Research and Innovation in Technical and Vocational Education and Training Vol. 2 No. 1 (2022) 011-020

RITVET

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/ritvet
e-ISSN : 2785-8138

IoT-Based Occupancy Display System in Office

Siti Balqish Aidil[1], **Alias Masek**[1]*

[1]Faculty of Technical and Vocational Education,
Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/ritvet.2022.02.01.002
Received 1 March 2022; Accepted 11 March 2022; Available online 30 March 2022

Abstract: A structured organization consisted of management personnel is important for an educational institution as each personnel must carry out their responsibility to achieve the goals set for each department. However, most of the management personnel in Faculty of Technical and Vocational Education (FPTV) at Universiti Tun Hussein Onn Malaysia (UTHM) also worked as a lecturer which requires them to manage their time with lectures and meetings. As this leads to the inflexibility of their schedule, it is difficult for any students to set up a personal appointment with them especially for the final-year students. In any case of emergency leave without early notice from these personnel, students are then left waiting in front of their office. Thus, the purpose of developing this project is to provide an informative board on each office of the personnel that is equipped with display to regularly update on their occupancy status. Thus, the Waterfall model is used to identify and analyze the requirements needed by the respondents on this project. Based on the developed prototype of using NodeMCU ESP8266 Wi-Fi Module as the microcontroller, the system is able to detect motion through the output sent by PIR motion sensor when the room is occupied which was displayed through I2C LCD and LED while a pop-up notification is sent to Blynk application when the system did not detect any motion after the specified delay time. The validation of this project has been collected from several experts within relevant field where the future suggestions for improvements include the installation of ESP 32-CAM on the system.

Keywords: Occupancy Status, Waterfall Model, NodeMCU ESP8266 Wi-Fi Module, PIR Motion Sensor

1. Introduction

An office is the core of an organization as it is a space for business activities other than a room or department where clerical work is performed or a venue where professional and commercial transactions are conducted out or a location where all types of activities inside the corporation are handled as in any sectors in Malaysia that have their own headquarters or main office to plan out their operations (Kapur, 2018).The office is defined as a location from where it plans, implements, monitors, and coordinates all its events and operations. Some of the departments that are usually implemented in an office are human resources, managerial, financial, training, marketing, personnel and many more

Corresponding author: aliasmasek@uthm.edu.my

where each departments carry out their tasks and activities to keep the organization or the institution on surface (Kapur, 2018).

According to the 9th Edition Oxford Advanced Learner's Dictionary (2014), time is described as a long or short period of time during which people are doing something or an event happens whereas management is defined as the act or skill of successfully dealing with people or events. Therefore, Ahyia Adu-Oppong et al. (2014) have stated that the time management may be described as a span of time, whether short or long, in which individuals use their time wisely to generate results. It will be hard to utilize all resources efficiently and effectively without time management. For that reason, time management is an important aspect of accomplishing organization performance in achieving established objectives and goals (Ahyia Adu-Oppong et al., 2014).

Establishment of this project is conducted with the thought of resolving the room occupancy issue through the observation made in Faculty of Technical and Vocational Education (FPTV) in Universiti Tun Hussein Onn Malaysia (UTHM) where most of the management personnel in the higher position tend to have a tight schedule that was filled with meetings and lectures (Kalu, 2012). Eventually, it is difficult for any students to set up a personal appointment with these personnel as their time are quite inflexible. Rarely, they tend to forget about their meeting with the students although the details for the meet-up has been agreed (Elizabeth & Nonye, 2011). Given the condition of the office without any transparent window on the front door, sometimes their colleagues or secretary or even the students might not be able to tell of their occupancy status in the room. Also, students who always visit their offices either for assignment submission or final year students under their supervision are left waiting for a period of time especially when there is no early notice given whether the personnel are still in meeting or have to leave the office urgently (Chatterton, 2021).

1.1 Objective of Study

According to the addressed problem statement, there are three (3) main objectives that has been identified to ensure the purpose of this research can be achieved:

i. To design a smart office system with occupancy sensor for management personnel in FPTV.
ii. To develop the office automation system equipped with occupancy sensors for the management personnel in the office of FPTV.
iii. To test the functionality of the smart office occupancy display system in each room of the management personnel in FPTV.

