing devices and mechanical and digital devices. Intruder Detection System is a system that manages to identify the intruder through a sensor and respond to prevent property loss and protect self-safety. This system is designed to be as cheap as possible to ensure everyone in the world can buy this system. The sensor used in this system is Door/Window magnetic sensor which is the cheapest, and ESP32-CAM.

Keywords: *Intruder Detection System, ESP32-CAM, Security, IoT*

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1. Introduction

The world has become increasingly insecure due to economic recession and the pandemic. As a result, the poor people are getting poorer while the rich people are getting richer. This situation has caused many people to have no choice but to commit crimes like robbing or stealing things from others, and this action has caused some people to lose their lives or belongings. Like other countries, Malaysia has been listed as among the country in South East Asia with high crime rates. Frequent stealing and robbery incidents happen around the country daily, like breaking into houses. For example, Petaling Jaya and Johor Bahru were listed as the ten most crime-ridden Asian Cities by worldatlas.com in 2016. However, this problem can be reduced with the help of current technology. As a result, Malaysia's crime index ratio per 100,000 population in 2017 improved to 309.7 against 2016 (355.2) [6].

The Internet of Things (IoT) is an emerging paradigm that enables the communication between electronic devices and sensors through the Internet to facilitate our lives. IoT uses intelligent devices and the Internet to provide innovative solutions to global challenges and issues related to various business, governmental and public/private industries [9]. Moreover, the authorities and citizens depend on this technology to protect people's lives and belongings [10].

Intruder Detection System is a system that helps users to prevent intruders from entering private compounds. It can be done by implementing sensors or detectors to monitor any unwanted entry to a building. Many intruder detection systems have been invented and released into the market, but most of the prices of them are considered expensive, especially for poor people who cannot afford to buy them.

So this Security Intruder Detection is designed for the lowest price to ensure it is affordable to everyone. This system was designed as quickly as possible to ensure every user could learn to use it easily. This system's functionality had only reached the minimum requirement to secure a room. ESP32-CAM is a low-cost development board with a built-in WIFI camera. This board created IP camera projects for video streaming with multiple types of resolutions. ESP32-CAM also captures photos through a web server or standard pin [3].

On the other hand, Blynk is a platform that helps users build a project's interface quickly and simple. Blynk helps users control and monitor their hardware projects, whether in IOS or Android. Blynk can be easily installed in AppStore or Play Store, and users can create the interface by just dragging and dropping the widget provided by Blynk [8]. Arduino is a free platform used to build an electronics project. It provides hardware and software support to the user, hardware in terms of electronics board,

Corresponding Author: Mohd. Rushdi Idrus, School of Computing, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, 04-9285095

sensors and many other components, software in terms of its own IDE that help the user communicate with the hardware by coding in the IDE and uploading it to the software [4].

2. Background and Related Studies

An intruder detection system is widely used worldwide and helps secure and monitor a place or room. This system is mainly used to secure places that do not allow unauthorized people, like the control room of a particular facility or military. Nevertheless, intruder detection systems are also commonly implemented at home due to increased crime rates.

National Chiao Tung University invented an intruder detection system using Zigbee wireless sensor module around the environment to monitor and identify intruders and abnormal situations. It then transmits an alert to the monitor centre through a wireless network. If an intruder is detected, the robot will be located at the location, capturing an image and transmitting the image to the mobile devices and the user to obtain the real-time situation [1].

An intruder detection system was also invented by embedding proposed a new algorithm to detect an intruder in the room, the basic idea is to estimate the variation of features from room acoustic transfer function, but instead of using image method or ray tracing method, they used Gaussian noise which is the broadband signal [2].

3. Methodology of The Study

The Waterfall Model was adapted to develop the intruder detection system. It is a straightforward and easy-to-understand methodology for software development. Every phase of the waterfall model must be completed before entering the subsequent phases. The waterfall model is also known as the earliest SDLC approach for developing software. Although the Waterfall model has few advantages, it is easy to use because all the phases are easily understandable and explainable. Besides, the Waterfall model can be easily managed because of its inflexibility. So, the Waterfall model can be advantageous in a small project. The disadvantage of the Waterfall model is that it is complicated to calculate time and cost for each phase, and once the application has reached the testing phases, it will be difficult to change something in the concept stage [5].

