Bulletin of Electrical Engineering and Informatics
Vol. 12, No. 1, February 2023, pp. 539~543
ISSN: 2302-9285, DOI: 10.11591/eei.v12i1.4407

The software requirements process for designing a microcontroller-based voice-controlled system

Nadia Mahmood Hussien[1], Yasmin Makki Mohialden[1], Mustafa Mahmood Akawee[2], Mostafa Abdulghafoor Mohammed[2]
[1]Department of Computer Science, College of Science, Mustansiriyah University, Baghdad, Iraq
[2]Imam Aadham University College, Baghdad, Iraq

Article Info

Article history:

Received Jul 14, 2022
Revised Aug 12, 2022
Accepted Sep 28, 2022

Keywords:

Android application
Arduino
Software engineering
Software requirements
Voice control systems

ABSTRACT

Smartphones of today are capable of controlling motors, music systems, and lighting. This project's objective is to construct a robot car for the elderly and disabled that is based on the Arduino platform. Voice instructions can be used to wirelessly control the robotic car that the user is riding. The robot is able to move to the left and right, as well as forward and backward, and it can also stop. The voice-controlled robot vehicle built using Arduino and operated by an HC-05 module is connected to Bluetooth. The exact spoken commands are sent to the robot through the phone via an application that runs on android. The Arduino, which is in charge of controlling the robotic automobile, gets commands through a Bluetooth transceiver module, which then relays them to the Arduino. The hardware consists of an android phone, an android-powered motor drive, an Arduino, and Bluetooth. This system was developed with the help of Arduino C and the android-meets-robot framework. The primary goals of this piece of writing are to gain an understanding of how to create the criteria for a voice-controlled system that is based on Arduino.

Corresponding Author:

Yasmin Makki Mohialden
Department of Computer Science, College of Science, Mustansiriyah University
Falastin St, Baghdad, Iraq
Email: ymmiraq2009@uomustansiriyah.edu.iq

1. INTRODUCTION

The unexpected surge in the usage of robots and automation provides a lot of benefits, and the fact that this has attracted the attention of both academic research and commercial enterprises is a testament to the importance of this development. There have been a lot of successful outcomes that have come about as a result of people researching new and innovative approaches to controlling robots and coming up with a lot of new and varied ways to control the movement of robots [1]-[4]. One of the more recent approaches to directing a robot is through the use of verbal engagement as a control method. Previous research on voice-controlled robots reveals that their designs were complex, and none of them were able to communicate with people, which is something that has not happened yet.

Even though robots are meant to get along with their humans, this hasn't been the case thus far. Voice control of robots is possible, but it's not particularly effective [5]-[7]. Saving money and power while still getting the job done is now achievable thanks to advancements in technology. Today's smartphones are more powerful, with quicker processors, more storage capacity, more entertainment options, and more ways to interact. In addition to data transfer, Bluetooth can be utilized to offer new functionality to smartphones [8]-[12]. Smart phones use Bluetooth technology developed by Ericsson in 1994, which demonstrates its usefulness. Digital technology is now used both at home and at work, leading to a shift away from wired

digital devices [13]-[16]. Up to seven Bluetooth modules can be connected to a host device simultaneously through a single link [16]-[18]. Combining twelve physical components, programming languages, and software creates an even better product. Anybody can utilize Arduino, which is a free and open-source electronics platform comprised of both hardware and software, to create interactive projects [19].

Various works are linked. The audio system needs users to be physically impaired. The command is provided through Bluetooth-enabled mobile phone and translated into a string using Arduino's BT voice control before being transmitted to the SR-04 Bluetooth module or wheelchair control Arduino board. This strategy saves money and time for physically challenged patients who use wheelchairs [20]-[22]. The recommended solution makes it easier to operate equipment in multiple rooms from a single place. They utilized Kinect V2 to construct this prototype using voice control. The Kinect V2 detected voices. The computer was then taught to understand oral instructions. Arduino and light bulbs were used to create a fake kitchen or bathroom. We ran tests to assess how well our system functioned. In this case, the Kinect sensor and the user are at least 4 meters away and the noise level is 53 dB more than 95% of the time. The suggested technique may be used with a Kinect V2 to control products with your voice [23]-[25].

Another project is voice-controlled smart lighting. Arduino Uno is used. This will save you time and simplify your life, work, and studies. To utilize it, say "turn on the lamp" or "turn off the lamp" you'll see how it works. Control light with "up," "down," "left," and "right." a nightlight, too. In a limited space, fluorescent lamps can detect light intensity changes and turn off for 10 seconds. When struck, the lights won't go off. The panel has a clock. The DS1302 clock module keeps time without electricity. Smart desk lamps are more handy than standard workplace lighting [8], [26].

