Research Article

Araştırma Makalesi

UMÜFED Uluslararası Batı Karadeniz Mühendislik ve Fen Bilimleri Dergisi, 4(1): 1-21, 2022

UMUFED International Journal of Western Black Sea Engineering and Science

e-ISSN: 2687-2927

CONTROLLABLE CLEANING ROBOT WITH BLUETOOTH THAT CAN DETECT OBSTACLES

Kübra Seda Kimyager[1,a,*], Yasin Ömer Bıdık[1,b]

[1]Düzce Üniversitesi İşletme Fakültesi,Yönetim Bilişim Sistemleri Bölümü, Düzce, Türkiye

[a] k.sedakimayager@yandex.com, ORCID: 0000-0002-4926-394X

[b] ybidik81@gmail.com, ORCID: 0000-0001-6232-8544

ÖZET

Teknolojinin gelişmesiyle robotların günlük hayatımızdaki yeri artmıştır. Bu çalışmada Arduino Uno R3 kartı ve çeşitli sensörler kullanılarak bir robot geliştirilmiştir. Çalışmanın amacı teknolojiyi aktif kullanarak rutin hale gelen ev işlerinin kolaylaştırılmasıdır. Bu amacın yapılabilmesi için evin içinde gezebilen, fan ile toz çekebilen ve DC motorların üzerine yerleştirilen özel bezler sayesinde zemini silmeyi başaran bir robot tasarlanmıştır. Ayrıca robotun silme ve süpürme işleminde engelle karşılaştığında görevine devam edebilmesi için yeni bir algoritma kullanılarak test edilmiştir. Tasarlanan sistemde kullanıcıların otomatik kullanımının dışında da kullanılmasına imkan tanıyan Bluetooth modülü içermektedir. İnsanlar evde olmasa bile temizlik işleminin yapılması sağlanacaktır ve temizlik işleminde daha az insan gücüne ihtiyaç duyulacaktır. Piyasada eş değeri olan robotlara göre maliyetinin oldukça düşük olması ve bazı durumlarda daha hassas temizlik yapabilme yeteneğine sahip olduğu için kullanıcılar tarafından tercih edilme sebebi olacağı düşünülmektedir. Prototipin dahada geliştirilerek robotun boyutlarında değişiklik yapılması gerekmektedir. Robotun çalışma sıklığının hesaplanması için temizlik alanlarının tespiti, temizlik sıklığı ve çalışma performansı göz önüne alınmıştır.

Anahtar Kelimeler: Temizlik robotu, arduino, bluetooth , engel tanıma

ABSTRACT

With the advancement of technology, the place of robots in our daily life has increased. In this study, a robot that has been developed by combining Arduino Uno R3 and various sensors,

***Sorumlu Yazar (Corresponding Author)**

Atıf (Citation): Kimyager, K.S., Bıdık, Y.Ö., "Controllable Cleanıng Robot wıth Bluetooth that can Detect Obstacles", UMÜFED Uluslararası Batı Karadeniz Mühendislik ve Fen Bilimleri Dergisi, 4(1): 1-21, 2022.

Geliş (Received): 14/08/2021

Kabul (Accepted): 29/11/2021

Yayın (Published): 13/03/2022

which will provide convenience in daily life, has been developed. The aim of the study is to make household chores that have become routine easier with the help of technology. For this purpose, a robot is designed that travels inside the house, draws dust with a fan, and wipes the floor thanks to the cloths placed on DC motors. A new Algorithms have been used to ensure that the robot can continue its task without getting stuck when it encounters an obstacle during the wiping and sweeping process. The system also includes a Bluetooth module that will provide manual control of the user. At the end of the study, people will be able to easily perform floor cleaning jobs without tiring themselves and having to be at home. It can clean more precisely than different models offered for sale at high prices in the market. However, it is thought that it will be preferable because of its low cost. As a result of the further development of the prototype, it will be able to serve home users as a result of changes in size. The cleaning frequency of the robot is presented by detecting the right areas and working performance analysis.

Keywords: Cleaning robot, arduino, bluetooth , obstacle recognition

1. INTRODUCTION

With the advancement of technology, a significant amount of convenience has started to be the subject of people's daily work. Due to the development of technology, robots with various features started to be produced. Thanks to these robots being produced, people's jobs and tasks in many areas have been made possible by robots. These robots bring many conveniences such as minimizing errors and reducing workload. Robots have a wide range of usage and depending on this area of use, there are fixed or mobile robots. Robots that can recognize obstacles are in the class of moving robots. Robots that can recognize obstacles are preferred in factories, home life and military missions. These robots are used especially for cleaning purposes in homes. Cleaning is an element that affects the health of all living things, so cleaning has an important place in our lives. Especially people show more detailed behaviors in cleaning. In floor cleaning, people can wipe at home or use a vacuum cleaner. Thanks to this study, two different cleaning methods have become one. It is not necessary to waste time or use force to use these methods.

Technology is used to fulfill the daily needs of the society and this effect of the technology is spreading day by day. The use of computer-based equipment that is designed to help people in daily work is increasing. As a result of the research on advanced robots and

computer systems, microcontrollers were found to be the main controller part. Microcontrollers are embedded systems used to perform tasks given in robotic applications.

People living in big cities can spend less time on their daily work due to their long working hours. Today, automated systems can easily perform house cleaning instead of people. As a result of these working hours, people may be too tired to perform cleaning work. Also, saving time is an important issue and thanks to this study, it will be sufficient to devote very little time to floor cleaning works even during busy working days. In this study, it is aimed to help people who do not have enough time to perform cleaning jobs, in other words, those who have difficulty in performing floor cleaning and those who have difficulty in moving, and an Ardunio-based cleaning tool is designed to achieve this goal. The opening button must be pressed to start this cleaning tool. Later on, the cleaning vehicle will travel through the room and perform the cleaning process. An ultrasonic distance sensor was used to recognize the items during the cleaning process of the vehicle and to change its course without hitting them. This sensor is mounted on the front of the vehicle to protect the vehicle from obstacles. In this study, we provide a vehicle designed with Ardunio with the ability to recognize obstacles and manual control, as well as the automatic cleaning ability. In order for the cleaning tool to perform vacuum cleaning and wiping, it is aimed to maximize the efficiency of cleaning by using various hardware parts. Arduino IDE editor is used in the software part of the study. The necessary codes and functions are written on the editor and put on the Arduino board. This is how the cleaning tool will know the tasks it has to fulfill.