The first phases of the Waterfall model involve understanding and identifying the system's requirement, design and purpose. Next, system design helps specify all the hardware and software requirements and determine the system architecture. After identifying all the inputs in the system design phases, all the input is used to develop a small system called units, and each unit developed will be tested for its functionality.

All the units tested in the implementation phases will be integrated into the system, and then a post-integration system will be tested for any bugs or errors. After the functionality and non-functionality of the system have been tested, the system will then be released to the customer. Again, fixes and patches will need to be done and released if the customer has discovered any bugs, bad feedback or improvement.

4. Design and Development

This section describes the design and the development of the Intruder Detection System. This section has been divided into two sections: (1) the requirement of the intruder detection system to respond after an intruder is detected, and (2) a mobile application is developed to demonstrate and gather the requirement.

The requirement gathering process was carried out using two methods: interviewing the student at UUM and analyzing the data through the Internet. The interview was conducted informally at the UUM dormitory, and several questions were asked mainly on the primary feature of a mobile application for the intruder detection system. An example of a question that has been asked was, do you think login and registration function is necessary and what feature do a mobile application that can control intruder detection system should have? The data had been recorded and documented. The requirements include system installation, registration, login, switch on/off, and intruder detection, as shown in Table 1.

Table 1. List of Requirement

ID	Requirement Description	Priority
IDS_01	System Install	M
IDS_01_01	The technician will help the user to install the system in their home or room.	M
IDS_02	Register	D
IDS_02_01	Users must register before using the system.	D
IDS_02_02	The system must display a page that allows a contractor to key in their site login detail: a) User ID b) Password	D
IDS_02_03	The system must display a page that allows a contractor to key in their details: a) First name b) Last name c) Email d) Password e) Address f) Activation Code g) Phone number	D
IDS_03	Login	D
IDS_03_01	Users must log in to the system by keying in the user ID and password.	D
IDS_03_02	If the user forgets the password, they must key in their email and user ID to recover their ID or password.	D
IDS_04	Switch On/Off	M
IDS_04_01	Users must switch on the system before going out of the area.	M
IDS_04_02	Users must switch off the system before coming into the area.	M

IDS_04_03	The user can switch on and off the system through mobile apps	D
IDS_05	Intruder Detection	M
IDS_05_01	The system detects the intruder through the Door/Window sensor.	M
IDS_05_02	The system will send a notification to the user.	M
IDS_05_03	The system will activate the alarm.	M
IDS_05_04	The user can activate or deactivate the alarm through the mobile app.	D

The requirement shown in Table 1 is translated into computer system functions and has been visualized and modelled. The requirement is modelled using a suitable model method and tools, Unified Modelling Language (UML). The models used in this work are a use-case diagram, sequence diagram and class diagram [7]. The diagrams were drawn using visual paradigms. Figure 1 illustrates the use-case diagram of the system that shows the communication between the actor and use cases. It helps to show the behavior of the system and also helps to design a system from the end-user perspective. This system has five major use cases: login, switch on/off, view photo, maintain and service and lastly, detect break-in. The use cases of a detect break-in will notify the user once an intruder is detected.

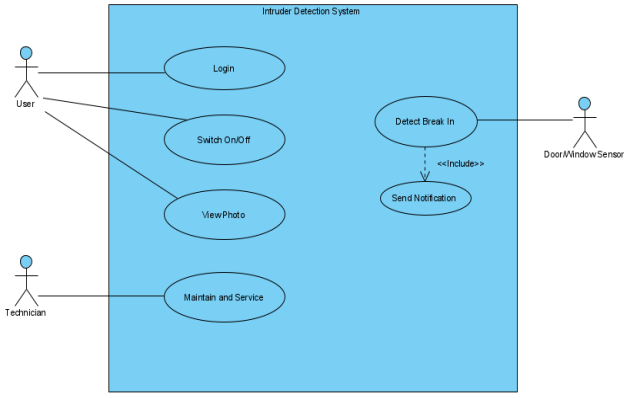

Figure 1. Use-case Diagram of Intruder Detection System

The use cases diagram only summarises some relationships between the actor and use cases. Moreover, it does not show the actual flow of the activity, so to visualize the activity flow of the system, a sequence diagram is illustrated in Figure 2.

