

Smart Solar LED Street Light with ESP32 Camera Module

Nurul Farhana Zailani, Suzi Seroja Sarnin, Mohd Nor Mad Tan, Nani Fadzlina Naim, Mohd Rizal Dohad, Ros Shilawani S. Abdul Kadir, Nur Syahirah Saipul

School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA (UiTM) Shah Alam, 40450 Shah Alam, Selangor, Malaysia.

Zarina Baharudin Zamani

Fakulti Kejuruteraan Elektronik dan Kejuruteraan komputer, Universiti Teknikal Melaka, Durian Tunggal, Malaysia
E-mail: suzis045@uitm.edu.my, mohdn829@uitm.edu.my, nanifadzlina@uitm.edu.my, syahirah.saipul25@gmail.my, zarina@utem.edu.my

Abstract

In 2016, there were 19,299 reports of street crime nationwide, according to the police. The most cases were in Selangor, Kuala Lumpur, Johor, and Perak with an increase in cases over 2013 in Kelantan, Negeri Sembilan and Perlis. The objective of this study was to determine how smart streetlights can adapt to the environment, which helps people today with their ability to observe their surroundings clearly while avoiding the existence of places where criminals can hide. This project is designed based on LDR sensor to turn ON the LED depends on light intensity while PIR sensor to control the brightness and microcontroller used is Arduino Uno. Furthermore, this project will also introduce the method to generate energy by using solar power that will store all the voltage in the battery. To ensure the safety of people at the surrounding, ESP32 camera module and emergency button are provided, and this will help to monitor the place and avoid any crimes that could possibly happened. The outcome from this project can be seen by the LDR sensor will turn ON the LED if the intensity of the light is less than 400 while the PIR sensor will increase the brightness of LED to 100% if there is motion detected but if there is no motion detected the brightness will remain 30%. Moreover, the push button will work as emergency button and when user press, it will turn on the buzzer and on the same time send the notification to the person in-charged. On the other hand, the ESP32 cam will display the live video through blynk apps. Automation is intended to reduce manpower with the help of intelligent systems, since the supply of electricity is limited for various of reasons, power consumption is always a top priority.

Keywords: LDR sensor, PIR sensor, solar energy power, ESP32 camera module, Arduino Uno.

1. Introduction

The world may have been exposed to environmental issues like climate change due to the design of the earlier conventional street light systems, which may have neglected carbon dioxide (CO₂) emissions. According to studies, LED lights generate significantly less heat than incandescent bulbs. In contrast to incandescent bulbs, which release 90% of their energy as heat, LEDs emit very little heat. LEDs also exert some degree of control over the light they produce. This suggests that LEDs do not need reflectors and diffusers to capture light. Since the light never exits the fixture, other lighting designs may waste 50% of it [1].

One of the technologies that enables the city to become a smart city is energy-saving street light systems. It is also one of the routes that gets the globe ready for a futuristic one. A study demonstrates that it is possible to produce electricity using solar energy. The PV cells on a solar panel capture the energy from the sun's rays as it shines on the panel. In reaction to an internal electrical field within the cell, this energy generates electrical charges that move, which results in the flow of electricity.

Public safety has been the main concern to the government. Many criminal activities, such as robbery,

murder, and chain snatching occur in open spaces like the streets. There is minimum safety for women to stroll along in the street at night. Thus, to avoid any crime from happening, an emergency button is provided at each streetlight [2]. This show that security sensor that include in streetlight can ensure the safety of the people of the surrounding by using nearby lamp posts as "gateways," the networked streetlights can instantly communicate the pertinent, real-time photos back to the control system, enabling law enforcement officials in responding to any occurrences right away. Smarter and more extensive surveillance is improved public safety by implementing smart street lighting systems [3].

1.1. Problem Statement

Nowadays, a significant amount of energy is used by streetlights, which undoubtedly results in energy waste. Most nations use standard street lighting, which simply turns on and off depending on the timer that had been set, and which often uses fluorescent bulbs that use more energy. This really cause a lot of energy wastage as there is some place that not fully occupied like the main city street and sometimes in certain period the road will be empty. For example, the standard streetlight will alight all night along the highway although there is less route

user during that time, and this will cause power consumption is relatively high.

