Smart City Lighting System

Hamam Elsaiti, Abdelsalam Saleh Elrashdi

College of Computer Technology-Benghazi, Benghazi, Libya, Email:
hamam.alsaiity@gmail.com
College of Computer Technology-Benghazi, Benghazi , Libya, Email:
abelsalam.elrashdi@gmai.com

Abstract

With over 50 billion objects are connected and deployed in smart cities in 2020. The IoT is considered as a core concept of a smart city that aims to apply leading-edge communication technologies to develop reliable and efficient services for the smart city citizens and to achieve smart recognitions, positioning, tracking, monitoring, and administration of all the physical objects in the smart city, however, one of the new opportunities to achieve an IoT-enabled smart city environment is to obtain a smart lighting system (SLS) the purpose of SLS is to gain an independent and operative lighting management system, this paper is presenting a system to switch street lights on and off using LDR sensor and video vehicle detection sensor to detect vehicles and pedestrians with Rasberry pi as a backend and a ZigBee Light Link (ZLL) to communicate, furthermore, we will present the advantages of using the proposed system.

Keywords: internet of things (IoT), ZigBee Light Link (ZLL), smart lighting system (SLS), Video Vehicle Detection(VVD), smart city

I. Introduction

The street lighting system is a primary electrical system deployed in public spaces. Today's world's electricity source is tremendously depleted by street lights that use constant intensity of power during the night and off-peak hours though there is no movement by vehicles or pedestrians. It is estimated that street lighting systems use up to 40% of a city's power consumption[1]. However, there are various types of street lamps. High-pressure sodium lamps usually consume range is from 50-400 watts, metal halide lamps range from 50-400 watts, Incandescent lamps from 25-150 watts, and fluorescent lamps range from 18-95 watts.

The street lambs vary in both size and consumption depending upon the area they are lighting a high way, residential area, or a city center; however, high-pressure sodium lamps, also known as HPS lamps, are one of the most common bulbs for street lights in existence today. HPS lamps are not energy effective since they require a warm-up time that varies depending on the light. It can take up to 10 minutes to get the HPS lamb up to its average operating temperature. Also, HPS lambs are chemically reactive, which is extremely harmful to the environment. Nowadays, LED street lights are popular since they use less power, last longer, and are environment friendly.

A smart lighting system (SLS), also called an intelligent lighting system (ILS), is a cutting-edge technology in IoT that uses actuators and sensors to detect sunlight present and vehicles and pedestrians' movement in the area.

The sensors send information to the back end of the device, signaling it to illuminate a particular area depending on the sensor's data. When these smart street lights are installed, and this technology is implemented in typical street lights helps in decreasing the amount of electrical energy the thing that will be a great benefit in terms of environment and the economy for the country.

II. RELATED WORK

The first large-scale implementation of a smart street lighting system took a place in Oslo, Norway in 2006 and it is predicted to decrease electricity consumption by 50%[2]. Smart lights can be intelligent through linking sensors and actuators with cameras that detect motion[3]. Further technologies are used to enable street lights to communicate with each other. Whenever a sensor detects a movement it communicates the information with the neighboring lights so they illuminate the area. The smart street lighting system of Anhalt University has implemented this and it has been installed in bernbug-Strenzfled, Germany. A more abecedarian system was proposed by Gumma University in Japan which introduce switching the street lights on and off when needed[4][3]. Many companies offer street lights that can be managed and monitored wirelessly. Customers can control the system from any given location using a smart device. Using the software they can set brightness or dimness level, receive errors and warnings, and gather data. The street lighting system is consuming a huge amount of electrical energy, however, at certain times the streets are not occupied by pedestrians and vehicles. The system introduces automatically on/off switching of street lights when there are no pedestrians and vehicles in the area [4][9]. These systems are now able to construct arbitrary spectra, humidity, temperature, pivot, and intensities in smart actuators and sensors merged in information and communication technologies (ICT). This paper presents a practical smart street lighting solution that contains diversified lighting technologies facilitating intelligent functionalities. The system can shift light intensity to maximize the visual space and it is intended with regard to human-centric lighting studies. Moreover, the system follows the regulation of the IEEE 21451-001 standard and ZigBee Light Link (ZLL). Also, it contains a smart transducer to perform artificial intelligence functions. Eventually, the REST application allows us to test the interoperability and visualize energy savings in an office room[6]. The lighting system is a TRIAC based light intensity control circuit. The voltage applied is controlled by the TRAIC that is directly corresponding to light intensity. The light intensity is calculated by the traffic on the street. The system is turned on or off depending on sunlight presence. This creates an independent system which is extremely decreasing energy consumption used by the street lighting grid. Monitoring the system can be achieved using a Graphical User Interface(GUI)[7].