The goal of Singh and Srivastava's project was to develop a voice-activated interface. This is a self-driving car. In order to complete the project, you'll need an Arduino board and a Bluetooth module. Open-source Arduino is a platform for creating digital gadgets (microcontrollers and kits). The idea is to design the task first, then write the code in the integrated development environment (IDE), and then connect it to the hardware. Using a Bluetooth module, a Bluetooth device can be connected to the control unit. They are able to decipher the vocal orders because they are listening for them. The remote control in this scenario is a Bluetooth app that was installed on an android smartphone or tablet by the user [26]. The purpose of this paper is to outline all of the particulars and requirements that must be met in order to construct software that makes use of an Arduino microcontroller and an app that recognizes voices. It finds application in a wide variety of products, such as robot automobiles, wheelchairs, and other similar devices. This paper is outlined as follows: section 2 reviewed the related works regarding the recommended method, while section 3 analyzed the evaluation results from the several experiments conducted in this study, while section 4 concluded the paper.

2. METHOD

The proposed system is designed to use an Arduino-based voice control system on a variety of devices, including a car and a wheelchair, as shown in the system block diagram in Figure 1. Here, the robotic car can be controlled wirelessly by using the user's voice commands throw an android app. The robot can move forward, backward, left, right, and stop completely. The voice-controlled Arduino robot car is attached to the HC-05 Bluetooth module. Voice commands are given to the robot via an android app installed on the phone. A Bluetooth module sends and receives commands and sends them to the Arduino, which lets you control the robotic vehicle.

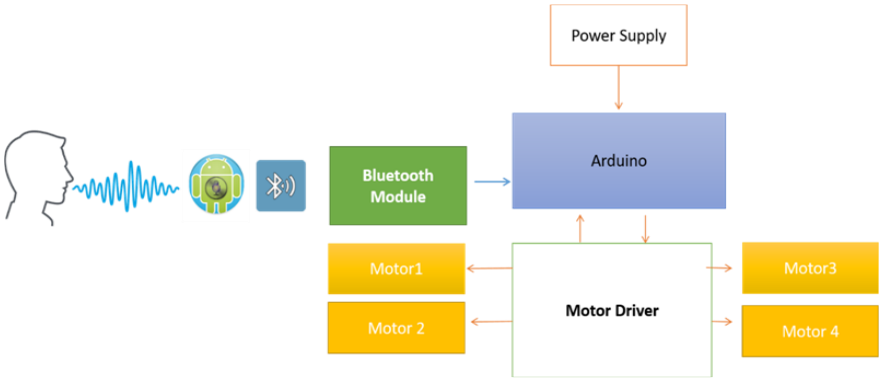

Figure 1. Depicts the system's block diagram

2.1. Requirements specifications

The following are high-level abstract statements about the proposed system's functions or services:

- Functional requirements:
  a. Cars or wheelchairs automatically come to a halt.
  b. Vehicles or wheelchairs move forward automatically.
  c. Vehicles or wheelchairs automatically reverse.
  d. Cars and wheelchairs automatically turn left.
  e. Cars or wheelchairs will automatically turn right.
  f. The system should be activated by a voice message.
- Nonfunctional requirement

Nonfunctional requirements are classified into three types: quality, platform, and methodology requirements.

i. Quality requirements: which include:
   a. Response time: one of the most important quality standards is response time. If the system has to work quickly in any situation, it should be made so that it can respond quickly.
   b. Reliability: the system should always give the same results every time.
   c. Availability: all the time, the system must be able to be used in order to achieve its goals.
   d. If you want to make your system more efficient, you should be able to add hardware or software to make it easier to do so.

ii. Requirements for platform: This type of requirement considers the system's environment and technology:
   a. Platform for computing: the system is powered by windows 10, has 4 GB of RAM, and a 1.80 GHz processor. It is equipped with an Arduino Uno microcontroller, a Bluetooth module, a motor drive, four motors, a breadboard, resistance, jumper wires, a PM3 module, a PC, a power supply, and a power cord.
   b. Requirements for methodology: the object-oriented system is designed and built using the unified modeling language (UML).

Figure 2 illustrates the use case diagram, which represents the functionality of the system. The system consists of two actors and “six” basic use cases with generalizations, inclusions relations.

