Indonesian Journal of Electrical Engineering and Computer Science
Vol. 26, No. 3, June 2022, pp. 1781~1790
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v26.i3.pp1781-1790

Based on mesh sensor network: design and implementation of security monitoring system with Bluetooth technology

Bilal Hashim Hameed[1], Anmar Yahya Taher[1], Raed Khalid Ibrahim[2], Adnan Hussein Ali[3], Yasser Adnan Hussein[3]
[1]Electrical and Computer Engineering, Altinbaş University, Istanbul, Turkey
[2]Department of Medical Instruments Engineering Techniques, Al-Farahidi University, Baghdad, Iraq
[3]Institute of Technology-Baghdad, Middle Technical University, Baghdad, Iraq

Article Info

Article history:

Received Nov 3, 2021
Revised Apr 8, 2022
Accepted Apr 21, 2022

Keywords:

Bluetooth mesh sensor network
Bluetooth technology
Internet of things
Motion sensor
Security monitoring system

ABSTRAC

One of the most critical aspects to consider in wireless sensor networks is security, particularly in internet of things (IoT) implementations. Sensor network applications had risen in the past 5 years since these networks have been used in various parts of life (smart residential and commercial buildings, medical, and agriculture). In this study, we provide a novel network of sensors based on the Bluetooth network that may be used to protect commercial buildings. The Bluetooth type HC 06 was chosen since it has a low energy consumption and a communication range of 100 meters. Such security network includes motion sensors and control cameras that are controlled by an Arduino Nano microcontroller. The motion sensor's primary characteristics are solely applicable to humans, and the Arduino Nano is an open-source microcontroller. The key benefit of this research is that it demonstrates how to create a low-cost Bluetooth sensor security network with limited storage space for control movies.

This is an open access article under the CC BY-SA license.

Corresponding Author:

Adnan Hussein Ali
Institute of Technology-Baghdad, Middle Technical University
Baghdad, Iraq
Email: dradnanmtu@gmail.com

1. INTRODUCTION

Due to recent technological advances, the manufacture of small sensors with low power consumption and wireless connectivity is possible and economically feasible. Making use of this type of sensor is possible to create wireless sensor networks. Combining the features of these devices, such as their small size, low production cost, and wireless connectivity, wireless sensor networks make a large area of implementation possible and, therefore, in great evolution.

The network of wireless sensors consists of small devices of this type, randomly distributed and dense in the middle and with the possibility of communication between them. In many cases, there is also a need for automated regulation, that is, there is no need to intervene externally at the stage of disposing of the sensors in the centre. Taking into account their characteristics, wireless sensor networks can be applied in several areas of the military to detect interference and monitor the environmental conditions of the network, industrial area, for example, to conduct inventory control [1], or for applications such as the geographical location of objects [2]-[9]. The internet of things (IoT) has dominated improvements in communication and networking technology during the previous decade [10]-[12]. In a real-world setting, IoT-based services improve the home environment and are used in a variety of applications. IoT-based home automation is a necessary and frequent application. All home appliances are networked together with home automation, giving them the ability to function without human involvement. Home automation makes a big difference in

people's lives by allowing them to operate their home equipment intelligently [13], [14]. In this paper, a new wireless sensor network has been designed and implemented that can monitor people and protect private and government buildings from theft or undesirable acts. This network has the ability to reduce the size of the control panels of the system by controlling the operation of cameras only when there is a person in this area [15]-[19].

The network is designed and simulate based on the Bluetooth between the monitor and control stations to transfer data and information from one monitoring control system to the other through wireless transmission [20]-[23]. In this network was used the Arduino nano as a microcontroller, this microcontroller is a small, complete, and breadboard-friendly board based on the ATmega328P. The Arduino software consists of a collection of C/C++ functions that are then sent straight to a C/C++ compiler for employment through any software. Arduino Software is an open-source application (IDE) Windows, Mac OS X, and Linux [24], [25] are all supported. The motion sensor [26]-[28] is the other major component. A motion sensor detects moving things, such as humans. This gadget is frequently used as part of a system that automates a process or notifies the user to movement in a certain region. Security, automated lighting control, home control, energy efficiency, and other beneficial technologies all rely on it. Other parts of the system network are the set of motor cameras and engine circuits for each camera to move it right and left [29].

The main objective of this work was to design and simulate a low cost and safe security monitoring system established on bluetooth mesh sensor network (BMSN). Such BMSN may be designed through low storage capacity related with record control videos. The rest of the paper is organised as shown in: Section 2 presents the system description of BMSN, section 3 discusses the simulation and software system results, and finally, section 4 presents conclusions

2. BMSN SYSTEM DESCRIPTION

The comprehensive system simulation model and software of the security monitoring system based on Bluetooth mesh sensor network (BMSN) and the basic building blocks are discussed in this part. The BMSN is made up of a simulation component and software applications, as shown in Figure 1. The planned system's simulation component is separated into four circuits, with all circuits being dependent on five pieces. The Arduino Nano, motion sensor, and Bluetooth HC-06 are the simulation's key components. The entire system was programmed using the free source Arduino IDE application.