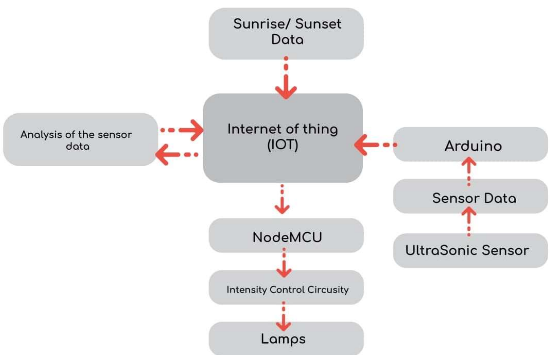

Figure 1.1 [4]

III. PROPOSED SYSTEM

This is how the system is designed and function in real-time

1- Lamp unit: the lamp unit contain two sensors [8][9]

- Light Depended Resistor(LDR):- the LDR is integrated into the lamp unit to sense the sunlight.

• Video Vehicle Detection:- a camera sensor built-in in the lamp unit, this sensor records the footage sensing vehicles and pedestrians motion around the street light pole up to a certain radius depending on the power of the video camera present in the sensor.

2- Communicator: A communicator component like the ZigBee is settled in the lamp unit to gather all the data from the sensor and send it to the backend[11].

3- Backend (Rasberry Pi):- it is where the data signaled by the sensors are decrypted and possessed.

A Python code is given in a way that light intensity is controlled and the lamp is turned on/off. This code executed and the output is transmitted to the lamp unit the light intensity is controlled in real-time.

IV. SYSTEM ARCHITECTURE

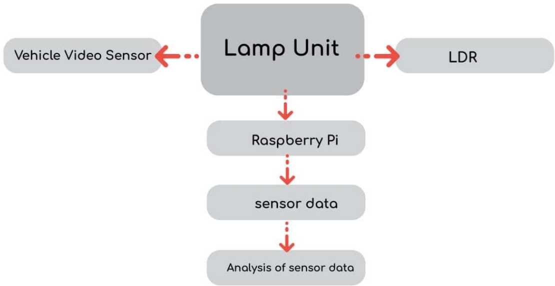

Figure 1.2

V. Working

• The lamp unit contains two sensors. LDR sensor and video vehicle detection sensor.

• When a sunrise or sunset is detected and depending on sunlight intensity the data is collected and sent by the communicator using the LDR.

• At the same time video vehicle detection sensor is activated when the LDR signals a low light intensity is low, VVD carries on the data to the communicator in case there is any movement of vehicles in a specific radius.

• The coming data that is collected by the communicator is transmitted to the back end.

• A Python program is coded in raspberry pi`s OS in such a manner that the LDR is given a particular starting time limit and if the LDR senses the intensity level to be less than the starting time limit the lamp is turned on and keep increasing if the intensity is decreasing i.e intensity of the lamp is indirectly corresponding with the intensity of the sunlight.

• The program is coded in such a manner that the data gathered from the video vehicle detection is analysed there is a vehicle detected along the street in the given amount of radius in the time of minimum or no sunlight, the lamp that illuminates the light of a certain intensity relying on the input of the LDR, emit furthermore intensity for a specific time frame until the vehicle crosses the point.

- The data that is gathered from this process that occurs on a regular basis is stored in an external memory chip that is inserted in the raspberry pi to be analysed and used to update the system.

VI. FUTURE WORK

This energy-saving technology can be enhanced in the future using the subsequent data that has been recorded in the process of the lamp emitting light on the road.

- A solar panel can be installed which will direct the electricity source to be the sun which is a renewable energy source, thus making the primary criteria of the system, i.e to consume energy even more power and energy-efficient since it uses non-renewable resources to generate electricity.
- The data record and the system pattern will be used and analysed for machine learning which will make the system even smarter in the future.
- Security can be enhanced by sending information to the cloud or the nearest police office or hospital in case the system captured any accident on the street, hence increasing well being and safety of the community.

VII. SOFTWARE AND HARDWARE

Raspberry pi 4 is a small single-board computer used for small projects. The sensors that are connected to the Rasberry pi are provided with instructions in the form of Python programming language. The reason for choosing Python is that Python is commonly used in IoT projects and it is well-documented regarding this aspect also Python is supported on all platforms. Also, raspberry pi and python are compatible when dealing with connecting raspberry to sensors and receive data to control hardware. The raspberry pi has evolved in many versions that have variations in peripheral device support and memory capacity. Raspberry pi 4 is used in this project has a 64bit quad-core processor with Bluetooth 5.0, wifi, and USB 3 capabilities. Also, it has a power supply like power over Ethernet (PoE) which allows using the raspberry pi 4 in hard to reach places like the street lamp pole. Figure (A) presents Rasberry pi 4 Model B which we used in the project.