1.2 Project Goals

This project is developed to create an informative board based on Internet of Things (IoT) concept for the management personnel to provide notification about his or her occupancy in the room for the students. The board can automatically inform the students on the occupancy of the personnel through the occupancy sensor installed inside the room. By adapting these motives into the system, it will save the times spent by the students on waiting outside the room to meet with the personnel and this will enable them to proceed with other routines first. This system is also built with the thought of providing information to the secretary or working colleagues on the whereabouts of the personnel.

1.3 Scope of Study

This project is focused on implying the objectives of the study towards the management personnel of the Faculty of Technical and Vocational Education at the Universiti Tun Hussein Onn Malaysia (UTHM) in their respective office. The office automation system, equipped with occupancy sensors will be mounted on the corner of the ceiling in the office as the researcher is considering the possibility of the user not being able to regularly update their occupancy through the smartphones. This research also aims on the students whether they will receive the benefit of saving time and energy instead of waiting for too long through the display that will be installed on the front door of the office.

2. Methodology

The methodology section describes all the necessary information that is required to obtain the results of the study. It is consisted of the block diagram and the flowchart of IoT-Based Occupancy Display System in Office along with the circuit design for the prototype. The Waterfall Model was chosen as the methodological method for developing the IoT-Based Occupancy Display System in Office.

2.1 Block Diagram

Block diagram of the system is important to understand clearly about the real function of the IoT-Based Occupancy Display System in Office. Futhermore, it will also lead to understanding the real operation of each of the components in the IoT-Based Occupancy Display System in Office.

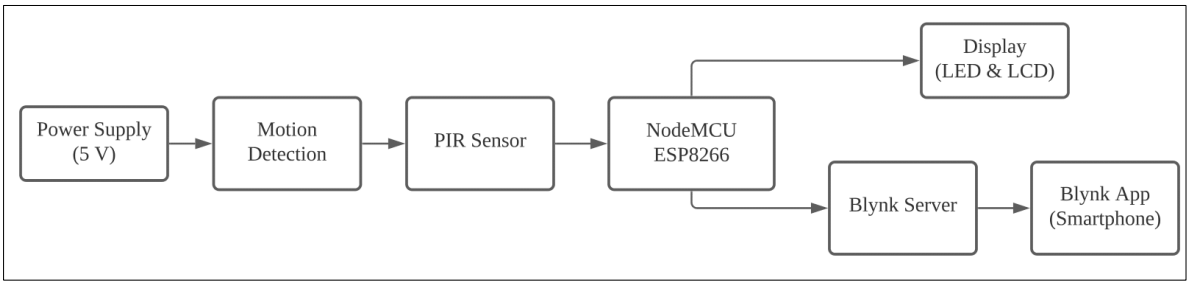

Figure 1: Block Diagram of IoT-Based Occupancy Display System in Office

The block diagram is consisted of three (3) main parts: input, process, and output. The whole block diagram of the software system in this project is represented as in Figure 1 above where a 5 volt power source is supplied to the microcontroller, Node Microcontroller Unit (NodeMCU ESP8266) for system activation. The passive infrared (PIR) sensor functioned as the input for the system where the sensor will detect any motion in the room based on the detection range provided by the manufacturer and the signal will be send to the microcontroller. Based on the input signals received by the sensor, NodeMCU ESP8266 will process the data received and sends the information to the outputs such as the Light Emitting Diode (LEDs) and the Liquid Crystal Display (LCD) to indicate the occupancy status of the personnel in their room. The output of the occupancy system in the room is also received by the Blynk server as the notification will be displayed in the Blynk application.

2.2 Flowchart of IoT-Based Occupancy Display System in Office

Any flowchart's aim is to aid in the visualisation of needed actions, which is especially beneficial while managing a project. Each graphic depicts activities, as well as who is in charge, as well as the inputs and outputs for each stage (Batovski, 2008). The process of this study is illustrated in a flow chart as the flow chart will show the flow of the IoT-Based Occupancy Display System in Office to function in the correct order.