Arduino is a physical programming platform consisting of an input / output board and a Java based development program. With the help of Arduino, objects can be made on their own, or they can be coded with computer software. Arduino IDE code editor is an application written in Java programming language that allows loading the compiled codes to the card [1].

2. LITERATURE REVIEW

In this section, a literature review has been made by examining the robots that are designed to facilitate the cleaning works of people and that can be used in offices, homes, shopping malls, etc. Park and Lee developed a cleaning robot for home cleaning services. The authors propose a new cleaning algorithm for the autonomous mobile robot in their work. They have named this algorithm as Plane Sweep Algorithm. The basic understanding of PSA is that it clears an area and pushes the starting points of the missing place into a pile in the future.

These points will be set as a new starting point. We save the cleaned area to the information bitmap, then we can check if the existing stacked point has been cleaned. If the current accumulation point is not cleaned yet, it is set as a new starting point and the robot continues a cleaning task. The robot should move from the current point to the exploded point, avoiding all obstacles. Therefore, we need a point-to-point transfer algorithm in this article, the selection is made in the algorithms available in the point to point algorithm [2].

Kim designed a robot for home-workplace, surface multi-purpose cleaning. The authors describe the principle of working together with the system structure of the cleaning robot, sensors, functions and integrated subsystems [3]. Kwon, Song and Kang have developed a cleaning robot that can perform house cleaning, workplace cleaning, ceiling cleaning that is more difficult to reach. Authors Localization methods have been used in ceiling corners. Pixel-based square differences (SSD) method for corner matching corners on the ceiling were observed by a cleaning robot equipped with a monocular monocular camera [4]. Kim, Yang, and Kwon Simultaneous localization and mapping (SLAM), this article proposes a robot cleaner's experience-based cleaning algorithm. In this article, Core density estimation (also known as Parzen Window), one of the best-known nonparametric modeling methods, was used. In this article, SLAM environment and user adaptive robot cleaner are recommended. Experiences of concentrated cleaning commands from a user due to undetectable obstacles such as electrical wire and malfunctions during cleaning are stored as data. They are used to find areas that should be avoided and should be cleaned with concentration. Core density estimation is used to estimate the shape of the areas. This density is used to find the threshold property area. After finding the areas, the robot determines the cleaning order between them. In this way, the working efficiency of the cleaning robot increases [5]. Özyalçın, Çakır, Çelik and Tekeş aimed to help people who complain about health problems such as joint pain with the cleaning robot they designed. The authors stated that by using sensors, the robot can avoid obstacles and clean the environment at this time. They also stated that the robot will perform cleaning when people are not in the environment [6].

By using artificial intelligence technologies, some methods were presented to slow the spread of the coronavirus disease and the importance of automatic cleaning systems was emphasized [7]. Liu, Zheng, Wang, Li, and Zhao designed a cleaning robot for house cleaning, office, office cleaning purposes. Indoor cleaning robots generally work in the environment where people are located. For this reason, cleaning the robots in the houses should not only be efficiently cleaned, but should also be integrated harmoniously with people. This article

specifies adding cognitive abilities to intelligent cleaning robots, including environmental cognition, dynamic barriers, and cleaning tasks. The robots should not only blindly perform the cleaning task, but should work in harmony with people and their weariness [8]. Rashid, Mahmood, Shekha developed the room cleaner robots using a DTMF receiver known as the MT8870 IC with band split filter and a digital decoder functions and these methods. For optimum operation of telephone equipment, the DTMF receiver should be designed to recognize tone sounds and pairs lasting more than 40ms [9].

However, remote controls, applications that provide radio-frequency wireless communication or etc. applications cause noise by creating negative effects on tone sounds. Therefore, tone sound times can be changed by adding extra resistance and a diode to the circuit. This saves a lot of time in the integrated laboratory and various manufacturing industries related to communication. Tomiyama, García, Kršlin, and Taykaldiranian have developed a cleaning robot for train cleaning, cabin, passenger seat and locomotive interior cleaning. The authors present and briefly describe the system and conceptual design used to obtain a train cabin pre-cleaning robot. Extensive analysis of current manual front-end cleaning allowed areas to be improved and better cleaning performance, as well as freeing cleaning personnel from the potential health and safety-friendly work environment, so train cabin cleanings were more detailed and the health of the cleaning staff was preserved. It contributes to the ease of human life many times in terms of both detail and health [10]. Patel and Patil have developed an automatic surface cleaner for use in the cleaning of homes and offices. In this study, the ability of avoiding obstacles and automatic direction decision is provided by using sensors on the robot. The authors stated that the robot they are working on is much more cost effective than the cleaning robots in the market [11]. Celik and Güneş Arduino Naono, Arduino Boards, Imu sensor devices to be used in arduino studies are mentioned. This article presents the control theory and image processing methodology. IMU sensors create many noisy signals due to their natural structure. The Kalman filter is used to block these noisy signals to have a smooth signal for better balance control [12]. Molina, Vera, Molina, and Garzon in this article writers Prototype is based on experimenting with electronic devices that use wireless transmitters and sensors to power the robot. With the design and implementation of this type of mobile robot with obstacle avoidance feature, it enables us to realize that robots can be made with some basic features of artificial intelligence at very low cost [13]. In this study, the control of the lamps in the prototype house and the camera at the garden entrance are realized with a short message sent via the Telegram application [14]. Aktaş, Polat and Oflezer in their work, they aimed to

contribute to the increase of the place of robots in daily work. For these purposes, the authors have designed a mobile robot controlled by Wi-Fi and Bluetooth. 3D printer was used to create the body of the robot. NodeMCU microcontroller and distance sensor were used in the study. Thus, the robot is prevented from hitting obstacles. The authors also aimed to access the ambient data by adding temperature, gas and humidity sensors to the vehicle. Wi-Fi communication between the designed robot and the phone is realized by MQ Telemetry Transport protocol. This protocol is a messaging protocol designed for use in unreliable networks, devices with low bandwidth. The authors observed that the battery power of the robot was insufficient as a result of their studies and suggested that the robot operate longer with Li-Po battery use [15].