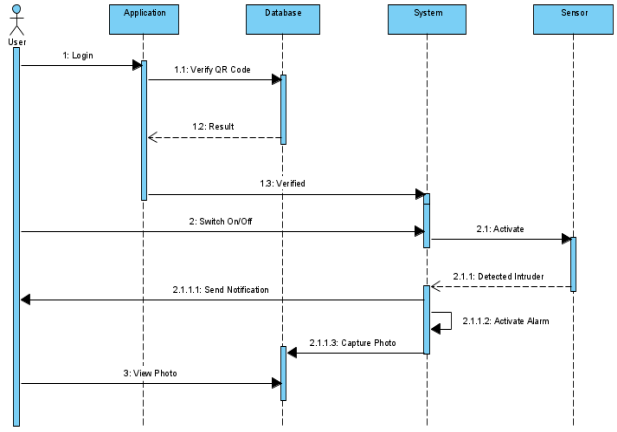

Figure 2. Sequence Diagram for Intruder Detection System

A sequence diagram shows how an operation is carried out by showing the interaction between objects in a time sequence. The structural component of the mobile application for the intruder detection system and the sensors are illustrated in Figure 3. There are two classes for mobile applications and four classes for hardware parts.

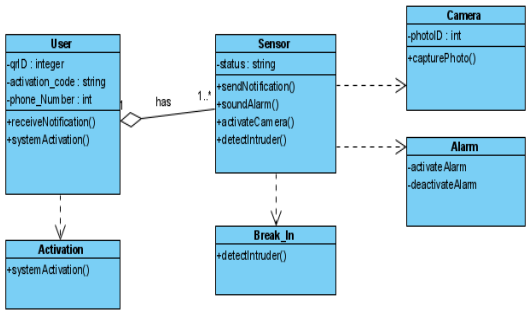

Figure 3. Class Diagram for Intruder Detection System

5. Prototype Development

A mobile application prototype was developed to control the intruder detection system and view the camera's photo capture. Software prototyping is the best way to demonstrate and identify the software requirement by gathering further feedback from the user based on their experience after interacting with the prototype. Blynk had been used to develop the mobile application for the intruder detection system. Blynk is a platform in IOS or Android apps that help user to communicate with Arduino, Raspberry Pi and others. The interface of the login page and system main page had been shown in Figure 4 and Figure 5.

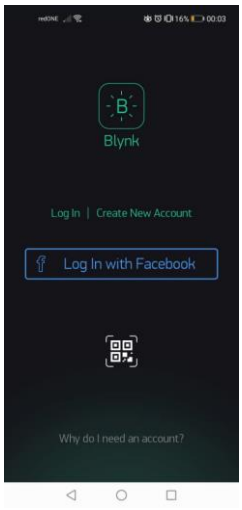

Figure 4. Interface for login page

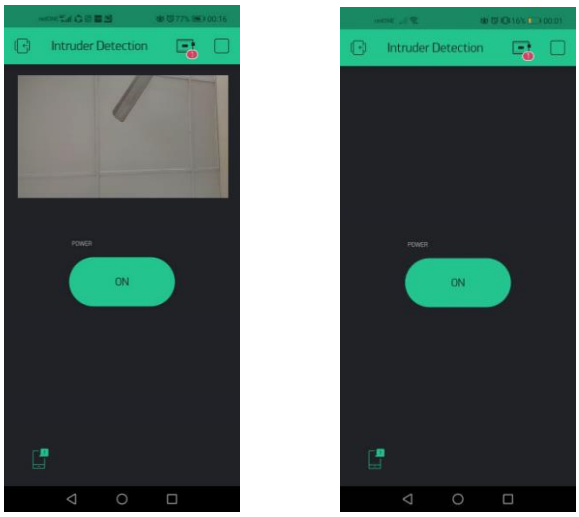

Figure 5. The interface of the system before capturing a photo and after capturing a photo

Figure 7. ESP32-CAM

ESP32-CAM is a low-cost development board with a built-in WIFI camera. This board created IP camera projects for video streaming with multiple types of resolutions. ESP32-CAM also captures photos through a web server or standard pins [3].

Figure 8. Door/Window magnetic sensor

The door/Window magnetic sensor is a very low-cost sensor. This sensor can be installed on doors, windows or any other object that can be opened or close. This sensor contains a magnet on one side and a sensor on the other. Once the magnet has been separated from the sensor, it will transmit a signal to the control system.