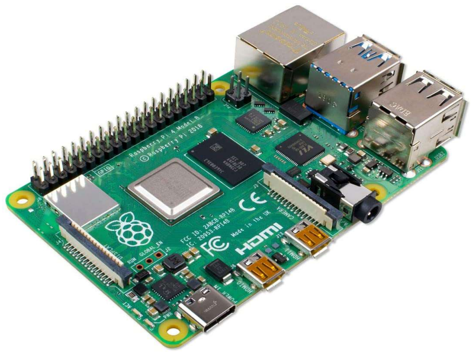

Figure A Rasberry Pi 4

A video vehicle detection sensor is used to detect both pedestrians and vehicles on the street an interesting part about this is that a few of these devices need to be used to cover the required area. If there is a crossing of the street at a junction then 3 or 4 devices will be used to perform the function of the system. This feature is economically effective in the implementation of this project in real life. Also, this device is used to detect both pedestrians and vehicles on the street. The image B below is showing the covered area by vehicles video detection sensor.

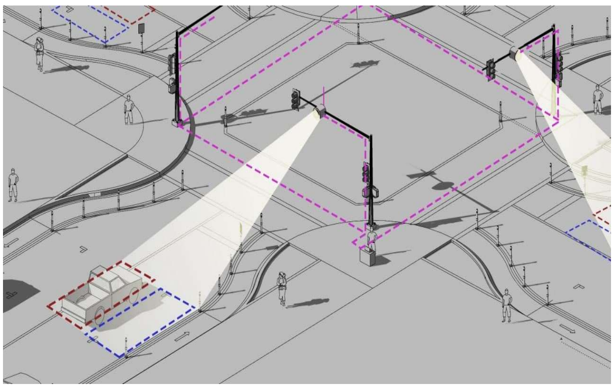

Figure B Video Vehicle Detection

VIII. Conclusion

This research is based on a smart street lighting system using the internet of things (IoT) with LDR to control street light intensity depending on the sunlight availability and a video vehicle detection to detect pedestrians and vehicles to light up at night.

This will decrease the electrical power consumption by a huge amount. And provide safety for both vehicles and pedestrians at all time Also this system support LED lamps only due to the fact that they are more energy affecting and are environment-friendly when disposed of. Below are some advantages:-

- Improve public safety: people will be safer when the street lights are on depending on the movement
- Reduce maintenance cost: the maintenance cost is decreased by using modern technology with wireless connectivity.
- Conserve energy: Using LED lights improve creating an extraordinary impact on the electricity consumption of the street light in the city and eventually in the whole country when implemented on a large scale
- Empower economic development: the decrease in electrical consumption will lead to saving money which will help in the country`s economical growth.

IX. Refrences

[1] Ożadowicz A, Grela J, The Street Lighting Integrated System Case Study, Control Scenarios, Energy Efficiency, Proceedings of the 2014 IEEE Emerging Technology and Factory Automation (ETFA), IEEE,2014

[2] Tom Kristoffersen, Eirik Bjelland, Intelligent street lighting in Oslo, Norway, Intelligent Road and Street Lighting in Europe (E–Street),2007, p. 4

[3] Deepak K Srivatsa, Preethi B, Parinita R, Sumana G, A Kumar, Smart Street Lights, *Texas Instruments India Educators' Conference*, 2013.

[4] Y. Wu, C. Shi, X. Zhang and W. Yang, "Design of new intelligent street light control system," *IEEE ICCA 2010*,Xiamen, 2010, pp. 1423-1427.

[5] Deepak K Srivatsa, Preethi B, Parinita R, Sumana G, A Kumar, Smart Street Lights, *Texas Instruments India Educators' Conference*, 2013.

[6] J. Higuera, W. Hertog, M. Perálvarez, J. Polo and J. Carreras, Smart Lighting System ISO/IEC/IEEE 21451Compatible, in *IEEE Sensors Journal*,vol.15, no. 5.

[7] Monika Vaghela, Harshil Shah, Hardik Jayswal et al., Arduino based auto street light intensity controller*, Invention Rapid: Embedded Systems*, 2013(3):1-4, 2017.

[8] *Power Electronics Principles & Applications* by Joseph Vithayathil, Third edition 2010, Tata McGraw-Hill Education, and Delhi.

[9] *Power Electronics* by P.S.Bhimra, Third edition, 2004 Khanna Publishers

[10] Velaga, R. and Kumar, A. 2012. Techno-economic evaluation of the feasibility of a smart street system: A case study of rural India. Procedia Social and Behavioral Sciences. 62, 1220-1224.

[11] Lin Jianyi, Jiu Xiulong, Mao Qianjie, Wireless monitoring system of street lamps based on ZigBee Tongji University, Shanghai, China