Jarande, Murakar, Vast, Ubale and Saraf they have developed an autonomous cleaning tool that recognizes obstacles and performs vacuum cleaning using an ultrasonic sensor. In their work, they aimed to reduce the time allocated to cleaning works. They developed a cleaning robot using the wifi module IR proximity sensor for the internet of things for house cleaning, workplace cleaning, street and street cleaning. The authors stated that the robot they designed works on the principle of the Internet of things. The IR sensor distance measurement used in this article is widely used in industrial systems for process and quality control purposes. It is said that the sensor measures the distance between the surfaces, and that cleaning robots or similar robotic objects move intelligently within the information received from the sensor [16]. Asafa, Afonja, Olaniyan and Alade have developed a cleaning robot with Patterned algorithm to be used in daily house cleaning. Using the ultrasonic sensors on the robot, the functions of recognizing and avoiding obstacles are assigned. In this study, new markers for covid disease have emerged. While defining these markers, a new data set was created [17],[18]. Wang, Tan, Ding, and Yan have developed a cleaning robot in the field of wall cleaning. The authors used various sensors, including the CCD camera and the visual sensor consisting of two laser diodes and the Motion sensor. The cleaning robot acts randomly to perform the cleaning task and expresses that it uses the built-in sensor for self-localization. These sensors are less expensive, time consuming and cannot ensure the complete cleaning task. These methods can perfectly carry out the cleaning task; however, the robot needs powerful sensors to create and localize a precise map [19]. Bhingarre, Ransing, Palve and Misal have developed a cleaning robot that offers remote use thanks to the Wi-Fi module. There are also level sensors on the robot that will inform you when the garbage tank is full. In the study, data from electronic compasses and encoders were combined using the Kalman filter [20]. Prabakaran, Elara. Pathmakumar, and.

Nansai developed a floor cleaning robot for the maintenance of buildings. In these works, a new floor cleaning robot called hTetro, inspired by Tetris, is presented. The developed robot can connect its morphology to any of the seven unilateral tetrominoes in response to its perceived environment to maximize coverage. The authors show that hTetro achieves significantly higher coverage performance than other platforms due to its deformability, which responds to navigating the environment [21]. Parmar, Meena, Bhovaniya and Priyadarshi have developed a cleaning robot that allows to be managed with Android devices for daily house cleaning. The cleaning robot is provided with the ability to perform wet cleaning using a water pump. The robot can be used in automatic or manual mode depending on the request of the user [22]. Developed a cleaning robot for the purpose of house cleaning, general surface cleaning. In this study, the feasibility of the condition of the cleaning robot and the estimation of the parameters were shown with experimental data by applying the odorless Kalman filter (UKF), regardless of the systemcod detected by the detection system. As a result of this work of the authors, although the system requires an improvement in cleaning, it shows that the proposed system can adequately predict the condition and parameters of the cleaning robot. As a result, the proposed system has the ability to perform autonomous cleaning with less acquisition costs and high flexibility. A relationship between people's daily life psychological resilience and life satisfaction has been revealed. It was concluded that general self-efficacy had a mediating effect on this association. [23],[24]. Radha, Priya, Bhuvaneswari and Umapathy have designed a cleaning robot that can be controlled by human hand movements. The robot has a dust bag indicator, battery status indicator, GSM module, RF module, accelerometer sensor on it. There are two modes, autonomous and manual. In autonomous mode, ultrasonic sensors are used to perform cleaning operations without being obstructed by obstacles [25]. This study contributed to the establishment of a relationship between fingerprints and blood groups. It is planned to increase the number of automatic sample taking by integrating the study into the cleaning robots [26].

3. BLOCK DIAGRAM

In this study, various parts are used on the robot to perform the specified functions of the cleaning tool. The main part of the system is Arduino Uno R3. The Arduino Uno used has an ATmega328p microcontroller. The data of the current region is collected with an ultrasonic distance sensor and processed on the Arduino board. Using the Bluetooth module, the user has

been given the possibility of manual control. A driver card has been used to make the system move. With the rotation of DC motors connected to this card, the cleaning tool moves. Sponges are integrated into the DC motor connected on the Arduino. With the rotation of these motors, sponges perform wiping. The battery is used to carry out the movement and other operations of the vehicle. Another element integrated into the system is the 3D printer fan. Thanks to this fan, vacuuming is performed. The equipment used in the study and the input / output of these parts are shown in Figure 1.

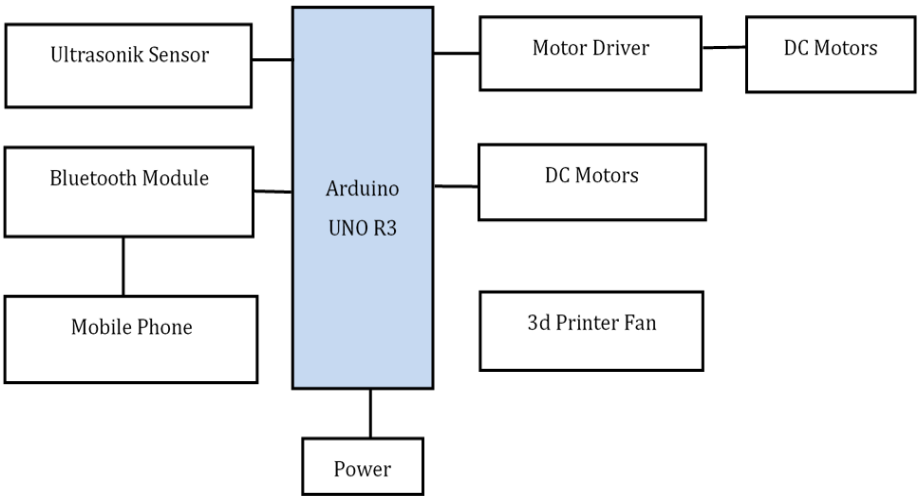

Figure 1. Block Diagram of the Study.