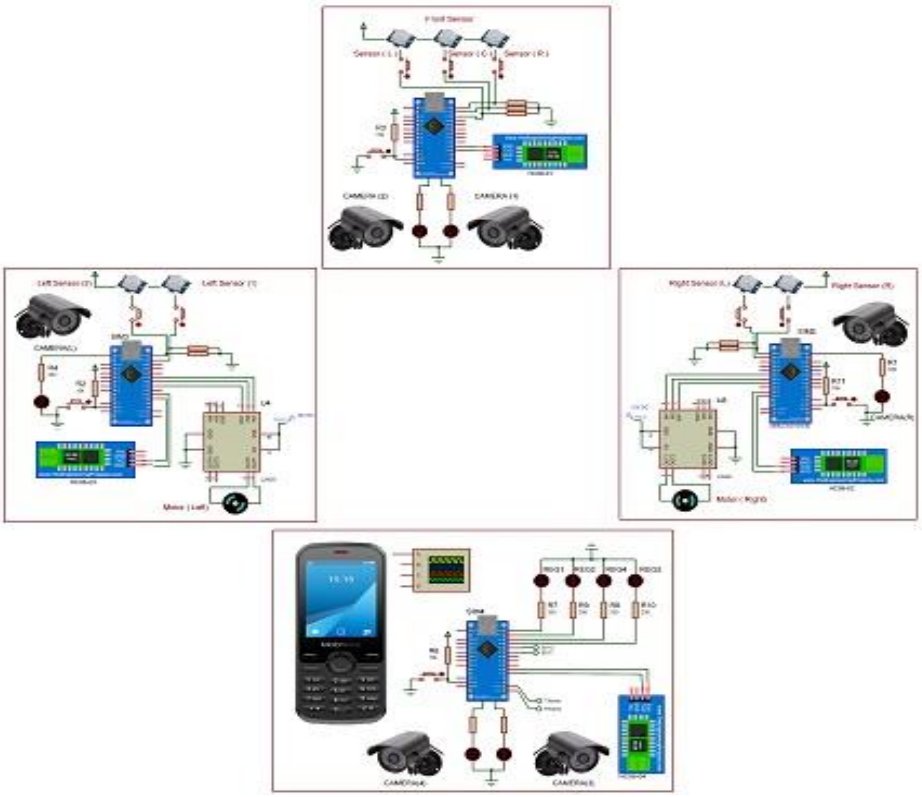


Figure 1. The full system simulation of the BMSN

2.1. BMSN circuit simulation

The BMSN simulation circuits' major circuits and components are separated into five segments in Figure 2. This Arduino microcontroller, shown in Figure 2(a), is the heart of the BMSN devices with the Arduino Nano's primary bin diagram can be shown in Figure 3, and the microcontroller's key features are listed in Table 1 [18].

A motion sensor, often known as a passive infrared sensor (PIR) shown in Figure 2(b), is indeed a sensor that detects human movement or allows a human to enter a space. And, unlike the infrared sensor, the infrared sensor (IR sensor) does not have a red-light transmitter, but instead receives it from the surrounding bodies as a result, Passive. The motion sensor applications are used to detect the human body in order to safeguard against theft, to light a lamp or open a door, or to save energy. However, in order to understand how to operate a sensitive movement, one must first understand that everyone with a temperature greater than zero degrees Celsius is capable of emitting infrared energy. The proportion of energy released by the body grew as the body's temperature climbed. This energy or radiation is invisible to the naked eye (though it may be viewed with a camera), but the PIR sensor's pyrolytic materials can detect it. Glymantride, Cassim Nitrate, and Lithium are just a few of the pyroelectric compounds employed in the PIR sensor [30].

Bluetooth HC-06, as shown in Figure 2(c), this Bluetooth module can easily establish serial wireless data transmission. It operates in the 2.4 GHz industrial, scientific and medical (ISM) frequency range, which is ideal for medical, industrial, and scientific applications. The Bluetooth 2.0+EDR standard is used. The signal transmission duration of various devices in Bluetooth 2.0 is set at a time interval of 0.5 seconds, which reduces the stress of the Bluetooth chip and allows for greater Bluetooth sleep time. This module has a serial interface, is simple to use, and makes the design and development process easier in general. Table 2 lists the Bluetooth HC-06's most important features [17].

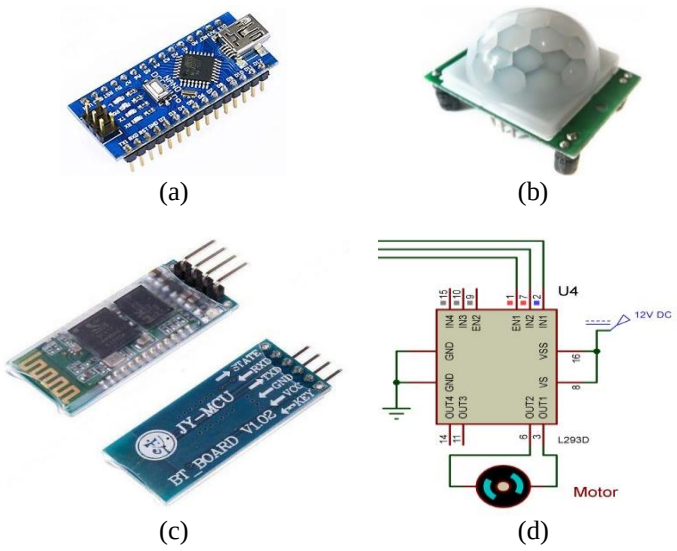


Figure 2. BMSN main component (a) Arduino kit, (b) the motion sensor, (c) Bluetooth HC-06 and (d) motor driver circuit

Table 1. Main properties of Arduino Nano [18]

Parameter	Value
Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage for Vin pin	7-12V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (2 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz
Communication	IIC, SPI, USART

Table 2. Main properties of Bluetooth transceiver module HC-06

Parameter	Value
Bluetooth protocol	Bluetooth 2.0+ EDR standard
USB protocol	USB v1.1/2.0
Operating frequency	2.4 GHz ISM frequency band
Transmit power	≤ 4 dBm, second stage
Sensitivity	≤-84 dBm at 0.1% Bit Error Rate
Transmission speed	2.1 Mbps(Max)/160 kbps(Asynchronous)； 1 Mbps / 1 Mbps(Synchronous)
Supply Voltage	+3.3 VDC 50 mA
Operating temperature	-20 to 55℃
Size and Weight	36.5*16 mm Weight: 4 g

Motor driver circuit: Such circuit can be considered as circle for driving the camera's motor in addition to the camera moving from left or right as indicated in Figure 2(d). Mobil phone: BMSN can be used any older phone instrument just in the full system for sending the SMS to the selected phone number.