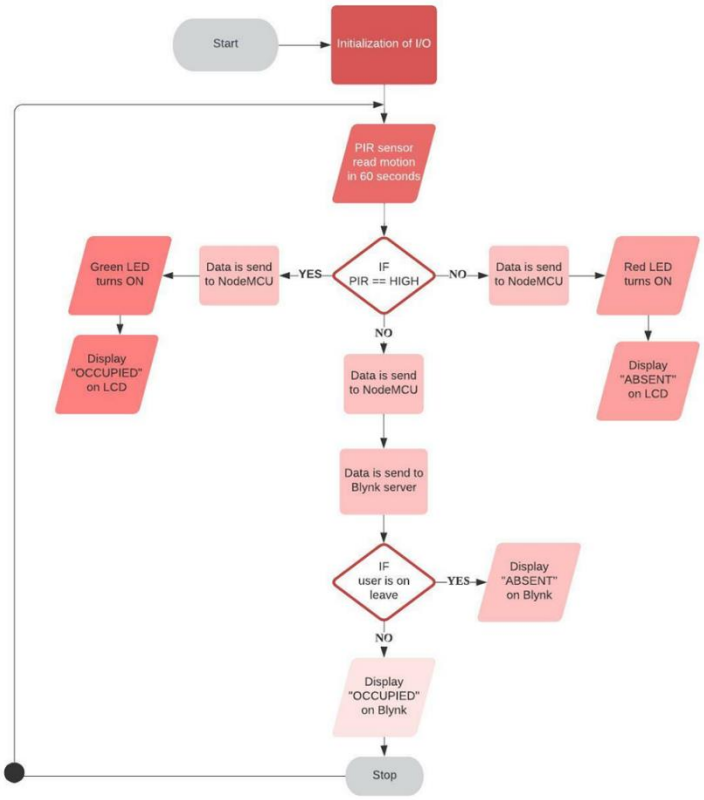

Figure 2: Flowchart of IoT-Based Occupancy Display System in Office

2.3 Schematic Circuit Design of IoT-Based Occupancy Display System in Office

The electrical connections and functions of a given circuit configuration are shown using visual symbols in a schematic diagram. The schematic diagram is used to trace the circuit and its operations without consideration to the component devices or parts' physical size, shape, or placement. The schematic diagram is very beneficial for the user to understand on IoT-Based Occupancy Display System in Office can operate. The schematic diagram for this system as shown in Figure 3 below is designed in EasyEDA.

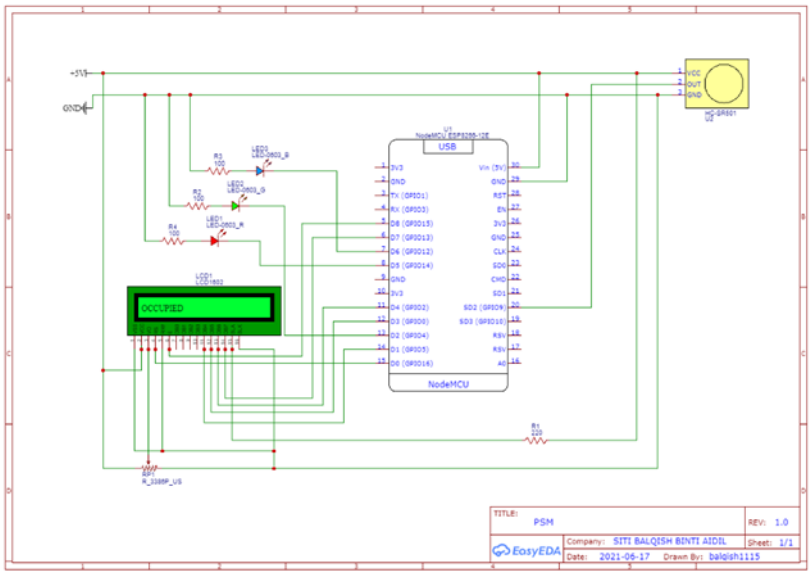

Figure 3: Schematic Circuit Design of IoT-Based Occupancy Display System in Office

3. Results and Discussion

The results and discussion section provided a systematic description of the main findings in a logical order to focus on the most relevant results by describing the aspects of development for the system along with its prototype. In terms of product design, the researcher will discuss on the process involved in developing the prototype along with the operation of the software used i.e., Blynk application and Arduino IDE. Moreover, the engineering analysis included will describe on the testing conducted for the prototype to ensure its functionality and the main objectives have been achieved. The evaluation from several experts within related background to this project will also be analysed to gain new insights from the perspective of a user.