4. METHOD

At this stage of the study, the necessary hardware and algorithms for the cleaning tool are mentioned. The robot operates with 12V power and the robot is operated by pressing the switch connected to the 12V battery in the system to work. And after the system is opened, the program coded to Arduino with a delay of 3000 ms is activated. It sends voltage to the L298n board according to the speed of the DC motors set in the Arduino program and the wheels move forward by calling the forward function. The condition required for calling the forward function is that the HC-SR04 sensor encoded in Arduino is larger than the distance limit, ie 20cm. As long as the distance between the sensor and the obstacle is greater than 20 cm, the robot will go forward. Also, as long as the robot calls the forward function, the turbo fan will be in motion on DC motors with sponges attached to the ends of the robot. If the robot is not moving, the fan and sponge motors will also stop. The purpose here is that the fan and sponge motors are not wasted and consume energy when the robot cannot move when it is attached to an obstacle. The

maximum distance to Arduino is coded as 20 cm for the robot to detect the obstacle and turn right. As the vehicle travels forward, the sensor continuously sends sound waves and reverses, constantly reporting distance to Arduino. If the distance is 20 cm or less, the reverse function is called first and the robot moves back for the specified time. Then the right function is called, and the robot moves to the right for the specified time, and as long as the distance is greater than 20 cm, it calls back and then the right function continuously. It sends a signal to the Arduino L298n so that the robot can move backwards, and the opposite (plus) and minus (-) ends of the DC motors are supplied with the opposite power, so that the robot's reverse movement is provided. In order for the robot to turn to the right side, the right motor is operated in the opposite direction and the left motor continues its normal movement. In this way, the vehicle moves right. In order for the robot to save energy, when it is attached to an obstacle and cannot get rid of it, a kind of counter was coded to Arduino. The principle of operation of the counter is as follows: When the robot distance is less than 20 cm, when the right function is called, counter 1 is added to the counter and if the robot calls the right function 5 times without calling the forward function, the counter becomes 5 and the stop function is called. If the forward function is called, i.e. the distance is more than 20 cm, the counter is reset. This is how the automatic mode of the robot works. To control the robot manually, HC-06 Bluetooth Module has been added to the system. Car Bluetooth RC, the Android interface, was used to send data to the HC-06 module and to control the vehicle manually. Each of the keys in the program corresponds to a letter in the Arduino ide program. For example, it corresponds to the letter "F", which is the first letter of the word forward, or the letter "B", which is the first letter of the word back in response to the back button. It is coded in such a way that when the letter "F" is pressed on the İde program, the forward function is called. When the forward button is pressed on the interface, the interface sends data to the HC-06 module via Bluetooth signals and this data is sent from the TX pin of the HC-06 module to the RX pin of Arduino. Arduino checks the program it is encoded and calls the assigned function in response to the incoming data. This process is the same for keys and functions that are pressed on all other interfaces. A button has been added to the system to switch between manual mode and automatic mode in a short time. The added button is programmed in IDE software. If the button is off (0), automatic mode is called, and if it is on (1), manual mode is called. Arduino: The Arduino Uno R3 used in the study has an Atmega328 microcontroller. Arduino IDE program is needed for programming. Working voltage is 5V. The input voltage is 7-12V. There are 14 pins on the

Arduino. 6 of the pins are used as PWM output. The analog input pins are 6. The main part of the cleaning robot worked on is Arduino. Arduino Uno on the robot is given in Figure 2.

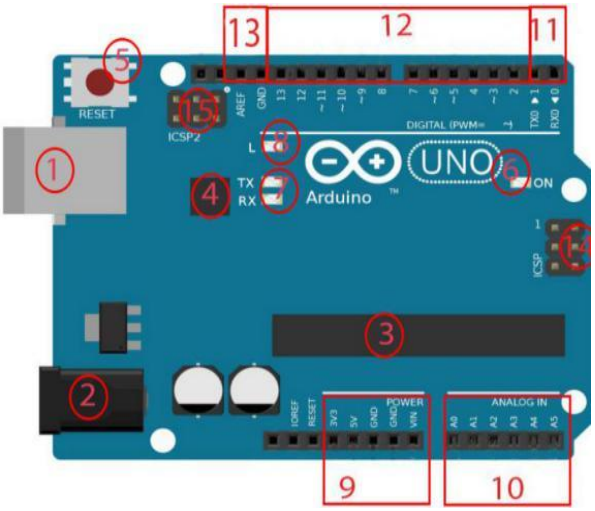

Figure 2. Arduino UNO R3.

ATmega328p: Atmega328p Arduino is a microcontroller on the Arduino UNO R3. This microcontroller has flash-type memory and has 28 pins on it. 23 of these pins consist of input and output pins. The microcontroller has a frequency of 20 MHz and is 8 bits. Supply voltage values are between 2.7V and 5.5V.

Figure 3. ATmega 328p Microcontroller.

Ultrasonic Sensor: In the study, the HCSR-04 audio receiver / transmitter module is fixed on three sides of the robot. The operating voltage of the sensor is 5V. The minimum viewing range is 2cm, the maximum viewing range is 4m. The ultrasonic sensor used on the robot is shown in Figure 3. Trig pin (trigger pin) is the output pin that enables the signal to be released. The Echo pin (reading) is the input pin that notifies Arduino that the reflected wave has arrived. The Vcc pin on the sensor is used for power input. The Gnd pin is used for grounding.

Figure 4. HCSR-04 Ultrasonic Sensor.

Battery: 7ah 12V rechargeable battery was used in the study. The battery measures 151x65x94 mm and weighs 1.7 kg. By operating the system, the battery can power the required parts continuously between 45 minutes and 60 minutes.

Bluetooth Module: HC-06 module was used in the study. Thanks to the module, the cleaning robot can be controlled manually from the Android based phones. It allows communication in a 2.4 GHz freq. It provides communication in an open area at a distance of approximately 10 meters. It has 4 pin entries on it. Vcc input is used for 5-3.3 V power and gnd is used for grounding. The RX pin is used to receive data and connects to the TX pin on the Arduino. The reason for this is to be able to exchange data. The TX pin on the module is plugged into the RX pin on the Arduino.

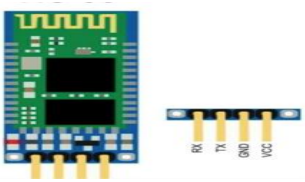

Figure 5. HC-06 Bluetooth Module.