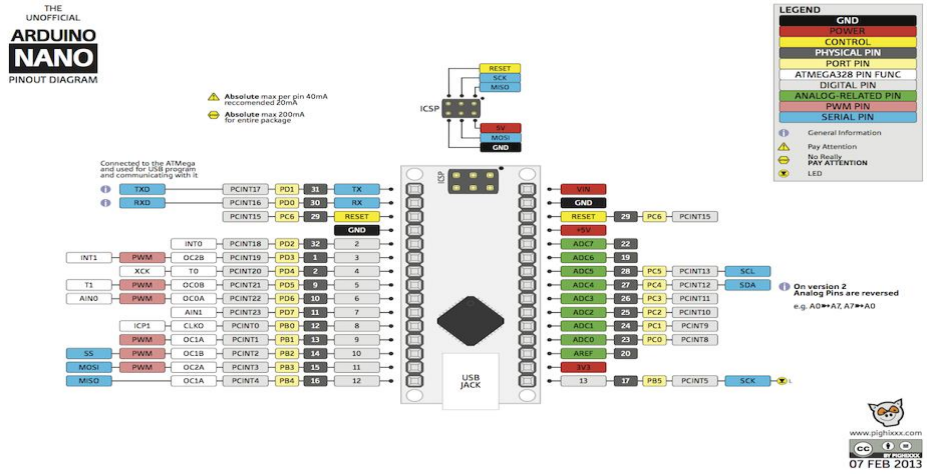


Figure 3. Arduino Nano main diagram [18]

2.2. Software's of the BMSN.

The Arduino language is essentially a collection of C/C++ functions that are then provided directly to a C/C++ compiler that can be used with my program. Arduino Software is an open-source application (IDE) It's compatible with Windows, Mac OS X, and Linux. The Arduino IDE is a free software electronics prototyping platform based on all sorts of Arduino hardware and software that is versatile and easy to use. The IDE makes writing code and uploading it to the board a breeze. Figure 4 depicts the IDE software's major windows [19].

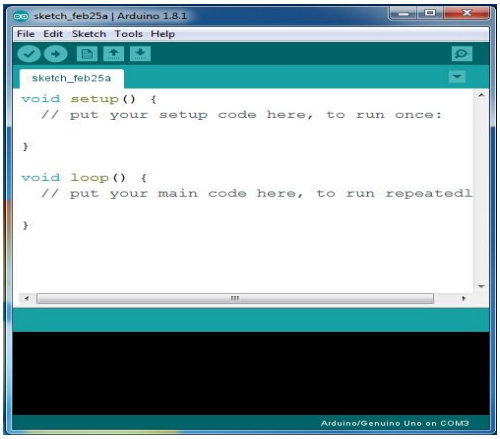


Figure 4. IDE software main widows [19]

3. SYSTEM SIMULATION RESULTS

Figure 5 depicts the flowcharts of a security monitoring system based on a Bluetooth mesh sensor network. The system's flowcharts are grouped into four programs. Figure 5(a) depicts the front monitoring circuit flowchart, which demonstrates how to check the status of the three motion sensors output, switch on/off the cameras, and then relay the sensor status to the main, left, and right circuits. A schematic of the right monitoring circuit is shown in Figure 5(b). This flowchart shows how this circuit receives signals from the front circuit, turns the cameras on/off, and sends the sensor states to the main circuit. A schematic of the left monitoring circuit is shown in Figure 5(c). This flowchart shows how this circuit receives signals from the front circuit, turns the cameras on/off, and sends the sensor states to the main circuit. The main circuit flowchart is shown in the last flowchart in Figure 5(d). This flowchart shows the system's entire condition based on Bluetooth signals from the front, right, and left circuits, as well as how to issue a warning SMS.