When the programming code has been uploaded into NodeMCU, turning on the user interface of the system in Blynk application is required to allow the notification to be received by the user. When the motion is detected within its range by the PIR sensor as shown in Figure 4, the sensor will be in HIGH condition and the signal will be sent to NodeMCU to instruct the display components on the prototype such as I2C LCD and green LED to provide their respective type of output to the user. As the LCD displayed 'Office is Occupied!' and the green LED turns on while the Blynk app did not received any pop-up notification from the system, this means there are people occupying the office in the current time (Raykov et al., 2016).

Figure 3: Display of Outputs When Motion is Detected

If there is no motion detected within its range in 60 seconds by the PIR sensor as shown in Figure 4, the sensor will be in LOW condition and the signal will be sent to NodeMCU to instruct the display components on the prototype such as I2C LCD and red LED to provide their respective type of output to the user. As the LCD displayed 'Office is Not Occupied!' and the red LED turns on while the Blynk app provided a notification with 'Office is NOT Occupied!' from the system, this means there are no people occupying the office in the current time.

Figure 4: Display of Outputs When Motion is Not Detected

The evaluation and verification of the completed prototype has been conducted to several experts in relevant field to this project ranging from the clerk of Utamma Global Enterprise which was a store

with electrical service that is located in Kuala Terengganu and the Deputy Dean of Students Affairs and Alumni from Faculty of Electric and Electronic (FKEE) along with an engineer assistant from Centre of Graduate Studies in UTHM. This section is focused on listing out any types of feedbacks given by these experts about their perspectives towards the overall development of the prototype. The product evaluation checklist is used to evaluate the IoT-Based Occupancy Display System in Office that has been developed where it focused on the design, functionality, and the commercial potential of the product to the targeted user.

There were four (4) sections in total where the items in the first three (3) sections were evaluated by using Likert Scale and the final section is an open-ended question. The sections included in the checklist were Product Design, Product Functionality, Product Commercial Potential and Suggestion and Comment for Improvement. The items were built based on the objectives and scope of the project while the scale used to evaluate for each item ranged from Scale 1 (Strongly Disagree), Scale 2 (Disagree), Scale 3 (Agree), and Scale 4 (Strongly Agree) only to avoid on receiving vague answers from the respondents (Bishop & Herron, 2015). The formula used to calculate on the percentage average of each item is as below where N is the number of experts:

$$Average\ Item\ A1\ (\%) = \frac{N}{3} x\ 100\% = 100\%$$

3.1 Analysis of Section A: Product Design

Table 1: Items in the evaluation checklist for Section A

No.	Section A: Product Design	N			
		1	**2**	**3**	**4**
1	The prototype developed is harmless and practical to be used by the user.				3
2	The overall layout of the system corresponds to the surrounding of the office.			2	1
3	The occupancy display mechanism is convenient and easy to be comprehend by the user.				3

$$Average\ Item\ A1\ (\%) = \frac{3}{3} x\ 100\% = 100\%$$

Based on Table 1, all of the experts have chosen Scale 4 which was Strongly Agree on item A1. From the calculation made for the particular item, the experts have strongly agreed that the prototype developed was harmless and practical to be used by the user.

$$Average\ Item\ A2\ (\%) = \frac{2}{3} x\ 100\% = 66.67\%$$

$$Average\ Item\ A2\ (\%) = \frac{1}{3} x\ 100\% = 33.33\%$$

For item A2, only two of the experts have chosen Scale 3 which was Agree while there was only one expert who chose on Scale 4 which was Strongly Agree. From the calculations made for the particular item where 66.67% was larger than 33.33%, the experts have agreed that the overall layout of the system has corresponded to the surrounding of the office.

$$Average\ Item\ A3\ (\%) = \frac{3}{3} x\ 100\% = 100\%$$

For item A3, all of the experts have chosen Scale 4 which was Strongly Agree. From the calculation made for the particular item, the experts have strongly agreed that the occupancy display mechanism was convenient and easy to be comprehended by the user.