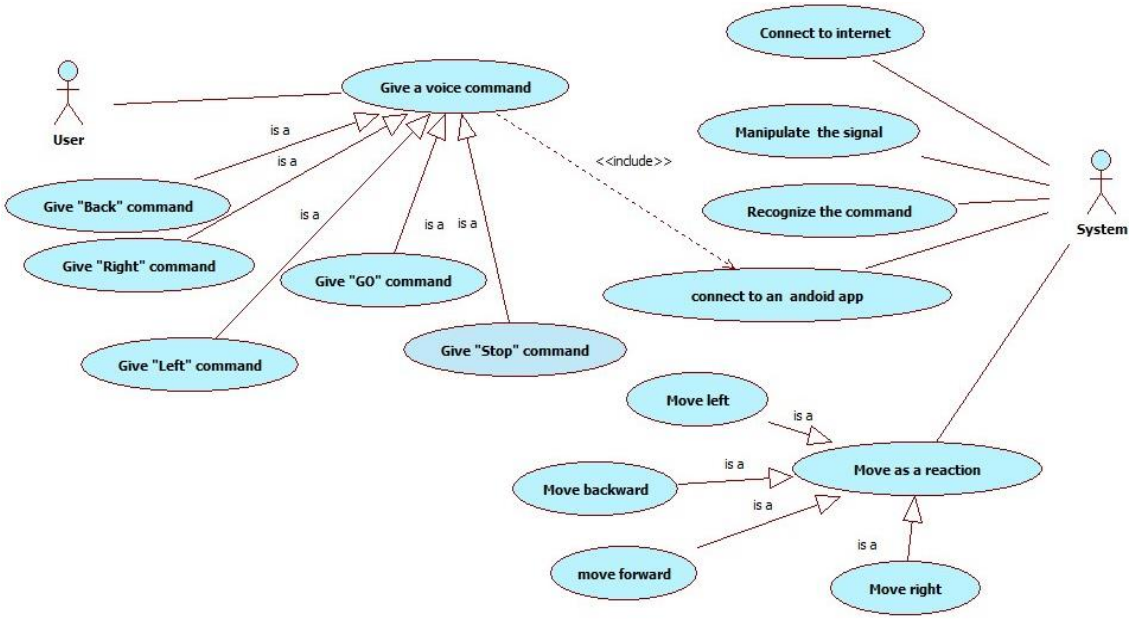

Figure 2. Use case diagram of the system

3. RESULTS AND DISCUSSION

The following movements can be used to test the system: forward, backward, left, right, and stop. To get the job done, the Arduino programming language and the Arduino development environment were adopted. First, as the control system prompts, the Bluetooth module is paired with a mobile phone using the android operating system. It uses a password to pair. For example, the password for pairing is "1234" or "0000". The requirements for the specification of the system depend on the needs of the users, who are physically handicapped and need to use a wheelchair for their movement. They are specified in Table 1.

Table 1. Requirements specifications for user commands and actions

User command	Arduino voice control action	Microcontroller action
"BACK"	The Arduino voice control program delivers the string "*BACK #" to the Bluetooth module linked to the circuit.	Back is recognized by the wheelchair's microprocessor.
"GO"	The Arduino voice control program delivers the string "* GO #" to the Bluetooth module linked to the circuit.	the microcontroller detects "GO," the wheelchair's motor moves FORWARD
"LEFT"	The Arduino voice control program sends the string "* LEFT #" to the Bluetooth module connected to the circuit.	When the microcontroller detects "LEFT," it moves the motor attached to the wheelchair's LEFT side
"RIGHT"	The Arduino voice control application sends the string "*RIGHT #" to the Bluetooth module connected to the circuit.	When the microcontroller senses "RIGHT," it moves the wheelchair's right motor.
"STOP"	The Arduino voice control application delivers the string "* STOP #" to the circuit's Bluetooth module.	When the microcontroller recognises "STOP," the wheelchair comes to a complete stop.

To disconnect the paired Bluetooth module, click the "DISCONNECT" icon.

4. CONCLUSION

The goal of this study is to establish the technical and detailed criteria for an Arduino-based voice control system. The technology can be used in a variety of applications, including robot autos, and wheelchairs. A robot car was used in this study. The proposed system includes basic operating modes that the system controls in a robot automobile via an android mobile application with graphical user interface touch buttons and voice recognition. Meanwhile, it has been demonstrated that the proposed technologies can control the automated vehicle's movement (forward, backward, left, right, and in a stop position). As a voice recognition program, the android meet robot connects to the system via a Bluetooth module. The offered system's equipment is low-cost and high-efficiency. During the last phases of a system's life cycle, when it has been used and tested, it has been completely successful for everyone who have used and tested it.