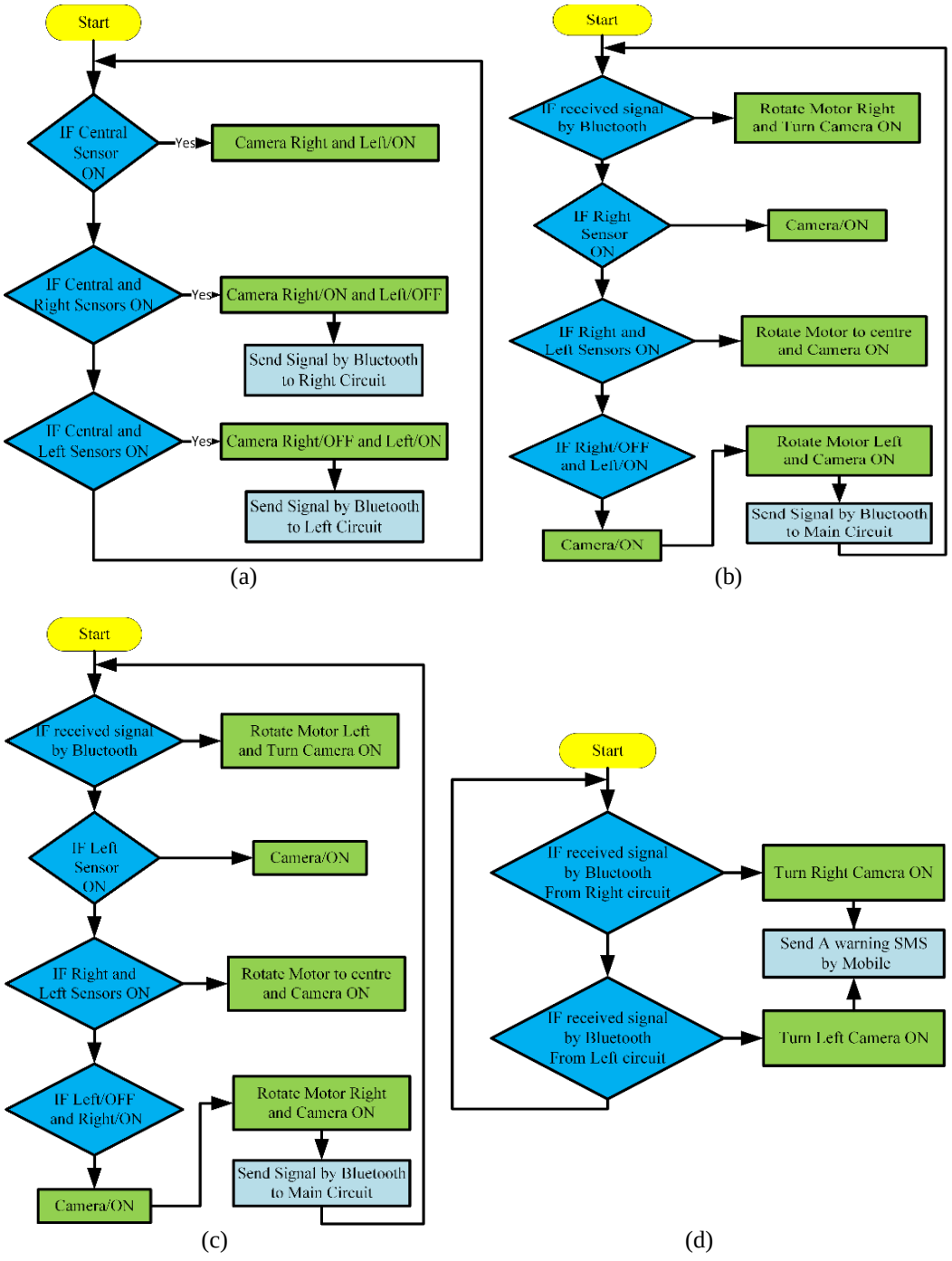
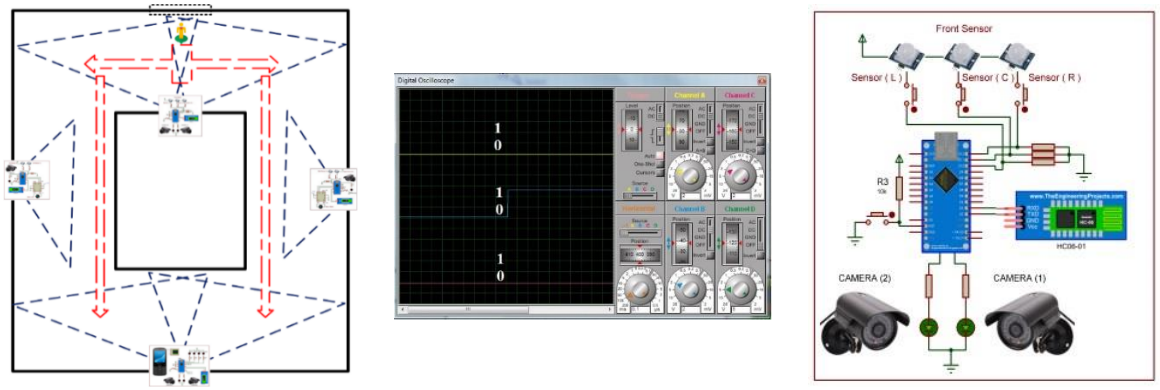


Figure 5. BMSN flowcharts (a) front circuit, (b) right circuit, (c) left circuit and (d) main circuit

The simulation results of the entire system will be presented and discussed in this section. Using Proteus 8.4 Professional software, the system simulates (1). The outcomes of this study can be divided into more than six scenarios, although only six will be discussed in terms of human movement:

3.1. Scenario 1

As shown in Figure 6, the person in this position is standing in front of the building's entrance. Figure 6(a) shows how to detect a person within that scenario, in which the central sensor at front circuit is ON with both left and right sensors are OFF, Figure 6(b) shows the sensor output results, and Figure 6(c) shows the camera situation result (the camera right and left are ON).

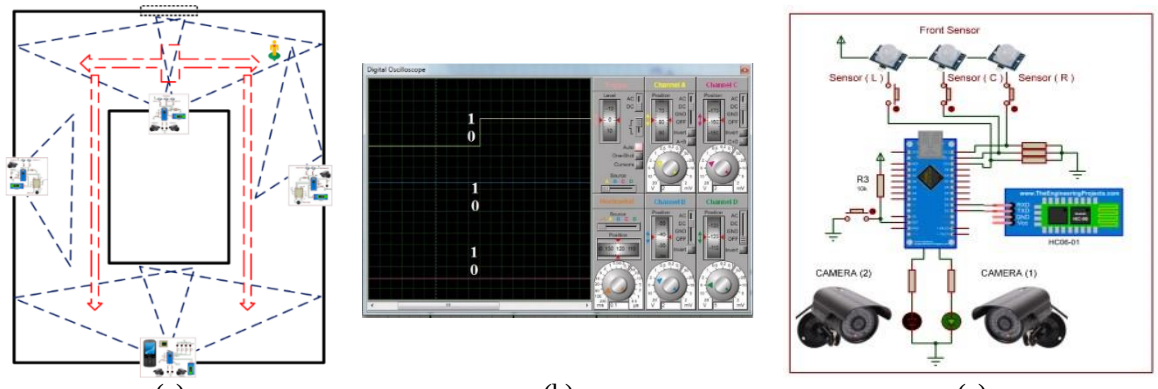


(a) (b) (c)