DC Motors: 3V-6V DC motor was used in the study. It has a speed of 250 Rpm. DC motors are machines that enable the conversion of flat current electrical energy into mechanical energy. When electric current is given to the windings inside the motor, it creates magnetic force in the opposite direction to the permanent magnets in the motor. Movement occurs with the effect of this force. It weighs 29 grams. The wheel connected to the engine is 70 mm in diameter and has a 45 mm wheel thickness.

Figure 6. DC Motors.

Floor Wipers and Vacuum: The cloths that will make the surface cleaning process are connected to two different DC motors, and in case of power to the motors, rotation starts and wiping takes place. 6V 250 Rpm motor and wheel set were used for movement and wiping. The snail fan is integrated into the robot, so that vacuum is carried out to collect dust. Vacuumed dusts are collected in a removable container and can be easily cleaned and replaced. 20w 12v 3d printer fan is used in the project. The connection of the equipment used in the study is shown in Figure 7.

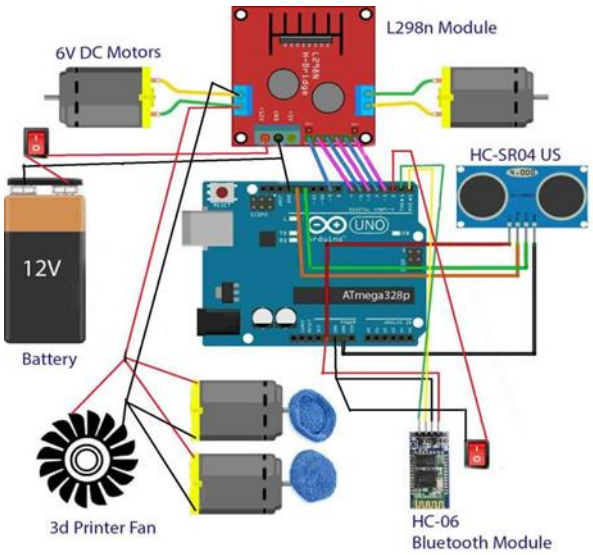

Figure 7. Connection Scheme.

When making the required connection specified in the connection diagram, the connection between the L298n and the Arduino has been established first. The reason for this is that DC motors can be controlled by Arduino and program the speeds of DC motors by giving the required voltage value. After connecting DC motors to Arduino with L298n, a 12V output battery was used for motors and cards to work, and 12V pin from L298n was connected to the plus (+) output on the battery. Since the Arduino UNO used in the study works with 5V power, the 5V pin on the L298n is inputted on the positive (+) side of the power input of the Arduino UNO. Again, for grounding, a connection was made directly to the GND pin of the L298n by the minus (-) of the 12V battery and a connection was made from the GND pin to the minus (-) side at the power input of the Arduino. In order to program all of these DC motors and Turbo fan, L298n's Jumper and other pins are connected to the digital pins on the Arduino. The DC motor and the fan are connected to the ground with the GND pins on the Arduino. Apart from the motor and fan, the plus (+) ends of the buttons connected to the system are connected to the

digital pins on the Arduino, and the negative (-) ends are connected to the GND pin on the Arduino. The L298n drive, which is used to move the robot to save energy so that DC motors, which act as fans and sponges, stop the vehicle barrier and stop working and consume energy, are connected in parallel with the DC motors connected to the left and right outputs of the motor. In this way, when the vehicle does not move, the motors that are attached to the fan and the sponge at the bottom will not be wasted. HC-SR04 sensor has been used to see and detect obstacles. The VCC pin is connected to the 5V pin on the Arduino so that SR04 can work. For grounding, the GND pin is connected to the GND pin on the Arduino. Echo and Trig pins are connected to the digital pins on the Arduino so that they can report to Arduino. The HC-06 Bluetooth module was used to control the vehicle with the android program (interface) and the VCC pin on the module was connected to the 5V pin on the Arduino so that the module could receive power and work. For grounding, the GND pin on the Module is connected to the GND pin on the Arduino. The RX and TX pins on the module are connected to the TX pin on the Arduino, and the TX pin on the module to the RX pin on the Arduino, in order to exchange data between the Arduino and the module. The reason for cross-linking the RX and TX pins is a TX transmitting pin, and if two TX pins are connected, there will be a conflict as they will try to transmit data on both sides. The same is true for the RX pin. Since both pins will try to receive data and there will be no data sent, the RX pin cannot function and receive data. Switching between modes is required to ensure control in manual mode with the help of the Bluetooth module. However, a software intervention or a hardware intervention is required to switch between manual mode and automatic mode. In this study, a hardware intervention was made and a button was added to the system. The cleaning tool is used by pressing the button of the mode in which the vehicle is desired to be used. The minus (-) end is connected to the GND pin on the Arduino for the grounding of the button. The plus (+) end of the button is connected to the digital pin on the Arduino. A simple algorithm is used to run the cleaning robot in automatic mode. The working principle of this algorithm can be explained as follows: when the system is started, the vehicle starts moving on an imaginary line. Thanks to the sound waves sent by the distance sensor, it is checked whether there is an obstacle in the program at a coded distance of 20 cm. When the distance between the system and the obstacle is 20 cm, the robot turns to the right, if this distance is greater, the robot continues to go straight and the sensor continues to read the distance. Each time the system turns right, it checks the counter coded on the Arduino. If it is detected in the meter that the system turns right 5 times in a row, the robot understands that it is stuck in the obstacle and cannot escape and stops itself. It continues to move when the

obstacle in front of the system is removed manually. In order to reset the counter, the cleaning robot needs to move forward. It is shown in Figure 8 how the system detects and moves obstacles in automatic mode.