ACKNOWLEDGEMENTS

We would like to express our heartfelt gratitude to the people in the Department of Computer Science at Mustansiriyah University in Baghdad, Iraq for their support with this research.

REFERENCES

[1] R. Syed *et al.*, "Robotic process automation: contemporary themes and challenges," *Computers in Industry*, vol. 115, Feb. 2020, doi: 10.1016/j.compind.2019.103162.
[2] N. Nathoo, M. C. Çavuşoğlu, M. A. Vogelbaum, and G. H. Barnett, "In touch with robotics: neurosurgery for the future," *Neurosurgery*, vol. 56, no. 3, pp. 421–433, Mar. 2005.
[3] M. Dideles, "Bluetooth: a technical overview: XRDS: crossroads,'' *The ACM Magazine for Students*: vol 9, no 4, pp. 11-18, 2003.
[4] G. SRIDHAR and M. Srinivas, "Home automatic control system using bluetooth and android mobile," *International Journal of Innovative Technologies*, vol. 3, no. 6, pp. 937-940, 2015.
[5] D. K. Lodhi *et al.*, "Smart electronic wheelchair using arduino and bluetooth module," *International Journal of Computer Science and Mobile Computing*, vol. 5, no. 5, pp. 433-438, 2016.
[6] K. A. S. V. Rathnayake, S. I. A. P. Diddeniya, W. K. I. L. Wanniarachchi, W. H. K. P. Nanayakkara, and H. N. Gunasinghe, "Voice operated home automation system based on Kinect sensor," *2016 IEEE International Conference on Information and Automation for Sustainability (ICIAfS)*, 2016, pp. 1-5, doi: 10.1109/ICIAFS.2016.7946530.
[7] L. Zhang *et al.*, "Intelligent voice control lighting device based on arduino UNO microcontroller," in *IOP Conference Series: Earth and Environmental Science*, vol. 252, no. 3, 2019.
[8] S. Srivastava and R. Singh, "Voice controlled robot car using Arduino,*" International Research journal of Engineering and Technology*, vol. 7 no. 5, pp. 4033–4037, May 2020.
[9] S. Packeer and D. T. V. Kannangara, "Detection of pedophilia content online: A case study using Telegram," *Iraqi Journal For Computer Science and Mathematics*, vol. 3, no. 2, pp. 72-77, 2022, doi: 10.52866/ijcsm.2022.02.01.007.
[10] Yan and H. Shi, "Smart living using bluetooth-based android smartphone," *International Journal of Wireless & Mobile Networks*, vol. 5, no. 1, pp. 65-72, 2013, doi: 10.5121/ijwmn.2013.5105.
[11] H. R. Ibraheem, Z. F. Hussain, S. M. Ali, M. Aljanabi, M. A. Mohammed, and T. Sutikno, "A new model for large dataset dimensionality reduction based on teaching learning-based optimization and logistic regression," *TELKOMNIKA Telecommunication, Computing, Electronics and Control*, vol. 18, no. 3, pp. 1688-1694, Jun. 2020, doi: 10.12928/TELKOMNIKA.v18i3.13764
[12] N. M. Hussien, Y. M. Mohialden, N. T. Ahmed, M. A. Mohammed, and T. Sutikno, "A smart gas leakage monitoring system for use in hospitals," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 19, no. 2, pp. 1048-1054, Aug. 2020, doi: 10.11591/ijeecs.v19.i2.pp1048-1054.
[13] B. I. Farhan and A. D. Jasim, "A survey of intrusion detection using deep learning in internet of things," *Iraqi Journal For Computer Science and Mathematics*, vol. 3, no. 1, pp. 83-93, 2022, doi: 10.52866/ijcsm.2022.01.01.009.
[14] Z. Rustum, "Investigating the use of an adaptive neuro-fuzzy inference system in software development effort estimation," *Iraqi Journal For Computer Science and Mathematics*, vol. 2, no. 2, pp. 18-24, 2021, doi: 10.52866/ijcsm.2021.02.02.003.
[15] R. A. I. Alhayali, M. Aljanabi, A. H. Ali, M. A. Mohammed, and T. Sutikno, "Optimized machine learning algorithm for intrusion detection," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 24, no. 1, pp. 590-599, Oct. 2021, doi: 10.11591/ijeecs.v24.i1.pp590-599.
[16] Z. A. Abdalkareem, O. Z. Akif, F. A. Abdulatif, A. Amiza, and P. Ehkan, ''Graphical password-based mouse behavior