Figure 6. Scenario 1 states and results (a) the person location, (b) sensors output results and (c) camera situation result

3.2. Scenario 2

In this case as shown in Figure 7, a person is standing just in front of the building's gate. Figure 7(a) shows how to locate a person in this scenario (2); in this example, the front circuit's center and right sensors are ON, while the right sensor is OFF; Figure 7(b) shows the sensor output results; and Figure 7(c) shows the camera situation result (camera right/ON and camera left/OFF).

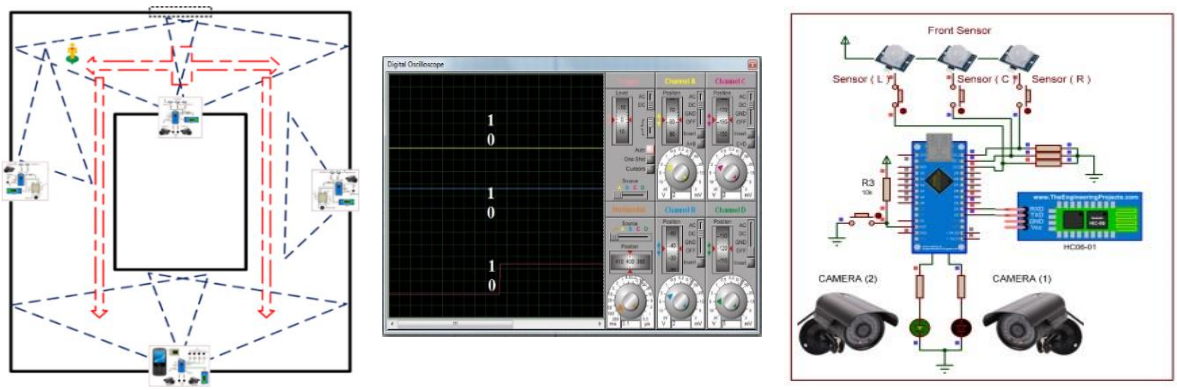


(a) (b) (c)

Figure 7. Scenario 2 states with results (a) the location of person, (b) output results of the sensors and (c) camera scenario result

3.3. Scenario 3

As shown in Figure 8, the person in this position is standing to the left of the building door. Figure 8(a) shows how to locate a person in this scenario (3); in this example, the front circuit's central and left sensors are ON, while the right sensor is OFF; Figure 8(b) shows the sensor output results; and Figure 8(c) shows the camera situation result (camera right/OFF and camera left/ON).

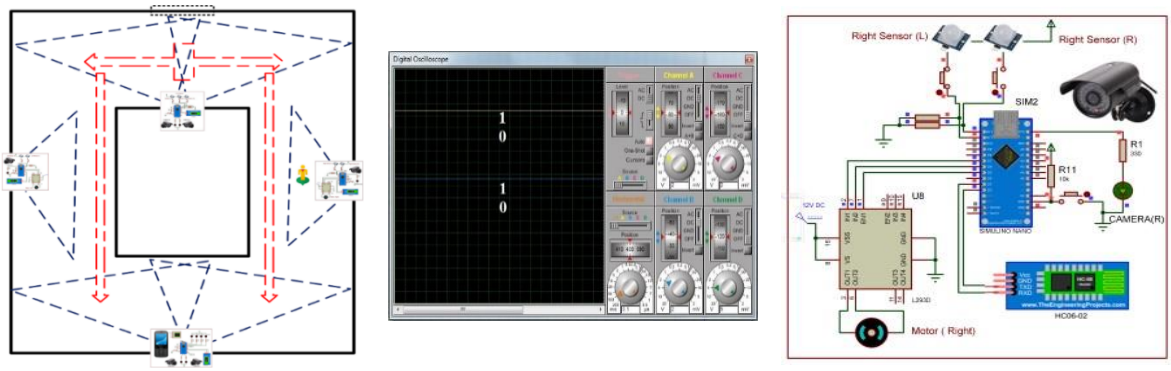


(a) (b) (c)

Figure 8. Scenario 3 states with results (a) the location's person, (b) output results of the sensors and (c) camera situation result

3.4. Scenario 4

As shown in Figure 9, the results are the same whether the individual is standing on the left or right side of the structure. The person within this position is standing in canter on the right side of the structure. In this scenario (4), the right and left sensors in the right circuit are ON, as shown in Figure 9(a). Figure 9(b) shows the output results of the right-side circuit sensors, while Figure 9(c) shows the camera situation result (the camera is ON).