3.2 Analysis of Section B: Product Functionality

Table 2: Items in the evaluation checklist for Section B

No.	Section B: Product Functionality	N			
		1	2	3	4
1	The motion sensor is able to detect gesture based on the sensitivity range set to the system.			1	2
2	The LCD and LED shows the correct display of signal to the user according to the situation.				3
3	The notification on Blynk application shows the correct display of signal to the user based to the situation.				3

$$Average\ Item\ B1\ (\%) = \frac{1}{3} x\ 100\% = 33.33\%$$

$$Average\ Item\ B1\ (\%) = \frac{2}{3} x\ 100\% = 66.67\%$$

Based on Table 2, only two of the experts have chosen Scale 4 which was Strongly Agree while there was only one expert who chose on Scale 3 which was Agree on item B1. From the calculations made for the particular item where 66.67% was larger than 33.33%, the experts have strongly agreed that motion sensor was able to detect gesture based on the sensitivity range set to the system.

$$Average\ Item\ B2\ (\%) = \frac{3}{3} x\ 100\% = 100\%$$

For item B2, all of the experts have chosen Scale 4 which was Strongly Agree. From the calculation made for the particular item, the experts have strongly agreed that the LCD and LED showed the correct display of signal to the user according to the situation.

$$Average\ Item\ B3\ (\%) = \frac{3}{3} x\ 100\% = 100\%$$

Finally, all of the experts have chosen Scale 4 which was Strongly Agree for item B3. From the calculation made for the particular item, the experts have strongly agreed that the notification on Blynk application showed the correct display of signal to the user based to the situation.

3.3 Analysis of Section C: Product Commercial Potential

Table 3: Items in the evaluation checklist for Section C

No.	Section C: Product Commercial Potential	N			
		1	2	3	4
1	The prototype developed is able to reach user from variety of background.				3
2	The total cost production for the system is affordable to the target audience.				3
3	The choice of components used for the system prototype is accessible.				3

$$Average\ Item\ C1\ (\%) = \frac{3}{3} x\ 100\% = 100\%$$

Based on Table 3, all of the experts have chosen Scale 4 which was Strongly Agree on item C1. From the calculation made for the particular item, the experts have strongly agreed that the prototype developed was able to reach user from variety of background.

$$Average\ Item\ C2\ (\%) = \frac{3}{3} x\ 100\% = 100\%$$

For item B3, all of the experts have chosen Scale 4 which was Strongly Agree. From the calculation made for the particular item, the experts have strongly agreed that the total cost production for the system was affordable to the target audience.

$$Average\ Item\ C3\ (\%) = \frac{3}{3} x\ 100\% = 100\%$$

Lastly, all of the experts have chosen Scale 4 which was Strongly Agree for item C3. From the calculation made for the particular item, the experts have strongly agreed that the choice of components used for the system prototype was accessible.

3.4 Analysis of Section D: Suggestion and Comment for Improvement

Table 4: Summary of suggestions and comments for improvement

Expert No.	Position	Comment
1	Clerk of Utamma Global Enterprise in Kuala Terengganu	Able to assist employees to check on their employee during office hour.
		Install switch for on and off to reduce electricity usage.
2	Deputy Dean of Students Affairs and Alumni from Faculty of Electric and Electronic (FKEE) at UTHM	Allowed user to check on the environment along with improving the office's security.
		Integrate with camera for verification in case of any inaccurate detection.
3	Engineer assistant in Centre of Graduate Studies (CGS) at UTHM	'Office is Occupied' output can be replaced with 'You will be attended shortly' while the display of 'Office is not Occupied' can be replaced with 'Please wait for a while'.
		State the optimum working distance of the system for the sensor to detect the motion.

This system is developed to assist the management personnel in an office by notifying the people outside of the office on its occupancy status as mentioned in Chapter 1. From the aspect of designing an occupancy display system in the office of management personnel where the first phase and the second phase of the Waterfall model is being applied, the usage of circuito.io website has helped the researcher by producing a clear illustration of the circuit after identifying the problem with respondents. The components arrangement provided on the website led in completing the schematic circuit as it is important to trace each connection in case of troubleshooting (Batovski, 2008).

The second objective which was to develop an occupancy display system in the office of management personnel where each main elements for this project such as the hardware, the software and the user interface is being assembled. This particular aspect in the third phase of the model required the researcher to choose the correct component to build the hardware. The PIR motion sensor was tested repeatedly to avoid the component giving false positive signals to the microcontroller (Zulqadar, 2019). After the selection of components is done according to the plan in the implementation phase, the product is developed in the testing phase where the circuit is developed and arranged in the casing. The change of material for casing which was from 3D-printing model to an acrylic box is due to the lower cost option (D. Mark, 2017).The researcher also ensures the course of the system development is done within the planned period.