In addition, the problem that led to this project is because of shortage of workers. Some street is using the workers to turn on and off the streetlight manually. In this case if the workers have lack of responsibilities which make the streetlight to alight all day, and this consumes large amount of electricity. This is why smart streetlight is useful as it is using LDR sensor to turns on and off based on the light intensity.

Moreover, by using standard streetlight is more expensive and can cause fortune. When purchasing equipment, a major factor to consider is the quality of the street lighting. Mostly the streetlight requires frequent maintenance and replacement and if the cost is too high it is difficult for the maintenance fee. This is the reason why this project is using LEDs as it consumes substantially less energy than incandescent bulbs because diode light is far more efficient, power-wise, than filament light. Compared to incandescent lights, LED bulbs consume more than 75 percent less energy. Besides, LED can continue to shine even with weak or reduced current flowing through it, LED is more efficient.

Furthermore, the sudden increase in crime that affect the passer-by especially during nighttime. Most manual streetlight do not include safety equipment, and this is dangerous especially at the place where there is not crowded as it can lead to crime. For example, if user have been followed by unfamiliar people it is hard for them to ask for help and this can cause major problem and make them feel unsafe to walk in the street especially for woman. Thus, crime prevention through this system is necessary as it can avoid any serious problem in the future.

1.2. Background of Study

The invention of artificial lights has made everyday life so much easier. Almost every home, workspace, school, and street are now well lit even during the night-time making it so much safer for the public to wander around. Ultimately, the need for electricity worldwide has increased exponentially as it contributes to 19% of the worldwide electricity consumption [4],[5] and accounts for nearly 5% of global CO2 emission [6]. Considering these data, it is now more important than ever to protect the limited resources while being energy and cost efficient by implementing a more self-sufficient system that do not harm the environment. Amidst the process of modernizing the lighting system at public spaces, a smart pathway and garden lighting system can be opted where it can be turned on and off on its own as well as adjusting the brightness according to the surrounding. This way, the system will be more effective and energy efficient. In

fact, the idea of street lighting control system has appeared a long time ago due to the hassle of managing large number of streetlamps. A new technology was necessary so that the lamps could be grouped in smaller numbers and controlled more proficiently in terms of switching on and off along with maintenance. The reformation of street lighting system was done by designing and utilizing the feeder pillars and power cabinet. This allowed each light section to be turned on manually which were later outfitted the controllers that replaces human involvement by serving as an automation for turning on and off the lights.

A few papers studied have already provide more advanced solution to reform the street lighting system [7], [8],[9].An author from previous study have suggested that an Ethernet-based communication interfaced to a multiple-phase digital control driving system to implement a smart light system with solar energy power system. Though this system is energy efficient, it is also very expensive to be installed and maintained.

1.3. Objectives

Multifunctional gadgets have been made possible by modern technology and computers are now more potent, portable, and quick than ever. Technology has advanced, expedited, and enhanced our lives along with all these developments. Thanks to technological improvements people are looking for more sensible methods of doing things than manual and mechanical process. The objective of this project is:

- i. To design a smart light system which targets the energy saving and autonomous operation on economical affordable for the sidewalk.
- ii. To implement an intelligent light system with sensors that can ensure the safety of user.

2. Methodology

This chapter will go over the block diagram and flowchart of this project. The process of the smart solar LED streetlight with an ESP32 camera will be thoroughly analyzed in this chapter. The block diagram in figure 2.0 described how this project functions based on the ESP 32 and Arduino Uno microcontroller and the notification received through a Blynk App. On the other hand, there is also a schematic diagram for the project for a smart solar LED streetlight with an ESP32 camera.

2.1. Block Diagram

Fig. 1 shows that how all the components are connected in this system. LDR, PIR, ESP 32 camera module, push button and solar power will act as the inputs of the system. Meanwhile, LEDs, buzzer, notification, and live video are the output of the system.