(a) (b) (c)

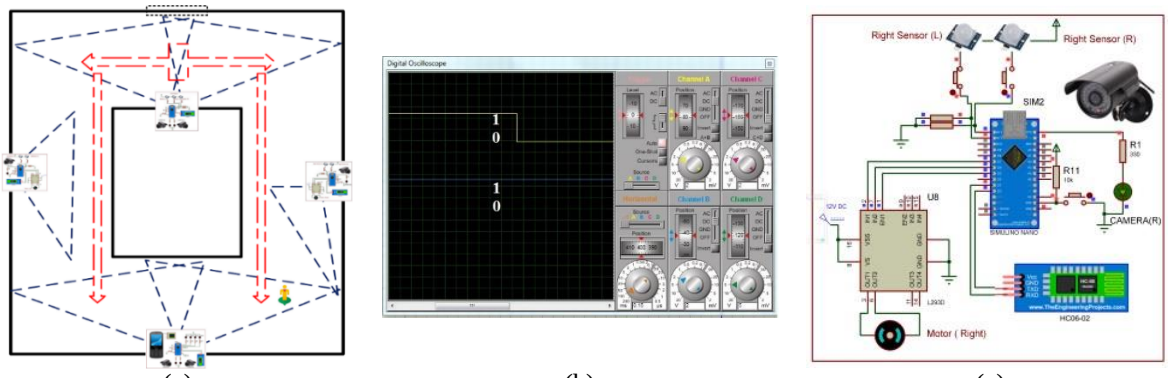
Figure 9. Situation 4 states and results (a) the person location, (b) output sensor results, and (c) motor situation result

3.5. Scenario 5

As shown Figure 10, the results are the same whether the user is standing on the left or right side of the structure. The person in this scenario is standing at the right-hand end of the structure. Figure 10(a) shows how to find the user in this condition (5), where the right circuit's right sensor is turned off and the left circuit's left sensor is turned on. Figure 10(b) shows the output results of the right-side circuit sensors, while Figure 10(c) shows the result of this camera scenario (the camera is ON).

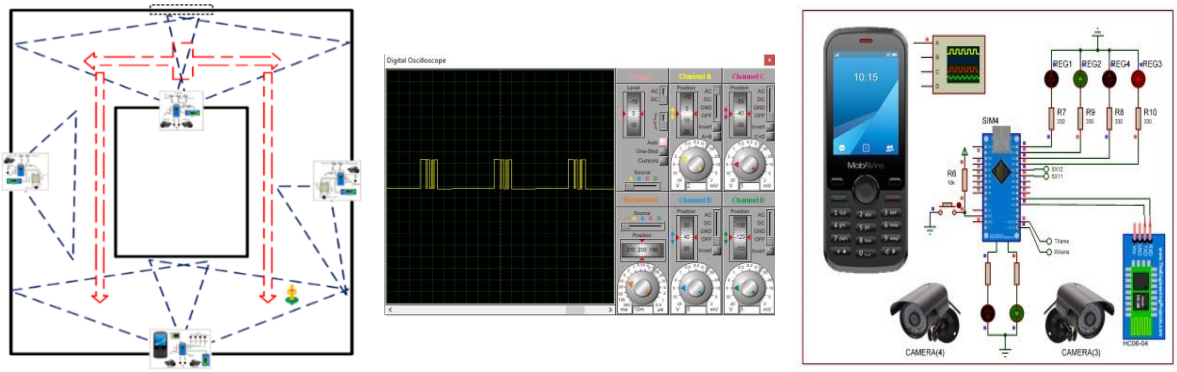
3.6. Scenario 6

As shown in Figure 11, the same findings are obtained whether the person stands on the left or right side of the building's end. Figure 11(a) shows how to find the individual in this case (4) by turning on the right sensor and turning off the left sensor at the end(master) circuit, turning on the camera, and having the master circuit at the end of the building transmit the conflicting SMS. Figure 2(a) depicts this scenario, whereas Figure 11(b) depicts the SMS output signal outcome. Figure 11(c) shows the camera position as a result of the master circuit (the camera is ON).



(a) (b) (c)

Figure 10. Scenario 5 states and results (a) the person location, (b) output sensor results, and (c) motor situation result



(a) (b) (c)

Figure 11. Scenario 6 states with results (a) the person location, (b) the output results of mobile and (c) motor scenario result

4. CONCLUSION

A new security monitoring system had been created for smart homes and bulling applications in this project. Because bluetooth (HC-06) has a low energy consumption and a communication distance of 100 meters between points, this system is based on Bluetooth mesh sensor network (BMSN). Furthermore, a global system for mobile communications (GSM) phone was utilized to convey a warning message from the master control system. One of the most essential internet of things (IoT) applications is the Bluetooth sensors network. Each portion of the network was controlled by an Arduino Nano microcontroller. Such microcontroller receives the motion sensor's signals till the cameras are controlled, and it also sends and receives signals through Bluetooth between two components of the mesh sensor network, and the cameras are switched on and off and moved right or left based on these signals. In our study, an explaination and simulation of the system had been discussed the outcomes. The key benefit of this study is the creation of a low-cost Bluetooth sensor security network with limited storage capacity for control movies.

REFERENCES

[1] H. S. Ahmed and A. Abdulkareem Ali, "Wireless sensor network for medical applications," *Iraqi Journal for Electrical and Electronic Engineering*, vol. 11, no. 1, pp. 49–59, Jun. 2015, doi: 10.33762/eeej.2015.102714.

[2] A. Jamaluddin, D. Harjunowibowo, D. T. Rahardjo, E. Adhitama, and S. Hadi, "Wireless water flow monitoring based on Android smartphone," in *2016 2nd International Conference of Industrial, Mechanical, Electrical, and Chemical Engineering, ICIMECE 2016*, 2017, pp. 243–247, doi: 10.1109/ICIMECE.2016.7910449.

[3] Y. Liu, L. Feng, S. Liu, and M. Sun, "Sensor Network oriented human motion segmentation with motion change measurement," *IEEE Access*, vol. 6, pp. 9281–9291, 2017, doi: 10.1109/ACCESS.2017.2787675.

[4] P. Gupta, and J. Chhabra, "IoT based smart home design using power and security management," *2016 International Conference on Innovation and Challenges in Cyber Security (ICICCS-INBUSH)*, pp. 6-10, 2016.