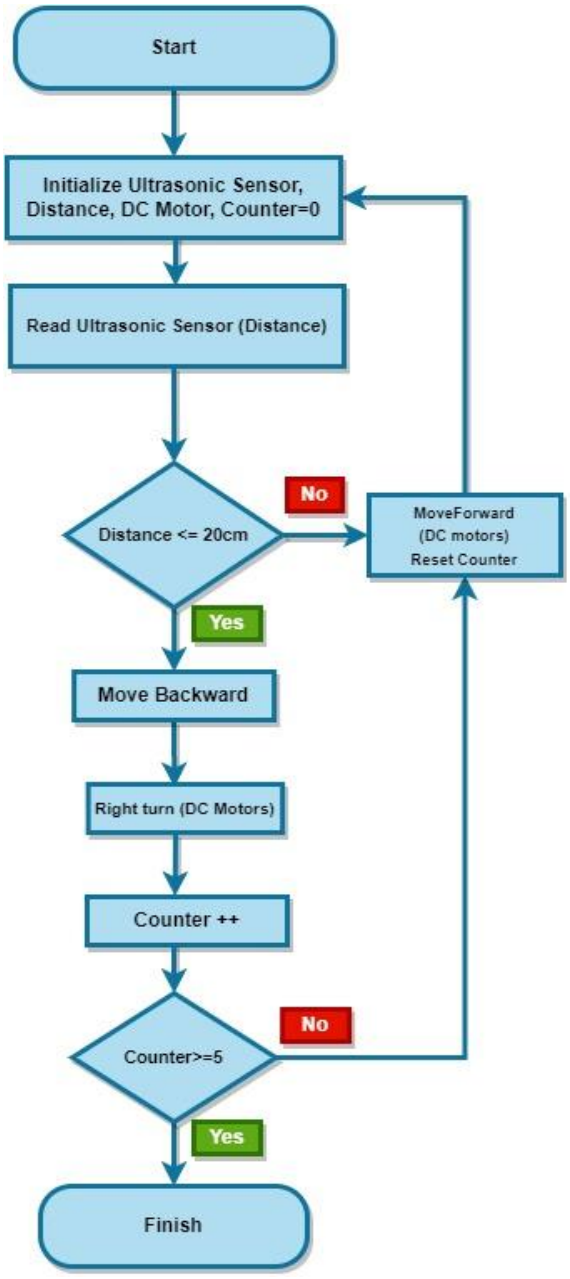

Figure 8. Flow Chart Obstacle Detection.

In this study **manual mode**, Android application called Car Bluetooth Cr was used to control the cleaning tool. Bluetooth module is used to use the system in manual mode. An Android interface is used to exchange data from the Bluetooth module. The functions corresponding to the keys on the Android application to be used for manual control are created

in the Arduino IDE program. The command given through the Android device is delivered to Arduino via the Bluetooth module. The function corresponding to the key pressed is found and operates. The screenshot of the Android interface used in the study is shown in Figure 9. The commands shown on the interface are assigned the desired commands with the Arduino IDE program.

Figure 9. Bluetooth Android Interface.

5. PERFORMANCE ANALYSIS

At this stage of the study, tests were conducted on how successful the cleaning robot was in detecting obstacles. Various codes have been used to change the direction of the installed system when it sees obstacles. The codes of the ultrasonic sensor used for the detection of obstacles have been developed in the Arduino IDE program. At the same time, this program defines the actions that the system will perform when it sees an obstacle. The study was carried out in the home. The results are given in Table 1. In cases where the cleaning robot fails to get rid of obstacles, the system stops itself. Thus, the system is prevented from consuming energy in vain. For this to happen, a counter has been defined to the software prepared on the Arduino board. The counter increases every time the robot sees obstacles. As long as the counter does not reach the specified number of obstacles, it calls the forward function, if the specified number of obstacles is reached, the system enters the infinite while loop and calls the stop function. If the distance between the ultrasonic sensor and the obstacle after the stop function is called is greater than the distance specified in the software, the system leaves the infinite loop and continues to move. The objects used as obstacles in the study are given in Figure 7. The information obtained as a result of the experiment is shown on the graphic given in Figure 10.

Figure 10. Obstacle Used in the Experiment.

Table 1. Obstacle Detection Test Results

Test No	Test (sec)	The Count of Continuing to Progress When Encountering an Obstacle						Amount of encounter with objects					
		Obs. 1	Obs. 2	Obs. 3	Obs. 4	Obs. 5	Obs. 6	Obs. 1	Obs. 2	Obs. 3	Obs. 4	Obs. 5	Obs. 6
1.	52	1	0	0	2	0	0	4	1	2	4	2	2
2.	54	0	0	1	1	0	0	3	0	4	3	2	3
3.	68	0	1	1	0	0	0	3	1	3	3	2	3
4.	17	0	0	0	0	0	0	0	0	0	0	0	0
5.	58	0	1	0	0	1	0	3	4	0	3	4	1
6.	54	0	0	1	0	0	0	1	3	5	1	3	2
7.	52	0	0	0	0	0	0	1	0	3	2	4	5
8.	62	0	0	0	0	0	0	3	2	4	0	4	2
9.	62	0	0	0	1	1	0	5	0	1	4	3	2
10.	61	0	0	0	0	0	1	3	2	4	0	2	4
Total	592	1	2	3	4	2	1	26	13	24	20	26	26

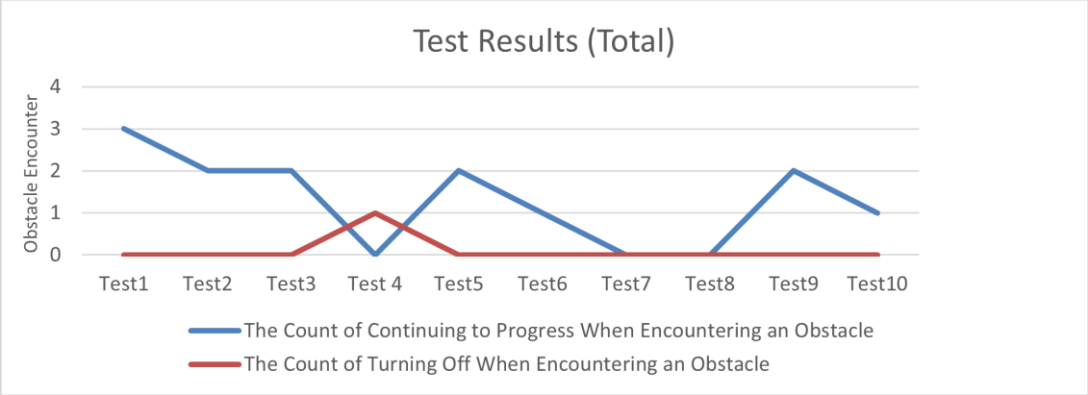

Figure 11. Result of the Cleanıng Robot's Decisions Against the Obstacle

In the testing phase of the study, an experiment area of 8.25 square meters was created. 6 different obstacles are placed in the designated area. Selected obstacles are shown in Figure 11. Experiments are terminated when the system encounters 15 obstacles and stops and stops itself. The system was operated 10 times and the amount of operation was specified as the experiment number. In 9 of the experiments, the system encountered 135 obstacles in total. The total number of progresses that hit the obstacle was 13. In experiment number 4, the cleaning robot failed to move between obstacle and wall when it encountered obstacle number 2 and stopped itself. From the objects placed in the designated area, it was seen that the cleaning tool experienced the most impact on obstacle number 4. Due to the small object number 4, it has been observed that the cleaning robot cannot recognize and crash this object. During the experiment, it has been observed that the cleaning interval hits the obstacle number 3 but moves with the obstacle without changing its direction.

