Pertanika J. Sci. & Technol. 25 (S): 77 - 88 (2017)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Smart Home System to Support Bandung Smart City Programme

Jaja Kustija*, Nur Adillawati K. S. and Dini Fauziah

Fakultas Pendidikan Teknologi dan Kejuruan Universitas Pendidikan Indonesia, Jalan Setiabudhi, No. 229 Bandung 40154, Indonesia

ABSTRACT

Smart home is a system that controls electrical equipment remotely via WLAN and Internet. The Smart Home system was created using Raspberry Pi as a data processor, Android Smartphone as a user interface, the relay module as electronic appliance controller, Wi-Fi dongle as a communication medium and a router for port forwarding. In addition, the system is equipped with a security system that can be used to monitor the situation around the home via a webcam as IP Camera, PIR sensor for motion detection and GSM modem for sending SMS and telephone. The test results showed that the Smart Home system can work properly to control four loads at once via the internet or through the media WLAN. The features of the security system works well to monitor the situation through the application interface based on Android and warnings in the form of SMS and telephone numbers sent to the user when the PIR sensor detects movement. Therefore, the smart home system is stable, safe, reliable, easy to use, thus, contributing to efficient energy usage in order to conserve precious natural resources by reducing electrical energy consumption.

Keywords: Energy Saving, Raspberry Pi, Smart Home

INTRODUCTION

There are a number of studies on smart city (Alamsyah, Susanto, & Chou, 2016; Jokinen, Latvala, & Lastra, 2016; Anggoro, Nainggolan, & Purwandesi, 2016; Purnomo, Heryadi, Gaol, & Ricky, 2016; Ikpehai, Adebisi, & Kharel, 2016; Siregar, Nasution, & Fahmi, 2016; Djimantoro, 2016; Dustdar, Nastic, & Scekic, 2016; Rathore, Ahmad, & Paul, 2016; Schleicher, Vögler, Dustdar, & Inzinger, 2016; Shwe, Jet, & Chong, 2016; Arroub, Zahi, Sabir, & Sadik, 2016). Bandung, Indonesia's third largest city, is an example of a leading Smart City. Therefore,

ARTICLE INFO

Article history:
Received: 12 January 2017
Accepted: 02 October 2017

E-mail addresses:
jaja.kustija@upi.edu (Jaja Kustija),
nur.adilawati@student.upi.edu (Nur Adillawati K.S.),
dini_fauziah24@yahoo.com (Dini Fauziah)
*Corresponding Author

ISSN: 0128-7680

this study focuses on creating a smart home in an effort to save energy, the basis of which is home automation.

Home Automation is also known as Domotics, a combination of the word domestic (housemaid) and informatics (informatics). Home Automation replaces a variety of human intervention in household chores by using a preprogrammed electronic system (Dennis, 2013).

Home Automation is use of technology at the home environment to improve the ease, comfort, safety and energy efficiency (Rao & Uma, 2015). It is the control of various household electronic equipment, both when we are at home and remotely. Currently, remote controls and voice commands can be used to control home appliances automatically (Kaur, 2010).

Previous studies have looked at smart home systems using Arduino (Behera, Devi, & Mishra, 2015; Adriansyah & Dani, 2014) and raspberry (Khedkar & Malwatkar, 2016; Ballesteros, Calderon, Calderon, & Strauss, 2015) as data processor and blue tooth (Ramlee, Othman, Leong, Ismail, & Ranjit, 2013; Li Chen, Logenthiran, & Woo, 2016) and WLAN as remote media, hence, the present study has developed smart home systems using Raspberry Pi and use WLAN as remote media. The present researchers have used internet as remote media (Ballesteros et al., 2015) so electrical switching monitoring at home can be done from afar and with some development of the prototype, this system can help the Bandung smart city program in terms of having important information to be monitored online.

METHODS

This is an experimental research with a focus on home automation and security system/home monitoring. The home automation system serves to control (turn off or turn on) electrical equipment, while the security system serves to monitor the situation around the house. A block diagram of the system is shown in Figure 1.