[5] A. H. Ali, A. D. Farhood, and M. K. Naji, "Analysis of a framework implementation of the transceiver performances for integrating optical technologies and wireless LAN based on OFDM-RoF," *International Journal of Electrical and Computer Engineering*, vol. 10, no. 4, pp. 4252–4260, Aug. 2020, doi: 10.11591/ijece.v10i4.pp4252-4260.

[6] C. G. Hidalgo, D. Hortelano, L. R. Sanchez, T. Olivares, M. C. Ruiz, and V. Lopez, "IoT heterogeneous mesh network deployment for human-in-the-loop challenges towards a social and sustainable industry 4.0," *IEEE Access*, vol. 6, pp. 28417–28437, 2018, doi: 10.1109/ACCESS.2018.2836677.

[7] M. K. Abed, M. M. Kareem, R. K. Ibrahim, M. M. Hashim, S. Kurnaz, "Secure medical image steganography method based on pixels variance value and eight neighbors," in *2021 International Conference on Advanced Computer Applications, ACA 2021*, Jul. 2021, pp. 199–205, doi: 10.1109/ACA52198.2021.9626807.

[8] F. Salamone, L. Belussi, L. Danza, M. Ghellere, and I. Meroni, "An open source 'smart lamp' for the optimization of plant systems and thermal comfort of offices," *Sensors (Switzerland)*, vol. 16, no. 3, p. 338, Mar. 2016, doi: 10.3390/s16030338.

[9] V. Teslyuk, V. Beregovskyi, P. Denysyuk, T. Teslyuk, and A. Lozynskyi, "Development and implementation of the technical accident prevention subsystem for the smart home system," *International Journal of Intelligent Systems and Applications*, vol. 11, no. 1, pp. 1, 2018.

[10] B. S. Hassen, S. A. S. Lafta, H. M. Noman, "Analyzing the performances of WSNs routing protocols in grid- based clustering," *International Journal on Advanced Science, Engineering and Information Technology*, vol. 9, no. 4, pp. 1211–1216, Aug. 2019, doi: 10.18517/ijaseit.9.4.8900.

[11] C. M. Yu and J. H. Lin, "Enhanced Bluetree: A mesh topology approach forming Bluetooth scatternet," *IET Wireless Sensor Systems*, vol. 2, no. 4, pp. 409–415, Dec. 2012, doi: 10.1049/iet-wss.2011.0059.

[12] S. A. S. Lafta, M. M. Abdulkareem, R. K. Ibrahim, M. M. Kareem, and A. H. Ali, "Quality of service performances of video and voice transmission in universal mobile telecommunications system network based on opnet," *Bulletin of Electrical Engineering and Informatics*, vol. 10, no. 6, pp. 3202–3210, Dec. 2021, doi: 10.11591/eei.v10i6.3139.

[13] J. K. Abed and H. M. Abd-aljabar, "Smart monitor of pacemaker patient by using IoT cloud in real time," *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, vol. 18, no. 1, pp. 158-166, 2020, doi: 10.11591/ijeecs.v18.i1.pp158-166.

[14] L. Leonardi, G. Patti, and L. Lo Bello, "Multi-hop real-time communications over Bluetooth low energy industrial wireless mesh networks," *IEEE Access*, vol. 6, pp. 26505–26519, 2018, doi: 10.1109/ACCESS.2018.2834479.

[15] H. H. Qasim, A. E. Hamza, L. Audah, H. H. Ibrahim, H. A. Saeed, and M. I. Hamzah, "Design and implementation home security system and monitoring by using wireless sensor networks WSN/internet of things IoT," *International Journal of Electrical and Computer Engineering*, vol. 10, no. 3, pp. 2617–2624, Jun. 2020, doi: 10.11591/ijece.v10i3.pp2617-2624.

[16] H. F. Hashim, M. M. Kareem, W. K. Al-Azzawi, and A. H. Ali, "Improving the performance of photovoltaic module during partial shading using ANN," *International Journal of Power Electronics and Drive Systems*, vol. 12, no. 4, pp. 2435–2442, Dec. 2021, doi: 10.11591/ijpeds.v12.i4.pp2435-2442.

[17] X. Lu, J. Wang, G. Lu, B. Lin, M. Chang, and W. He, "Quality level identification of West Lake Longjing green tea using electronic nose," *Sensors and Actuators, B: Chemical*, vol. 301, p. 127056, Dec. 2019, doi: 10.1016/j.snb.2019.127056.

[18] S. Sirur *et al*., "A mesh network for mobile devices using Bluetooth low energy," in *2015 IEEE SENSORS - Proceedings*, Nov. 2015, pp. 1–4, doi: 10.1109/ICSENS.2015.7370451.

[19] C. M. Yu and Y. B. Yu, "Reconfigurable algorithm for bluetooth sensor networks," *IEEE Sensors Journal*, vol. 14, no. 10, pp. 3506–3507, Oct. 2014, doi: 10.1109/JSEN.2014.2339351.

[20] M. A. Mohammed, A. D. Farhood, and A. J. Abid, "A smart energy consumption manager based on protues simulation," *International Journal of Power Electronics and Drive Systems*, vol. 11, no. 1, pp. 143–150, Mar. 2020, doi: 10.11591/ijpeds.v11.i1.pp143-150.

[21] M. J. Mnati, R. F. Chisab and A. Van den Bossche, "A smart distance power electronic measurement using smartphone applications," 2017 19th European Conference on Power Electronics and Applications (EPE'17 ECCE Europe), Warsaw, 2017, pp. P.1-P.11, doi: 10.23919/EPE17ECCEEurope.2017.8099394.