In addition, when the battery used in the system decreases, the movement speed of the cleaning tool slows down and accordingly the cleaning tool becomes more sensitive to obstacles. With the slowing of the movement speed of the system, the situations that do not want to hit obstacles, etc. are reduced. After all the motion functions of the cleaning tool have been defined and the necessary tests have been completed, the cleaning ability of the tool has been measured. Various items are left in the designated areas to measure cleaning ability. While the vehicle passed through the dirty surface, it carried out vacuuming and wiping operations. Surfaces after completion of the cleaning process are shown in Figure 12.

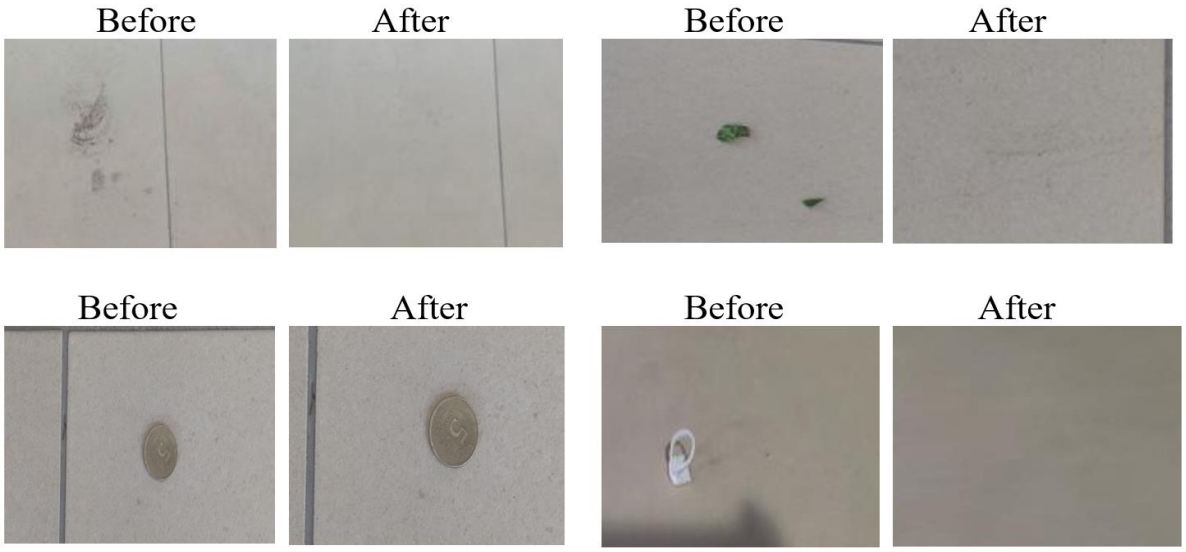

Figure 12. Observation Result of the Cleaning Robot during the Cleaning of the environment.

6. CONCLUSIONS

The cleaning robot performs the cleaning process in two modes. While it cleans itself in automatic mode, it acts according to commands from the user with the help of Bluetooth in manual mode. The production cost of the designed cleaning robot is quite low and the electronic circuit connection is easily understood. The designed smart vacuum cleaner cannot be successful in cleaning edges and corners. The reason for this is due to the robot dimensions. If the number of sensors used increases, the sensitivity to obstacles can be increased. We can provide a more efficient cleaning by reducing the distance between the sensors. The vacuuming system of the cleaning robot needs further development. It can be further improved by adding different sensors to the cleaning robot. For example; By adding a weight sensor to the robot, a warning can be given according to the level of the garbage amount. Preferring the laser mapping method will provide faster processing compared to the ultrasonic distance sensor. As the cleaning robot moves on the floor, it will detect obstacles and change direction and automatically mop the floor. The structure and design of the robot can be made more attractive and functional to provide better visualization in home or office environments. The cleaning robot is connected to a rechargeable battery and is particularly suitable for ideal working conditions and cost-effectiveness. The Android interface used for manual control in the designed cleaning robot can be changed and developed according to the user's purpose. By

changing the Android interface, a simpler, more efficient and better control and management usage can be offered for manual control. Easier use of the cleaning robot can be achieved with smart watches, the prevalence of which is increasing rapidly. In the design of the cleaning robot, the size and weight of the battery were large, so its size was large. The dimensions of the robot can be further reduced by using smaller batteries that can produce the same power.

Contribution and Acknowledgment

We would like to thank Dr. Fatih İLKBAHAR for supporting our study. This project started with the artificial intelligence and applications course.

REFERENCES

[1] W H. Ersoy, R. O. Madran, and Y. Gülbahar, “Programlama dilleri öğretimine bir model önerisi: robot programlama,” Akad. Bilişim’11 - XIII. Akad. Bilişim Konf. Bildir., pp. 731–736, 2011, [Online]. Available: http://ab.org.tr/ab11/kitap/ersoy_madran_AB11.pdf

[2] J. Y. Park and K. D. Lee, “Study on the cleaning algorithm for autonomous mobile robot under the unknown environment,” Robot Hum. Commun. - Proc. IEEE Int. Work., pp. 70–75, 1997, doi: 10.1109/roman.1997.646955.

[3] S. Kim, “Autonomous cleaning robot: roboking system integration and overview,” Proc. - IEEE Int. Conf. Robot. Autom., vol. 2004, no. 5, pp. 4437–4441, 2004, doi: 10.1109/robot.2004.1302416.