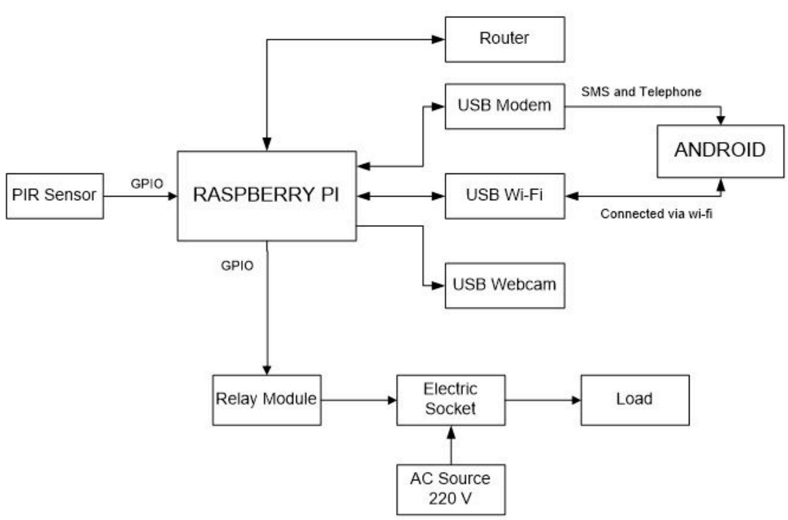

Figure 1. Block diagram of the system

Figure 1 shows that the system consists of Raspberry Pi B +, 4 channel relay module 5V, 4 pieces of light fittings, PIR sensor, webcam, USB Wi-Fi dongle, GSM modem, router and Android-based smartphones. Raspberry Pi B + acts as a microcontroller to control (turn on or off) electrical equipment. The electrical equipment is controlled via the Android-based applications in internet communication media.

The home automation systems uses a motion sensor (PIR) and a webcam to monitor the situation around the house. The PIR sensor will function when there is a trigger in the form of movement. When there is movement, the PIR sensor then sends input to the Raspberry Pi to send SMS and make phone calls using a GSM modem. In addition, when there is movement, the webcam will record and store video and photos. Webcams can be used as a medium for monitoring the situation around the house by streaming via Android based smartphone or through a web browser on a PC / laptop.

In this project, the Raspberry Pi model B + acts as a microcontroller and a server. The role of Raspberry Pi as the microcontroller is to control (turn on or off) the electrical equipment. The electrical equipment is controlled using Android-based applications. The Raspberry Pi Foundation on its official website revealed that the Raspberry Pi is a credit card-sized computer that can be connected to a monitor or TV and uses a standard USB mouse and keyboard. This mini device can be used as a normal computer and to learn a programming language such as Scratch and Python (a programming language primarily on Raspberry Pi). This device uses a Linux-based operating system and Raspbian that is a native operating system of the device. Raspberry Pi has similar functions like a computer desktop such as browsing the Internet, play high definition video, create spreadsheets and even play games. It is not only able to function as a normal computer but can also be used as a microcontroller for Raspberry Pi which has GPIO pins (General Purpose Input Output). Input sources needed are 2A / 5 VDC. Raspberry Pi comes with GPIO pins that can be directly connected with various sensors. Figure 2 shows the Raspberry B+ hardware.