Figure 9. 3-24V Piezo Electronic Tone Buzzer

3-24V Piezo Electronic Tone Buzzer is a buzzer that works on 3900+-500Hz frequency and can support sound pressure at a maximum of 95dB. The range power supply is 3V – 24V, which supports high voltage projects with a max current of 10mA.

Figure 10. Arduino Uno

Arduino Uno is an open-source microcontroller board developed by Arduino.cc. The board has multiple sets of digital and analog input/output (I/O) pins that can help expand various boards or other circuits. The board contain 14 digital (I/O) pins and six analogues (I/O) pins and is programmable by Arduino IDE.

6. Evaluation

The evaluation was conducted on 30 participants recruited through email and WhatsApp for this study. The target participants for this evaluation were students and lecturers. The instrument used during the evaluation are Blynk apps, used to access the interface of the system; Google Form, an online questionnaire tool used to collect feedback from the target audiences; WhatsApp social media platform, used to share questionnaire surveys and the project hardware, which is the complete system and the sensors. The Google Form questionnaire was divided into two sections with 32 questions. Section A asked the respondents' demographic information, while Section B asked the respondents' opinions about the application on a seven-point Likert scale where one represents strongly disagree, and seven represents strongly agree.

Based on the analysis, 96.6% of the respondent is student and 3.33% of the respondent is lecturer, 53.33% of the respondent is around Male and 46.7% of the respondent is around Female, 6.5% of the respondent is from semester 3-4, 45.2% of the respondent is from semester 5-6, 35.5% of the respondent is from semester 7-8, 9.7% of the respondent is from semester 9 and 3.2% of the respondent is lecturer, 19.4% of the respondent Less, 29% of the respondent Moderate, 41.9% of the respondent Many and 9.7% of the respondent Most, 13.3% of the respondent did not experience any theft cases in their dorm or room, 86.7% of the respondent had experience a few theft cases in their dorm or room and 0% of the respondent had experience many cases of theft cases, 80% of the respondent say yes if they left something meaningful in their room, 20% of the respondent say no if they left something meaningful in their room, 70% of the respondent say yes that they were satisfied with their dormitory or school security, 30% of the respondent say no that they were not satisfied with their dormitory or school security. 63.3%% of the respondents say that they wish to have an intruder detection system if the price is affordable, and 36.7% of the respondents say no that they did not wish to have an intruder detection system even if the price is affordable.

Analysis was conducted in Section B. This section measures the usefulness and ease of use of the system. It also measures the satisfaction and stability of the system. Tables 2, 3, 4 and 5 reported the frequency and average of the responses. Most respondents rated five, six or seven of the post-task scales for the three usability aspects. None of the respondents rated one and two. Only a few rated 4, which is neutral, and three slightly disagree.

Table 2. The respondents' responses on the usefulness of the system.

Usefulness	**1**	**2**	**3**	**4**	**5**	**6**	**7**
The Mobile Intruder Detection system made my room/dorm more secure.	0	0	0	0	3	18	9
The Mobile Intruder Detection system helps me to monitor my room.	0	0	0	0	5	17	8
The Mobile Intruder Detection system makes me feel more secure when I leave my room/dorm.	0	0	0	0	5	18	7
The Mobile Intruder Detection system meets my needs.	0	0	0	1	9	16	4
The Mobile Intruder Detection system does everything I would expect it to do.	0	0	0	1	8	17	4

Table 3. The respondents' responses on ease of use of the system.

Ease of use	**1**	**2**	**3**	**4**	**5**	**6**	**7**
The Mobile Intruder Detection system is simple to use.	0	0	0	0	2	8	20
The Mobile Intruder Detection system is user friendly	0	0	0	0	2	12	16
The Mobile Intruder Detection system is flexible.	0	0	0	2	9	16	3
The Mobile Intruder Detection system is easy to learn how to use it.	0	0	0	0	5	17	8
I can use the Mobile Intruder Detection system without written instructions.	0	0	2	1	5	16	6
I can easily remember how to use the Mobile Intruder Detection system.	0	0	0	0	8	15	7
I don't notice any inconsistencies as I use the Mobile Intruder Detection system.	0	0	0	1	10	14	5
I can recover from mistakes quickly and easily when using the Mobile Intruder Detection system.	0	0	0	1	5	22	2
I can use the Mobile Intruder Detection system successfully every time	0	0	0	0	5	17	8

Table 4. The respondents' responses on their satisfaction with the system.