[4] T. B. Kwon, J. B. Song, and S. C. Kang, “MCL-based global localization of cleaning robot using fast rotation-invariant corner matching method,” ICCAS 2010 - Int. Conf. Control. Autom. Syst., pp. 1988–1992, 2010, doi: 10.1109/ICCAS.2010.5669754.

[5] Durstine, J., "The truck steering system from hand wheel to road wheel", SAE Technical Paper 730039, (1973).

[6] İ. Özyalçın, M. Çakır, A. R. Çelik, and V. Tekeş, “Microcontroller based cleaning robot design,” 4th Int. Vocat. Sch. Symp. - 2015, pp. 1455–1462, 2015.

[7] F. İlkbahar and E. Sungu , "Analysis of artificial ıntelligence technologies used ın the covid-19 outbreak process", International Journal of Applied Mathematics Electronics and Computers, vol. 8, no. 4, pp. 154-162, Dec. 2021, doi:10.18100/ijamec.800910

[8] S. Liu, L. Zheng, S. Wang, R. Li, and Y. Zhao, "Cognitive abilities of indoor cleaning robots," Proc. World Congr. Intell. Control Autom., vol. 2016-September, pp. 1508–1513, 2016, doi: 10.1109/WCICA.2016.7578317.

[9] H. Rashid, A. Mahmood, S. Shekha, S. M. T. Reza, and M. Rasheduzzaman, "Design and development of a DTMF controlled room cleaner robot with two path-following method," 19th Int. Conf. Comput. Inf. Technol. ICCIT 2016, pp. 484–489, 2017, doi: 10.1109/ICCITECHN.2016.7860246.

[10] T. Tomiyama, L. R. García, A. Kršlin, and G. Taykaldiranian, "Systems and conceptual design of a train cab front cleaning robot," Procedia CIRP, vol. 59, no. TESConf 2016, pp. 61–66, 2017, doi: 10.1016/j.procir.2016.09.031.

[11] D. C. Patel and H. S. Patil, "Design and development of low cost artificial ıntelligence vacuum cleaner," Int. J. Recent Trends Eng. Res., vol. 3, no. 11, pp. 59–67, 2017, doi: 10.23883/ijrter.2017.3494.s78zf.

[12] Y. Celik and M. Güneş, "Designing an object tracker self-balancing robot," Acad. Platf. J. Eng. Sci., vol. 6, no. 2, pp. 124–133, 2018, doi: 10.21541/apjes.414715.

[13] M. Molina, A. Vera, C. Molina, and P. Garzon, "Design and construction of an obstacle avoiding robot based on arduino platform and programming too," 2018 9th IEEE Annu. Ubiquitous Comput. Electron. Mob. Commun. Conf. UEMCON 2018, pp. 788–791, 2018, doi: 10.1109/UEMCON.2018.8796577.

[14] F. İlkbahar, Ş.Ünal, A.Karakaya, B.Eren "Akıllı ev sistemleri üzerine bir model önerisi," AJIT-e Online Academic Journal of Information Technology, vol. 12, pp. 0–0, May 2021.

[15] M. Aktaş, F. Polat, M. Oflazer, "Bluetooth ve Wifi kontrollü mobil robot tasarımı ve uygulması," İleri Teknoloji Bilimleri Dergisi. 2017.

[16] P. B. Jarande, S. P. Murakar, N. S. Vast, N. P. Ubale, and S. S. Saraf, "Robotic vacuum cleaner using arduino with wifi," Proc. Int. Conf. Inven. Commun. Comput. Technol. ICICCT 2018, no. 9, pp. 1513–1517, 2018, doi: 10.1109/ICICCT.2018.8473256.

[17] T. B. Asafa, T. M. Afonja, E. A. Olaniyan, and H. O. Alade, "Development of a vacuum cleaner robot," Alexandria Eng. J., vol. 57, no. 4, pp. 2911–2920, 2018, doi: 10.1016/j.aej.2018.07.005.

[18] M.T. Huyut, F. Ilkbahar, "The effectiveness of blood routine parameters and some biomarkers as a potential diagnostic tool in the diagnosis and prognosis of covid-19 disease",

International Immunopharmacology,2021,107838,ISSN 1567-5769,https://doi.org/10.1016/j.intimp.2021.107838

[19] M. Wang, S. Tan, J. Ding, and L. Yan, “Complete coverage path planning of wall-cleaning robot using visual sensor,” 2007 8th Int. Conf. Electron. Meas. Instruments, ICEMI, pp. 4159–4164, 2007, doi: 10.1109/ICEMI.2007.4351106.

[20] K. M. Bhingare, V. S. Ransing, A. B. Palve, and H. M. Misal, “Vacuum cleaner using microcontroller,” Open Access International Journal of Science & Engineering. vol. 3, no. 12, pp. 15–17, 2018.

[21] V. Prabakaran, M. R. Elara, T. Pathmakumar, and S. Nansai, “Floor cleaning robot with reconfigurable mechanism,” Autom. Constr., vol. 91, no. July 2017, pp. 155–165, 2018, doi: 10.1016/j.autcon.2018.03.015.

[22] H. Parmar, A. Meena, J. Bhovaniya, and M. Priyadarshi, “Automatic smart mop for floor cleaning,” International Research Journal of Engineering and Technology, pp. 3159–3165, 2019.

[23] T. Nemoto and R. E. Mohan, “Heterogeneous multirobot cleaning system: state and parameter estimation,” Autom. Constr., vol. 109, no. July 2019, p. 102968, 2020, doi: 10.1016/j.autcon.2019.102968.

[24] Durak, İ . (2021). Psikolojik sağlamlık ile yaşam doyumu arasındaki ilişkide öz yeterliğin aracı etkisi . Elektronik Sosyal Bilimler Dergisi , 20 (78) , 1175-1190 . DOI: 10.17755/esosder.816639

[25] R. Radha, M. Priya, G. Bhuvaneswari, and M. Umapathy, “Hand gesture controlled robot and obstacle avoidance system using arduino for cleaning application,” International Journal of Research in Engineering, Science and Management. no. 2, pp. 362–364, 2019.

[26] E.B. Ceyhan, M. Gullu and C. Ulucan , "Analysis of blood groups from fingerprint patterns of turkish citizens", *Journal of Engineering and Technology*, vol. 2, no. 1, pp. 29-38, Jun. 2018