[22] S. Rhaif, A. Abdulrazzaq, R. Abdulnabi, "Fiber optics based schemes modeling and simulation of QoS for Wi-Fi scenarios using OPNET modeler," *International Journal of Electrical and Computer Engineering*, vol. 10, no. 3, pp. 2569-2578, 2020, doi: 10.11591/ijece.v10i3.pp2569-2578.

[23] A. Sekiguchi and M. Haruta, "Motion analysis for a three-wheeled walker by using motion sensor," in *2017 56th Annual Conference of the Society of Instrument and Control Engineers of Japan, SICE 2017*, 2017, pp. 1252–1257, doi: 10.23919/SICE.2017.8105482.

[24] I. H. L. Nava and M. M. Angelica, "Wearable Inertial Sensors for human motion analysis: A review," *IEEE Sensors Journal*, no. 99, pp. 7821–7834, Nov. 2016, doi: 10.1109/JSEN.2016.2609392.

[25] M. A. Saad, S. A. S. Lafta, R. Kh. Al-Azzawi, A. H. Ali, S. Alani, M. M. Hashim, B. Hasan, "Total energy consumption analysis in wireless Mobile ad hoc network with varying mobile nodes." *Indonesian Journal of Electrical Engineering and Computer Science*, 2017, vol. 14, no. 2, pp1397-1405.

[26] W. Kim and M. Kim, "Sports motion analysis system using wearable sensors and video cameras," in *International Conference on Information and Communication Technology Convergence: ICT Convergence Technologies Leading the Fourth Industrial Revolution, ICTC 2017*, 2017, pp. 1089–1091, doi: 10.1109/ICTC.2017.8190863.

[27] M. M. Kareem, S. A. S. Lafta, H. F. Hashim, R. K. Al-Azzawi, and A. H. Ali, "Analyzing the BER and optical fiber length performances in OFDM RoF links," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 23, no. 3, pp. 1501–1509, Sep. 2021, doi: 10.11591/ijeecs.v23.i3.pp1501-1509.

[28] H. Singh, V. Pallagani, V. Khandelwal, and U. Venkanna, "IoT based smart home automation system using sensor node," in *Proceedings of the 4th IEEE International Conference on Recent Advances in Information Technology, RAIT 2018*, 2018, pp. 1–5, doi: 10.1109/RAIT.2018.8389037.

[29] R. K. Nath, R. Bajpai, and H. Thapliyal, "IoT based indoor location detection system for smart home environment," in *2018 IEEE International Conference on Consumer Electronics, ICCE 2018*, Jan. 2018, vol. 2018-January, pp. 1–3, doi: 10.1109/ICCE.2018.8326225.

[30] H. M. Noman, A. A. Abdulrazzaq, M. M. Kareem, and A. H. Ali, "Improvement ivestigation of the TCP algorithms with avoiding network congestion based on OPNET," *IOP Conference Series: Materials Science and Engineering*, vol. 518, no. 5, p. 052025, May 2019, doi: 10.1088/1757-899X/518/5/052025.

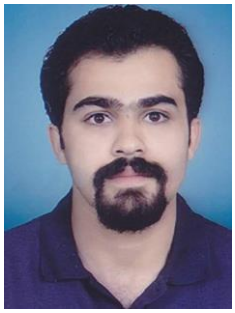
BIOGRAPHIES OF AUTHORS

Bilal Hashim Hameed is Ph D student at Altinbaş University, Istanbul, in Electrical and Computer Engineering. He received the, MSc. from Altinbaş University in 2019. Previously, the bachelor's degree of computer Engineering B.A. Awards was obtained in 2016 from Al-Esraa College University, Baghdad, Iraq. He can be contacted at email: bbhhyyaadd@gmail.com.

Anmar Yahya Taher is Ph D student at Altinbaş University, Istanbul, in Electrical and Computer Engineering. He received the, MSc. from Altinbaş University in 2019. Previously, the bachelor's degree of computer Engineering B.A. Awards was obtained in 2016 from Al-Esraa College University, Baghdad, Iraq. He can be contacted at email: enganmaryahya@gmail.com.

Raed Khalid Ibrahim is an Associate Professor at the Al-Farahidi University, Iraq, where he has been a faculty member since 2017. Raed graduated with a M.Sc. degree in laser engineering from Nahrain University, Iraq, in 2001, and a Ph D in laser & Opto-electronics engineering from Nahrain University, Iraq, in 2007. His research interests are primarily in the area of knowledge technology, cloud computing, internet of things. Where he is the author/co-author of over 20 research publications. He can be contacted at email: dradnanmtu@gmail.com.

Adnan Hussein Ali is Professor at the Middle Technical University, Baghdad, Iraq, where he has been a faculty member since 2007. Iam graduated with a Bs C degree in Electronic Engineering from University of Technology- Baghdad, Iraq, in 1987, and an M.Sc. in Electronic and communication technology from University of Technology-Baghdad in 1999, and Ph D from Laser & Opto-electronics Dept. University of Technology-Baghdad in 2007. Our research interests in the area of Optical Communication, cloud computing, RoF, WSN, and PV. Iam an author/co-author of over 60 research publications. email: dr.adnan@mtu.edu.iq, aaddnnaann63@gmail.com.



Yasser Adnan Hussein He completed his Bachelor's from Technical college of Electrical engineering, computer engineering dept. in 2012 Baghdad. Thereafter, he has completed his Masters's from Universiti Kebangsaan Malaysia (UKM), Malaysia in 2019. Now, he is a researcher at Ministry of science and Technology, Baghdad. He can be contacted at email: yasseradnan89@gmail.com.