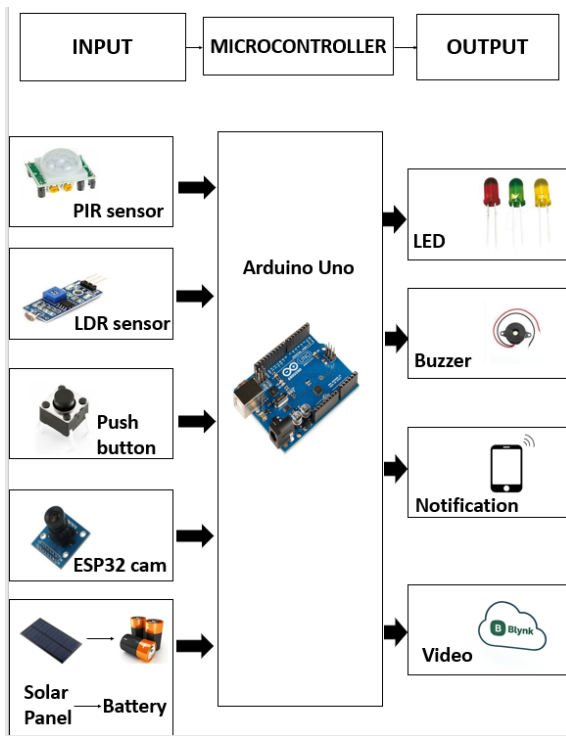


Fig.1 Block Diagram of the System.

2.2. Flowchart

Fig. 2 shows that, the system starts when solar power generates electricity during daytime, and it stored in battery. The power gained from the solar will be used to supply the lighting system. There will be two system which is the system to turn on the LED and the system when user press the push button. When, the LDR sensor detect whether the intensity of light of the surrounding is below than 400. If this condition is satisfied then the streetlight will turn on and if not, the light will be off. Then, when the PIR sensor detects any motion within the parameter of the garden it will increase the brightness of the LED to 100% but if there is no motion detected the brightness of the LED will remain 30%. While, for the push button, if the user press, it will turn on the buzzer and on the same time sending the notification, “Emergency Alert” to the person in-charged through Blynk apps. In addition to this, camera module will send live video through Blynk apps to the person in-charge.

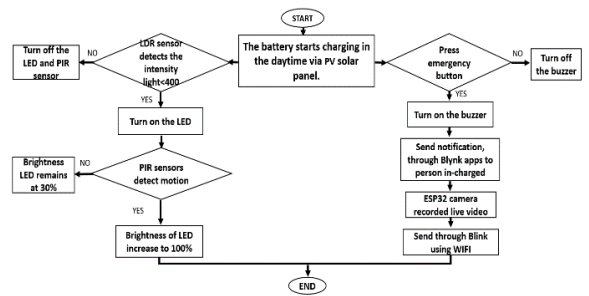


Fig.2 Flowchart of Smart Solar LED Street Light with ESP32 Camera Module.

2.3. Schematic Diagram

Fig. 3 shows that the schematic diagram of this project. This shows the details of the connection for Arduino Uno with other components.

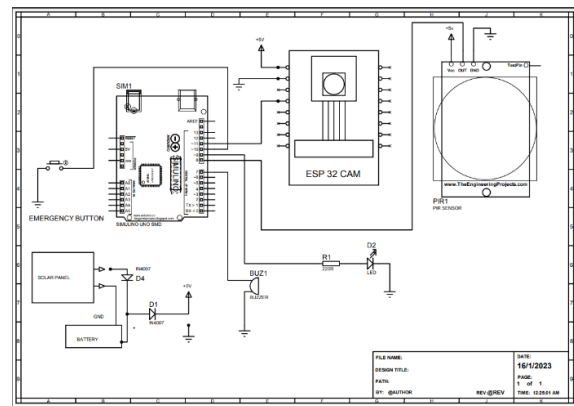


Fig.3 Schematic Diagram.

2.4. Method Description

Fig. 4 shows that, a photoresistor, also known as a light-dependent resistor, is a light-sensitive electrical component. This project utilized a digital kind of LDR, where the value of "1" indicates light and the value of "0" indicates darkness. The resistance alters as light strikes it. The resistance of the LDR can vary by order of magnitude, with the resistance decreasing as the light intensity rises. To save energy, we used LDR in this project to switch on and off the LED.