The third objective which was to test the functionality of the occupancy display system in the office of management personnel is carried out in testing and maintenance phase. From the previous chapter, the results provided has shown that the system is able to operate even within the use of less complicated components. Although the prototype is not implemented in the real office environment, but the main purpose for the system developed was achieved by displaying the correct display to the user according to the existence of motion in the room. After the functionality testing is done, the researcher also seek

validation from some experts in relevant field to ensure the developed product is in accordance with the specified characteristics. It can be concluded that the system has achieved its objectives (Verma, 2015).

4. Conclusion

To conclude the results of the development of this product, the objectives of the study that has been stated in Chapter 1 has been achieved. The main purpose of the researcher in the designing, developing, and testing the IoT-Based Occupancy Display System was to create an informative board based on Internet of Things (IoT) concept for the management personnel to provide notification about the occupancy status in the room. The board can automatically inform the students on the occupancy of the personnel through the occupancy sensor installed inside the room.

At the design stage, the researcher has designed an initial sketch for the system where the preliminary design proposals are made based on the study and preliminary information obtained. Selection of appropriate components is also done to ensure the process of development can be achieved. In addition, the proper use of equipment is also necessary to facilitate the development phase while maintaining the safety aspects. Moreover, the use of NodeMCU ESP8266 Wi-Fi Module as the microcontroller has helped to gain more knowledge on its working operation. Overall, the prototype is considered successful although there are a few improvements that still need to be made to sustain the operation.

In the suggestion and comments section, the experts have agreed on the functionality of the system where it can display the occupancy status based on the motion detected in the room. However, they also give constructive suggestions for the future development of IoT-Based Occupancy Display System in Office. Recommendations and suggestions on the current findings of the study are given by the experts who have evaluated IoT-Based Occupancy Display System in Office in hope to improve the features of the completed prototype include by notifying the user about the detection range applied for the system. Secondly, the system can also be implemented with ESP 32-CAM onto the board for face recognition in the room and finally, the other option to display the output is by replacing 'Office is Occupied' with 'You will be attended shortly' while the display of 'Office is not Occupied' can be replace with 'Please wait for a while'.

Acknowledgement

The author would like to express appreciation to the Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia.

References

Ahyia Adu-Oppong, A., Agyin-Birikorang, E., Darko, G. M., & Aikins, E. D. (2014). *Time Management and Administrative Effectiveness: Lessons for Educational Administrators. 3*(4), 76–82.

Batovski, D. (2008, January). *How to prepare block diagrams, flow charts and pseudocode*. https://www.researchgate.net/publication/235985768_How_to_prepare_block_diagrams_flow_charts_and_pseudocode

Bishop, P. A., & Herron, R. L. (2015). Use and Misuse of the Likert Item Responses and Other Ordinal Measures. *International Journal of Exercise Science*, *8*(3), 297. /pmc/articles/PMC4833473/

Chatterton, J. (2021). *5 Things You Need to Know About University Lecturers*. https://www.whatuni.com/advice/student-life/5-things-you-need-to-know-about-university-lecturers/75848/

D. Mark. (2017, September 13). *Safety in Design*. https://scalar.usc.edu/works/design/safety-design

Elizabeth, O. O., & Nonye, A. C. (2011). Managing Time In Education Organization: Policy Implications for Educational Managers in Rivers State, Nigeria. *Mediterranean Journal of Social*

Sciences, *2*(4), 63. https://www.richtmann.org/journal/index.php/mjss/article/view/10882

Kalu, J. N. (2012). Time Resource Management for Effective School Administration. *Journal of Educational and Social Research*, *2*(10), 115. https://www.richtmann.org/journal/index.php/jesr/article/view/12083

Kapur, R. (2018). *Office Management*. https://www.researchgate.net/publication/323731787_Office_Management

Raykov, Y. P., Ozer, E., Dasika, G., Boukouvalas, A., & Little, M. A. (2016). Predicting room occupancy with a single Passive infrared (PIR) sensor through behavior extraction. *UbiComp 2016 - Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, 1016–1027. https://doi.org/10.1145/2971648.2971746

Verma, E. P. (2015, May 11). *Waterfall Model : Design Phase, advantages disadvantages and applications | Engineer's Portal*. https://er.yuvayana.org/waterfall-model-design-phase-advantages-disadvantages-and-applications/

Zulqadar, A. (2019, February 12). *SDLC Waterfall Model: The 6 phases you need to know about*. https://rezaid.co.uk/sdlc-waterfall-model/