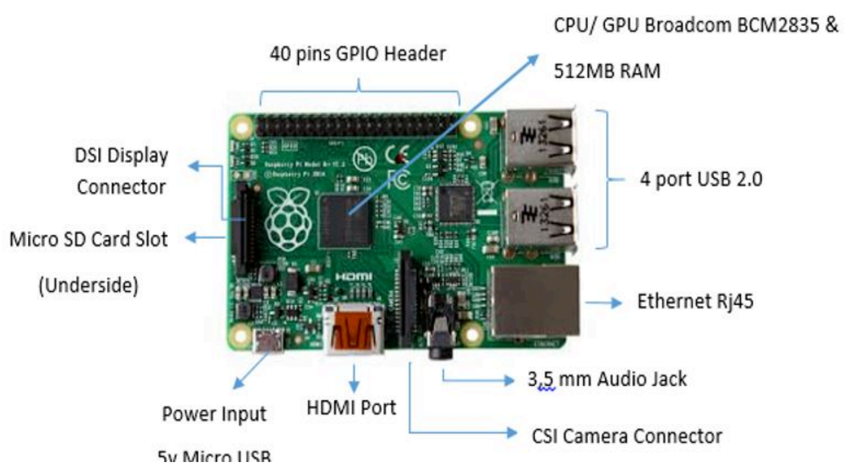

Figure 2. Raspberry B + Hardware

PIR sensors are used to detect motion and when there is a movement, the PIR sensor will provide output to raspberries to send SMS and make calls. The PIR motion sensors are typically used to detect human movement which is at reaching area. Basically, PIR is made of pyroelectric sensor that can detect infrared radiation levels. All objects emit infrared; the hotter the object, the greater the radiation (Ada, 2016).

The USB Wi-Fi dongle is used as a medium of communication between the Raspberry Pi and Home Automation applications pre-installed on Android-based smartphone. The modem is used to send SMS and make phone calls when motion is detected by the PIR sensor. The USB webcam is used to monitor the situation around the house. When movement occurs, the webcam will record and save the recording to a chosen folder.

In the android based smartphone, there is an application to turn on or turn off electrical appliances by changing the state GPIO on WebIOPi. The application can also be used for recording the streaming webcam. Relay module acts as a switch that will turn on and turn off electrical equipment in accordance with an output from Raspberry Pi. On the router Port Forwarding is a feature that allows for open access to the local network to be accessible from the internet.

Raspberry Pi Programming

Software of the Raspberry Pi using Python programming language and script writing is created using nano editor on Raspberry Pi. This program is part of the system security features. When the main program on the Raspberry is running, the former will also initialize GPIO pin, which specifies the name of the pin used and determines the state of GPIO to be input or output. When the PIR sensor detects motion, the PIR sensor will provide HIGH output to Raspberry. If the GPIO pin Raspberry connected with PIR sensor gets a HIGH input, then the program will make a call to another subprogram. There are two subprograms, one is the subprogram that contains an order to send SMS and the other is a subprogram that contains commands to make a phone call. When the second subprogram is called, Raspberry will send AT commands (commands to the module / modem GSM) to the GSM modem. Then the GSM modem will send SMS and make phone calls to a designated number. The Raspberry will give instructions to the PIR sensor to delay / pause for 30 seconds. In addition, at the same time (when the PIR sensor detects motion), a webcam video recording is made and will be stored in designated folders. Figure 3 is a flow chart of the design program of the Raspberry Pi.