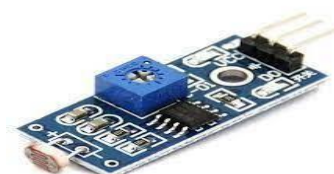


Fig.4 LDR Sensor.

Fig. 5 shows that, an application involving thermal sensing, a passive infrared (PIR) sensor is employed. Which utilized frequently in applications for autonomous lighting, motion detection alarms, and security alarms. PIR sensors are employed in this system to identify human presences, although they can only do so when a person is moving. By recognizing the human in a stationary posture, the Grid-EYE sensor solves the PIR sensor's drawback.



Fig. 5 PIR sensor

Fig. 6 shows that, when an electric current flow through a PN-junction LED in the forward direction, it creates light. White was chosen as the colour. This output correlates with the motion sensor and LDR sensor. When the environment is dark and the LDR determines the detection, the LED will turn on. While the LED will brighten more if motion is detected, this prevents energy from being squandered.



Fig.6 LED.

Fig. 7 shows that, OV7670 which is the most affordable camera module for the Arduino. Users will connect to Arduino, and it will send data when buzzer have been pressed and notification through Blynk. This is used for image processing so that Blynk apps can communicate the recorded video.



Fig.7 ESP32 camera module.

Fig. 8 show that, a push-button, that can be referred to as a button, is a straightforward switch mechanism used to run a machine or process. Buttons are composed of durable materials and are typically made of metal or plastic. It is usually flat or curved to accommodate a

human finger or hand, making the surface easy to push against or compress.



Fig.8 Push button.

Fig. 9 show that, a sounding device that can transform audio signals into sound signals is a buzzer. The effect is alarm. To protect the user, the smoke sensor activates the buzzer when it senses smoke.



Fig.9 Buzzer.

These cells are made from a single crystal, as the name would imply. In comparison to polycrystalline panels, monocrystalline panels have higher efficiency. Efficacy is at 18%. Electricity is produced during the day by a high-efficiency monocrystalline solar panel shown in Fig. 10 and is stored in a battery.

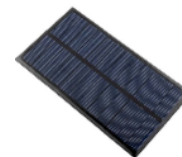


Fig.10 Solar panel.

3. Results and Discussion

The result was inferred from the fact that the project is to avoid from the issue of streetlight, and this is for sensors connected to streetlight. The system works on the principle of detecting light by using sensor technology then sending data to the microcontroller so that the data can be processed to align the streetlight. Beside this help in saving the energy by using solar power to generate power. This project is generally used by the authorities responsible for resolving the issue. Moreover, in this project show that the power consumes from smart light system with solar power is less compared to manual light system. According to this, it helps in minimize power wastage and this method also help to reduce electricity cost while implement an innovative way to generate

electricity. The table below show the summarize result for this project (Table 1).

Table 1. Summarize from Result

Day	LDR sensor	Condition of LED	PIR sensor	Condition of LED
Morning	Light intensity more than 400	LED turn OFF	PIR sensor is turning off	-
Night	Light intensity less than 400	LED turn ON 30%	If there is motion detected	LED increase brightness to 100%
			If there is no motion detected	LED remain brightness of 30%

Fig. 11 shows that, solar panels provide electricity during the day, which is then stored in the rechargeable battery. The LDR sensor commands the Arduino controller from night to daylight. When LDR sensor detect light intensity more than 400, LED will turn off. When morning comes, LDR will instruct Arduino to turn off the streetlight. Typically, streetlights run on electricity that is stored in the battery. In Fig. 12 shows that, when LDR sensor detect light intensity less than 400, LED will turn on and if there is no motion beneath the streetlight, the programmed is carried out, and the LED is turned on to 30% of its maximum intensity. While in Fig. 13 shows that LED remain the brightness on 30% if there is no motion detected and Fig. 14 shows that, the brightness of the LED is increases as motion sensor turns on when a human or vehicle approaches a nearby streetlight, and then instructs the Arduino to increase the brightness to 100%.