technique,'' in *Journal of Physics: Conference Series IOP Publishing*, vol. 1755, no. 1, p. 012021, Aug 2019.
[17] Z. A. Abdalkareem, M. A. Al-Betar, A. Amir, P. Ehkan, A. I. Hammouri, and O. H. Salman, ''Discrete flower pollination algorithm for patient admission scheduling problem,'' *Computers in biology and medicine*, vol. 141, Feb. 2022, doi: 10.1016/j.compbiomed.2021.105007.
[18] A. Ali, A. F. Hussain, and S. N. Abd, ''Big data classification efficiency based on linear discriminant analysis,'' *Iraqi Journal for Computer Science and Mathematics*, vol. 1, no. 1, pp. 7–12, 2020, doi: 10.52866/ijcsm.2019.01.01.001.
[19] A. H. Ali and M. Zaki, ''A brief review of big data analytics based on machine learning,'' *Iraqi Journal for Computer Science and Mathematics*, vol. 1, no. 2, pp. 13–15, 2020.
[20] A. D. Jasim, "A survey of intrusion detection using deep learning in internet of things," *Iraqi Journal for Computer Science and Mathematics*, vol. 3, no. 1, pp. 83-93, 2022, doi: 10.52866/ijcsm.2022.01.01.009.
[21] A. H. Ali, M. N. Abbod, M. K. Khaleel, M. A. Mohammed, and T. Sutikno, "Large scale data analysis using MLlib," *TELKOMNIKA Telecommunication Computing Electronics and Control*, vol. 19, pp. 1735-1746, 2021, d.
[22] O. H. Salman, M. I. Aal-Nouman, Z. K. Taha, M. Q. Alsabah, Y. S. Hussein, and Z. A. Abdelkareem, "Formulating multi diseases dataset for identifying, triaging and prioritizing patients to multi medical emergency levels: Simulated dataset accompanied with codes," *Data in Brief*, vol. 34, p. 106576, Feb. 2021, doi: 10.1016/j.dib.2020.106576.
[23] Z. A. Abdalkareem, A. Amir, M. A. Al-Betar, P. Ekhan, and A. I. Hammouri, "Healthcare scheduling in optimization context: a review," *Health and Technology*, vol. 11, pp. 445-469, Apr. 2021, doi: 10.1007/s12553-021-00547-5.
[24] O. A. Hammood *et al*., "An effective transmit packet coding with trust-based relay nodes in VANETs," *Bulletin of Electrical Engineering and Informatics*, vol. 9, no. 2, pp. 685–697, 2020, doi: 10.11591/eei.v9i2.1653.
[25] P. Grandinetti *et al*., "Results of the COVID-19 mental health international for the general population (COMET-G) study," *European Neuropsychopharmacology*, vol. 54, pp. 21-40, January 2022, doi: 10.1016/j.euroneuro.2021.10.004.
[26] H. Abubakar, A. Muhammad, and S. Bello, "Ants colony optimization algorithm in the Hopfield neural network for agricultural soil fertility reverse analysis," *Iraqi Journal For Computer Science and Mathematics*, vol. 3, no. 1. pp. 32-42, 2022, doi: 10.52866/ijcsm.2022.01.01.004.

BIOGRAPHIES OF AUTHORS

Nadia Mahmood Hussien is assistance lecturer at college of–College of Science, Mustansiriyah University, Iraq. She holds a master degree in Computer Science with specialization in software engineering. Her research areas are software engineering, artificial intelligent, internet of things. She can be contacted at email: nadia.cs89@uomustansiriyah.edu.iq.

Yasmin Makki Mohialden is lecturer at college of–College of Science, Mustansiriyah University, Iraq. She holds a master degree in Computer Science with specialization in Software Engineering. Her research areas are software engineering, artificial intelligent, internet of things, and cloud computing. She is head of computer center in the college of science. She can be contacted at email: ymmiraq2009@uomustansiriyah.edu.iq.

Mustafa Mahmood Akawee currently works at the al-imam Adhm. Mostafa does research in information systems (business informatics), computer communications (networks) and communication engineering. Their current project is 'offloading in mobile cloud computing'. He has finished his master from computer science department at Kharkiv University, Ukriane. He can be contacted at email: it.diyala2@gmail.com.

Mostafa Abdulghafoor Mohammed currently works at the Al-Imam AlAadham University college. Mostafa does research in Information technology, computer communications (Networks), cloud computing and communication engineering. Their current project is 'offloading in mobile cloud computing'. He has finish his master from computer science department at BAMU University, India, and he finish Ph.D in Computer science and IT at University Polytechnic of Bucharest Romania. He can be contacted at email:dr.alqaisy86@gmail.com.