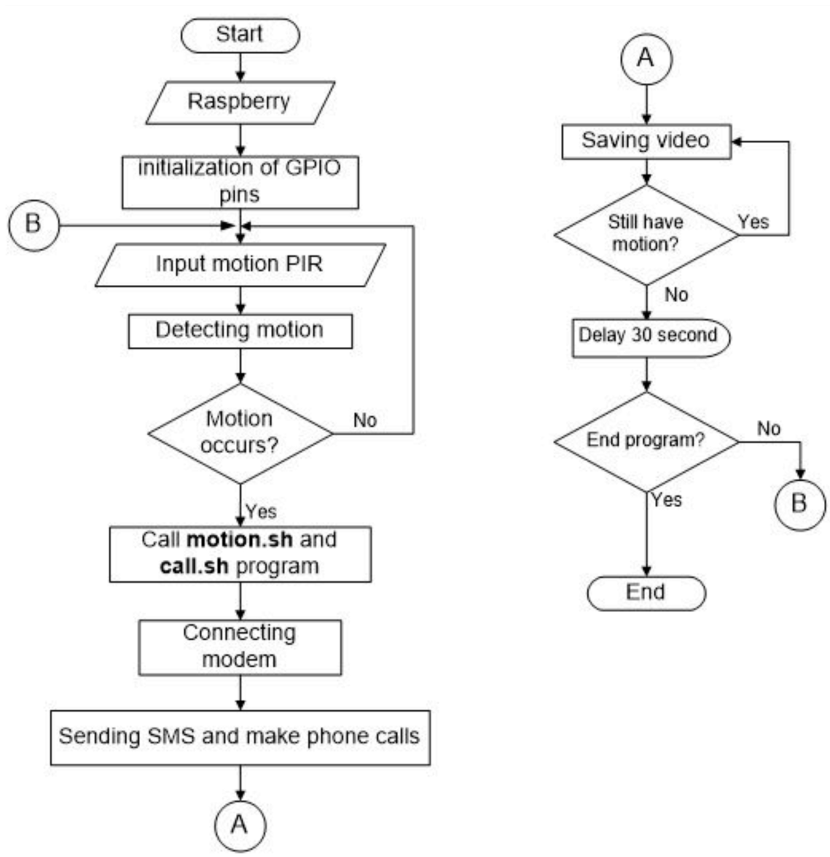

Figure 3. Flowchart of Main Program on Raspberry

This Android based application is created using Eclipse program. Application on Android is divided into two programs, the main program to control the load and the other for streaming video. The program that control the load is the core of the Home Automation system. Figure 3 shows the necessary package used to control the Raspberry Pi GPIO. The next step after import a package is to initialize GPIO and set up connections. Connection settings are intended to make an application to connect with WebIOPi, then a class is developed to contain the host, port, username and password to login WebIOPi. The next step is to perform settings on the check box. In this program, the check box is used to change the state GPIO to be input or output. If the check box is active, it will serve as a GPIO input, otherwise, if the check box is not active then it will serve as a GPIO output. To control the load, then the state must be in good GPIO output (the check box is not active).

In addition, to turn on or turn off the load, it needs toogle button. Toogle button serves to change the state GPIO be high or low. To control the load, then the state should be in conditions of low GPIO because the relay used is active low (active when getting input 0 / low). Figure 4 is the flowchart Design Load Control.