When the timer expires and no movement is seen, the intensity progressively decreases to 30%. Furthermore, Fig. 15 shows that, when user press the push button it will turn on the buzzer and send a notification of “Emergency Alert” through Blynk apps to the person in-charge. This help to notified people at the surrounding of any danger that have been occurred. Besides, Fig. 16 shows that, ESP32 will record the video live and this can be view through Blynk apps that connected to the phone of the person in-charge.

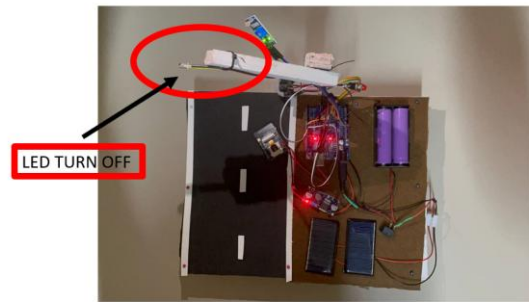


Fig.11 LED turn off.

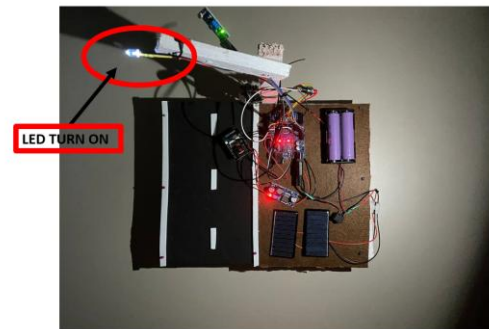


Fig.12 LED turn on.



Fig.13 Brightness of LED remain 30%.



Fig.14 Brightness of LED increases to 100%.

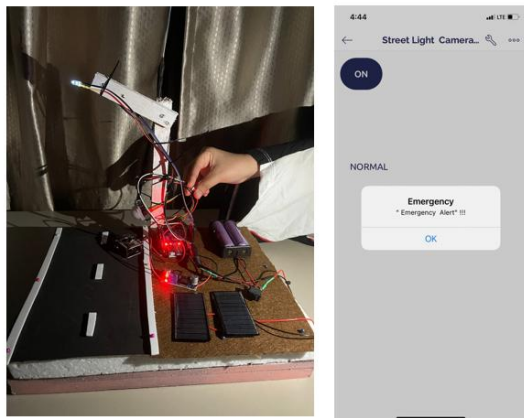


Fig.15 Notification through Blynk apps when press the push button.

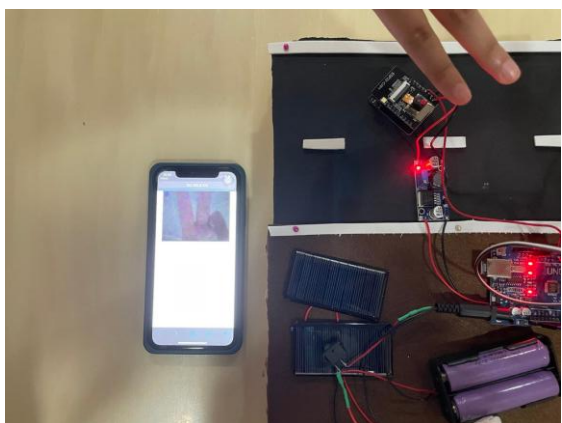


Fig.16 Blynk apps to view the recorded video.

4. Conclusion

Streetlights are crucial for the operation of smart cities. The internet of things introduces the idea of smart lighting with solar electricity. Numerous sensors can be used to automate life's operations. The resources are having trouble keeping up with the rising demand for electricity. People require new processes to reduce the cost of electricity and discover new methods of generating it. In this research project, the student proposes an energy-efficient technique for automating solar-powered street lighting. Streetlights can be powered by the electricity that solar power have generate. In the future, the system can be upgraded with light levels will change in response to motion detection. By finishing the project, students will learn more about the function and applications of the entire component, including how to find out more about the ESP32 camera module or other sensors.