Satisfaction	**1**	**2**	**3**	**4**	**5**	**6**	**7**
I am satisfied with the Mobile Intruder Detection system.	0	0	0	0	4	21	5
I would recommend the Mobile Intruder Detection system to my friend.	0	0	0	2	13	9	6
The Mobile Intruder Detection system works the way I want it to work.	0	0	0	1	11	16	2
I feel I need to have a Mobile Intruder Detection system.	0	0	0	0	8	14	8
The Mobile Intruder Detection system is wonderful and pleasant to use.	0	0	0	0	13	12	5

Table 5. The respondents' responses on the stability of the system.

Stability	**1**	**2**	**3**	**4**	**5**	**6**	**7**
I can get the picture in the app every time the sensor activates.	0	0	0	0	2	11	17
The alarm sounds every time the sensor is activated.	0	0	0	0	4	5	21
The power button of the system works perfectly.	0	0	0	0	1	12	17
The Mobile Intruder Detection system is secure.	0	0	0	0	9	14	7

The evaluation's overall result indicated that Intruder Detection System is useful and easy to use. The respondents also reported that they were satisfied with the feature of the mobile application in detecting the intruder and responding.

Many respondents conclude that the system helps them feel more secure when they leave their room. In terms of the user interface, the respondent also concluded that Mobile Intruder Detection System was easy to use without any help of instruction. However, quite some respondents had only rated 5 in the system in security. Most of them comment because they feel unsecure to log in using QR code only.

7. Conclusion and Future Works

This paper describes the design and development of a mobile application and prototype hardware, a sensor to detect intruders and respond when intruders are detected. The project manages to design in a very low-cost and efficient material. Many aspects can be improved in terms of functionality. We plan to add the photo capture functionality by the camera, which can be saved to external storage as a backup and help record capture time.

The limitation of the Mobile Intruder Detection System is that the system's security is less secure. We plan to improve the security by adding a login and register page into the system. The project is considered successful due to the overall users' acceptance which also proves that the project is conducted according to the requirement. The project's major success is the hardware component, the ESP32-CAM, Door/Window magnetic sensor, buzzer and cellular connections.

8. References

[1] K. T. Song, Intruder detection system and method. U.S. Patent No. 8,111,156. 7 Feb. 2012. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[2] Y. K. Choi, Acoustic intruder detection system for home security, IEEE Transactions on Consumer Electronics, Vol. 51 No. 1, 130-138, 2015.

[3] M. F. Wicaksono, D. R. Myrna, Implementasi Arduino dan ESP32 CAM untuk Smart Home, Jurnal Teknologi dan Informasi (JATI) Vol. 10 No. 1, 40-51, 2020.

[4] Arduino, Store Arduino. "Arduino." Arduino LLC (2015).

[5] N. M. A Munassar, A. Govardhan, A comparison between five models of software engineering, International Journal of Computer Science Issues (IJCSI), Vol. 7 No. 5, 94, 2010.

[6] Department of Statistics Malaysia, Press Release Crime Statistics, Malaysia, 2018.

[7] H. Gomaa, Software modeling and design: UML, use cases, patterns, and software architectures, Cambridge University Press, 2011.

[8] H. S. Doshi, S. S. Minesh, S. A. S. Umair, Internet of Things (IoT): integration of Blynk for domestic usability, VJER-Vishwakarma Journal of Engineering Research, Vol. 1, No. 4, 150-157, 2017.

[9] A. R. Sfar, C. Zied, Y. A. Challal, Systematic and cognitive vision for IoT security: a case study of military live simulation and security challenges, in Proceeding of 2017 international conference on smart, monitored and controlled cities (SM2C), Sfax, Tunisia, 17–19 Feb. 2017.

[10] Z. M. Dahalin, M.R. Idrus, M.K. Kasiran, A. R. Rahmat, R.A., N.N.A Wahab, Online services index performance: Countries' analysis in OSI ranking to improve Malaysia UN ranking, International Journal of Innovative Technology and Exploring Engineering, Vol. 8 No. 8, 116–172, 2019.