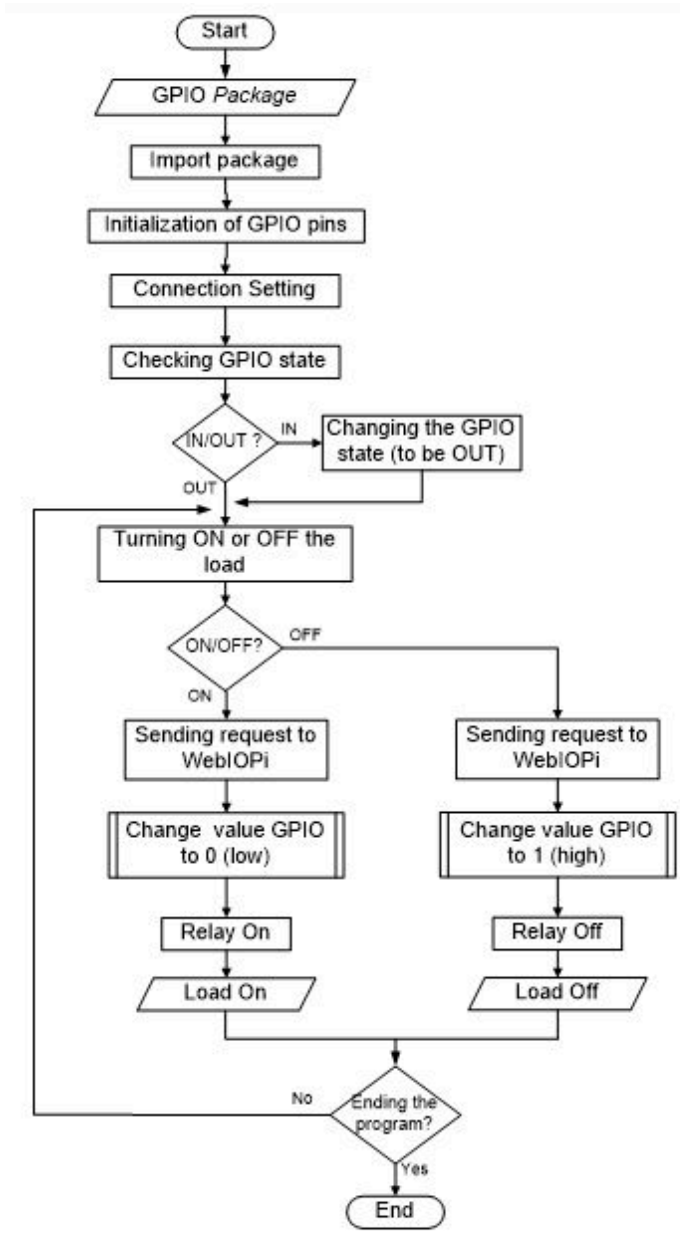

Figure 4. Flowchart Design Load Control

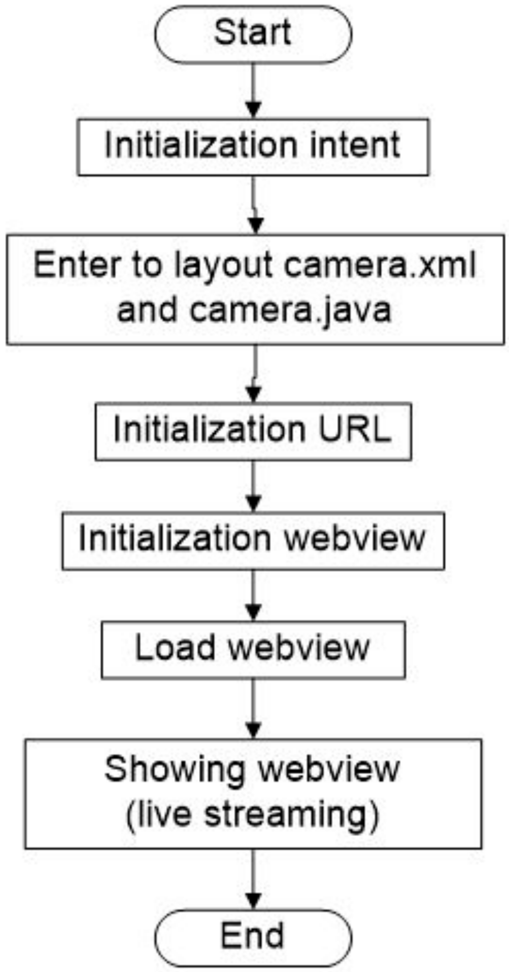

Figure 5. Flowchart program streaming video

The second program is for streaming video that is captured by the webcam. Flowchart of design program for streaming video that is captured by the webcam via Android is shown in Figure 5. Thus, the first step in developing this program is to initialize intent on major programs to be able to communicate with this streaming program. Camera.xml program is used to set the display layout program on Android-based smartphone. Next, on the camera java program, initialisation of URL and WebView takes place, as well as loading and displaying web pages streaming video.

RESULTS AND ANALYSIS

Testing of Load Control

The purpose of the test load control is to determine the performance of the system that has been created. In this test load, four lamps are used. This testing is done by turning on the electronic equipment one by one, and then turning on all loads simultaneously. Testing was conducted on two different communication media: WLAN and Internet.

Testing of both communication media was done on the system using two methods. The first is by turning on and turning off the lights one by one at 5 times. The result is that each load can be controlled properly. The second is by turning on all load at the same time as well as 5 times and the result is that all of the load can be switched on and off properly.

Testing of PIR Sensor

PIR sensor testing was conducted to determine the sensitivity of the PIR sensor to detect movement. Testing was conducted in a room in a way to move around the PIR sensor with different distances and angles until it finds a maximum distance of PIR sensor detects movement. Figure 6 is a picture of PIR sensor test scenarios from various angles while Table 1 shows the test results.