This smart streetlight project not only helps in rural areas but also beneficial in urban areas too. The usage of renewable resources is helpful and useful as the world

develop and need more electricity to do so. With the help of this technology, other features may also include such as intelligent parking for vehicles, which is beneficial for driverless vehicles. This technology has a promising future because it would not only save energy but also lessen natural disasters and even crime. Example, the security team can respond quickly with GPS positioning live feed and online voice call at the step when the user presses the push button, for instance, since this will direct link to the command centre for public emergency. With the help of this smart project, can also assess the speed of the car, identify the license plate, and identify accidents.

Acknowledgements

The authors would convey their profound appreciation and gratitude to the College of Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia for permitting us to perform this study. Special thanks to those who contributed to this project directly and indirectly.

References

1. S.N.A.Kazmi, "How street lighting upgrades can have a positive impact on our climate," 2020.
2. S. Singh, C. Shekhar, and A. Vohra, "Advanced footstep power generation system to charge e-vehicles," 2020, International Journal Of Engineering Research & Technology (IJERT).
3. Z. Zhang, F. Luan, and S. Cheng, "How smart street lighting can improve city's safety," 2017.
4. Segers, K. Steenhaut, and A. Touhafi, "Everything you need to know about smart street lighting," vol. 14, no. 2, pp. 1918–1949, 2014. [Online serial].
5. Segers, K. Steenhaut, and A. Touhafi, "inteliLIGHT@ StreetLight Control softwar," vol. 14, no. 2, pp. 1918–1949, 2014. [Online serial].
6. UK Prime Minister Boris Johnson brings forward end date for new conventional petrol and diesel vehicles to 2030.
7. Y. L. Bo He, "Iot for energy efficient green highway lighting system," vol. 158, pp. 102575, 2020.
8. K.V.M.S.K.P.P.J. Dr.A. Senthil Kumar, "A study on IoT based smart street light systems," vol. 8, no. 7, 2020.
9. L. Li, K. Lian, J. Fu, P. Zhu, Z. Hu, and C. Guo, "Intelligent street light controller with security system," vol. 8, 2020.

Authors Introduction

Nurul Farhana Zailani



She is currently serving as a Protege trainee at Telekom Malaysia. She holds a degree in Electronic Engineering and Diploma in Electric & Electronic Engineering from UiTM. Her interests encompass Communication.

Assoc. Prof. Ir. Ts. Dr Suzi Seroja Sarmin



She is working as a Senior Lecturer at School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. She received PhD in Wireless Communication UiTM, Master of Science in Microelectronic and Degree in Electrical Engineering UTM. Her interests include Wireless Communication and IoT.

Ts. Zarina Baharudin Zamani



She is working as a Senior Lecturer at Fakulti Kejuruteraan Elektronik dan Kejuruteraan komputer, Universiti Teknikal Melaka, Durian Tunggal, Malaysia. She received Master in Microelectronic, UKM. Her interests include VLSI, IC Design, PCB.

Mohd Nor Md Tan



He is working as a Senior Lecturer at School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. He received Master in Radio Frequency Communication Engineering, Bradford University, Bradford, UK. His research themes include Antenna Design Technology.

Ir. Ts. Dr Nani Fadzlina Naim



She is working as a Senior Lecturer at School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. She received PhD in Electrical, Electronic and System Engineering UKM, Bangi. Her interests include Optical sensor, Fiber Bragg Grating (FBG) based sensor, Optical Network.

Mohd Rizal Dohad



He is working as a lecturer at the School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. He received a Master of Science in Telecommunication and Information Engineering at UiTM and Bachelor of Engineering (Electrical) with Honors at UTM. Directly engaged in research projects based on the Internet of Things and Electronic Engineering.

Ts. Dr. Hjh Ros Shilawani S. Abdul Kadir



She is working as Senior Lecturer at School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. Her research interests include Biomedical Engineering, with a particular focus on human body electromagnetic radiation and other human-related studies.

Nur Syahirah Saipul



She holds a Bachelor's degree in Electronic Engineering and a Diploma in Electrical & Electronic Engineering from UiTM. Currently, she is pursuing an MSc in Electrical Engineering at UiTM Shah Alam. Her areas of interest include communication systems and embedded systems.