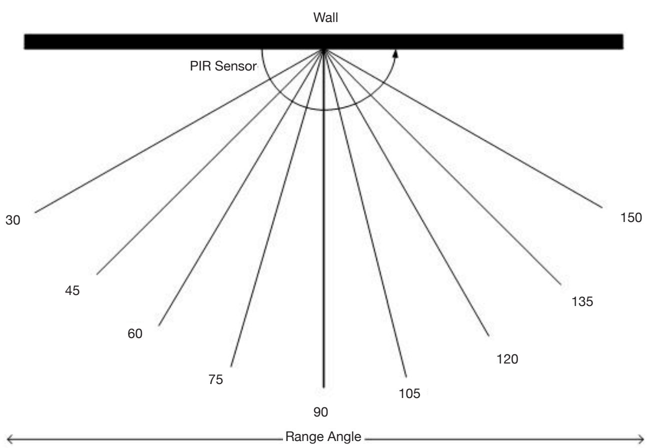

Figure 6. PIR sensor test scenarios from various angles

Table 1
Result of PIR sensor testing

Distance	Angle								
	30°	45°	60°	75°	90°	105°	120°	135°	150°
1 m	√	√	√	√	√	√	√	√	√
2 m	√	√	√	√	√	√	√	√	√
3 m	√	√	√	√	√	√	√	√	√
4 m	√	√	√	√	√	√	√	√	-
5 m	-	-	√	√	√	√	-	-	-
6 m	-	-	-	√	√	√	-	-	-

Based on testing of the system, it has function to control the load well on the WLAN communication media. In a radius of 1-4 meters, motion sensor can detect at each vertex specified. But at 5 meters upwards there are some blank spots that can't be detected and the sensor can only detect a corner approaching a perpendicular position; thus storage should be kept in the middle of the room where people are not expected to enter.

Program to Save Energy. In general, a middle class family uses 1300 VA for lighting, heating and electrical machinery. Assumed power used for outside lighting is 100 VA and inside lighting is 400 VA. Electrical equipment using heating such as iron, rice cooker and dispensers use 500 VA. Remaining power is used for electrical machinery such as water pumps, refrigerators and fans of 300 VA.

Outdoor lighting is expected to last for 12 hours, at 18.00 until 06.00. The below expresses energy consumption for one day (outdoor lighting):

$$\frac{12\ hours\ \times 100\ VA}{1000} = 1{,}2\ kWh$$

So, for a month, energy consumption is

30 days x 1,2 kWh = 36 kWh

But in reality, majority of the population in developed cities leave their lights on Saturday and Sunday as they leave to the outskirts of the city to visit families or for holidays. During 8 days in a month, namely the weekends, energy consumption is:

8 days x 24 hours x $\frac{100\ VA}{1000}$ = 19,2 kWh

The remaining 22 working days in a month) energy usage is

22 days x 1.2 kWh = 26.4 kWh

Energy needed for a month without turning off outdoor lighting when the home is empty:

19.2 kWh + 26.4 kWh = 45.6 kWh

So, there is difference between energy usage with and without using smart home system as expressed below:

45.6 kWh – 36 kWh = 9.6 kWh / month

So, if we use a smart home system, we can save energy 9.6 KWH per month because the lights can be controlled at a distance during weekdays and weekends.

That is savings that can be made for outdoor lighting in one house a month, assuming if a big city has 1000 homes whose occupants always turn on outdoor lighting when on holiday, it can be estimated energy saved is

9.6 kWh x 1000 = 9.6 MWh.

Besides saving energy, setting programming electrical equipment in accordance with the time needed can extend the lifespan of the equipment. And then with remote settings, these tools can help to facilitate efficient energy usage. Because it has security features, this tool also provides additional security advantages for homeowners.

CONCLUSION

This research was focused on the Smart home which has various benefits such as saving energy, saving lifetime of household appliances, facilitate the work of switching energy, as well as having benefits for home security monitoring. Based on results obtained, the system works properly using WLAN and internet media as expected.

REFERENCES

Ada, L. (2016, February 25). *PIR motion sensor*. Retrieved from https://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor.

Adriansyah, A., & Dani, A. W. (2014, August). Design of small smart home system based on Arduino. In *Electrical Power, Electronics, Communications, Controls and Informatics Seminar (EECCIS), 2014* (pp. 121-125). IEEE.

Alamsyah, N., Susanto, T. D., & Chou, T. C. (2016, July). A comparison study of smart city in Taipei and Surabaya. In *ICT for Smart Society (ICISS), 2016 International Conference on* (pp. 111-118). IEEE.

Anggoro, T. P., Nainggolan, B., & Purwandesi, E. (2016, July). Social media analysis supporting smart city implementation (Practical study in Bandung district). In *ICT for Smart Society (ICISS), 2016 International Conference on* (pp. 80-86). IEEE.

Arroub, A., Zahi, B., Sabir, E., & Sadik, M. (2016, October). A literature review on Smart Cities: Paradigms, opportunities and open problems. In *Wireless Networks and Mobile Communications (WINCOM), 2016 International Conference on* (pp. 180-186). IEEE.

Ballesteros, E. A. D., Calderon, C. E. C., Calderon, Y. C., & Strauss, E. G. (2015, September). Android management tool that controls electronic devices through a Raspberry Pi under the IOT model. In *Computing Colombian Conference (10CCC), 2015 10th* (pp. 237-244). IEEE.

Behera, A. R., Devi, J., & Mishra, D. S. (2015, October). A comparative study and implementation of real time home automation system. In *Energy Systems and Applications, 2015 International Conference on* (pp. 28-33). IEEE.

Dennis, A. K. (2013). *Raspberry Pi home automation with Arduino*. Packt Publishing Ltd.

Djimantoro, M. I. (2016, July). Smart city planning system on settlement area. In *ICT for Smart Society (ICISS), 2016 International Conference on* (pp. 74-79). IEEE.

Dustdar, S., Nastic, S., & Scekic, O. (2016, October). A Novel Vision of Cyber-Human Smart City. In *Hot Topics in Web Systems and Technologies (HotWeb), 2016 Fourth IEEE Workshop on* (pp. 42-47). IEEE.

Ikpehai, A., Adebisi, B., & Kharel, R. (2016, October). Smart street lighting over narrowband PLC in a smart city: The Triangulum case study. In *2016 IEEE 21st International Workshop on Computer Aided Modelling and Design of Communication Links and Networks (CAMAD)*, (pp. 242-247). IEEE.

Jokinen, J., Latvala, T., & Lastra, J. L. M. (2016, October). Integrating smart city services using Arrowhead framework. In I*ndustrial Electronics Society, IECON 2016-42nd Annual Conference of the IEEE* (pp. 5568-5573). IEEE.

Kaur, I. (2010). Microcontroller based home automation system with security. *International Journal of Advanced Computer Science and Applications, 1*(6), 60-65.

Khedkar, S., & Malwatkar, G. M. (2016, March). Using raspberry Pi and GSM survey on home automation. In *International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT)*, (pp. 758-761). IEEE.

Li, C., Logenthiran, T., & Woo, W. L. (2016, March). Development of mobile application for smart home energy management: iSHome. In *2016 IEEE 6th International Conference on Power Systems (ICPS)*, (pp. 1-6). IEEE.

Purnomo, F., Heryadi, Y., Gaol, F. L., & Ricky, M. Y. (2016, July). Smart city's context awareness using social media. In *2016 International Conference on ICT for Smart Society (ICISS)*, (pp. 119-123). IEEE.

Ramlee, R. A., Othman, M. A., Leong, M. H., Ismail, M. M., & Ranjit, S. S. S. (2013, March). Smart home system using android application. In *2013 International Conference of Information and Communication Technology (ICoICT)*, (pp. 277-280). IEEE.

Rao, P. B., & Uma, S. K. (2015). Raspberry Pi home automation with wireless sensors using smart phone. *International Journal of Computer Science and Mobile Computing, 4*(5), 797-803.

Rathore, M. M., Ahmad, A., & Paul, A. (2016 October). IoT-based smart city development using big data analytical approach. In *IEEE International Conference on Automatica (ICA-ACCA),* (pp. 1-8). IEEE.

Schleicher, J. M., Vögler, M., Dustdar, S., & Inzinger, C. (2016). Application architecture for the internet of cities: Blueprints for future smart city applications. *IEEE Internet Computing, 20*(6), 68-75.

Shwe, H. Y., Jet, T. K., & Chong, P. H. J. (2016, October). An IoT-oriented data storage framework in smart city applications. In *2016 International Conference on Information and Communication Technology Convergence (ICTC)*, (pp. 106-108). IEEE.

Siregar, B., Nasution, A. B. A., & Fahmi, F. (2016, July). Integrated pollution monitoring system for smart city. In *2016 International Conference on ICT for Smart Society (ICISS)*, (pp. 49-52). IEEE.