LifeQuake

Presented in partial fulfillment of the requirements for Bachelor degree in Computer Engineering

Faculty of Engineering and Information Technology | Computer Engineering Department

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Hardware Project

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Disclaimer:

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Abstract

The devastating earthquakes that struck Turkey and Syria, where people are still dealing with the aftershocks and trying to rescue the injured from the rubble, have been recently brought to everyone's attention. One of the most pressing difficulties was the large number of volunteers and rescuers needed to find people under the wreckage; the search must be done with extreme caution because vibrations could cause the debris to move again and injure the victims or rescuers. As a result, sophisticated robotic technology is increasingly being deployed by rescuers.

Our project is a robot that can go beneath rubble and detect whether or not there is a human presence by utilizing a motion sensor and sending live video to a smartphone app.

LifeQuest Robot will assist rescuers in determining the level of risk on earthquake victims who are trapped beneath the rubble by reading the values of sensors that detect flames and CO2 levels. They will also be able to see the victims through the video streaming in order to determine their state of health and to reassure their families and lovers abroad.

The Robot is controlled by a mobile app that can move it toward, backward, left and right, by buttons (connecting to the app via wifi) or by audio (connecting to the app via bluetooth), in addition to controlling the amount of Camera Flash, and the ability to detect whether there is any victims by the IR sensor.The robot provided with ultrasonic which stop it if there is any obstacle in front to it.

The design, which must be portable, lightweight, and able to maneuver in tight spaces, as well as the caliber of the real-time videos, and the accuracy and dependability of the sensor readings, are the most crucial aspects of this project.

1. Introduction

1.1 Problem

At the time of earthquakes and wars, as we have recently seen, the devastating earthquake in Syria, Turkey and the wars waged by the Israeli occupation on Gaza, homes and even cities are destroyed on the heads of their inhabitants. And here the challenge falls on the rescue and civil defense teams to find the victims in the rubble of the buildings as soon as possible, but this must be done with great caution because the land is ready for bounces and this could lead to further destruction that could endanger the lives of the victims and rescuers.

1.2 Objectives

The goal of the project is to use what we learned at university to serve our country and maintain it ready to face wars and natural catastrophes by using this technology to discover victims as quickly as possible and save their lives as well as the lives of rescuers.

1.3 Importance of the work

This project's major importance is to encroach on crises and disasters with least damage. As a country that lacks advanced rescue procedures and the large number of rescuers required in such situations, we decided to use current and inexpensive technology to aid in overcoming calamities.

1.4 Organization of the report

- ➔ **First Chapter - Introduction:** Gives background information for understanding the sections that follow as well as the project's major themes.
- ➔ **Second Chapter - Constraints and Previous Coursework:** Which reflect the project constraints and how we were able to overcome these limits, as well as how previous coursework was used to complete the project efficiently.
- ➔ **Third Chapter - Literature Review:** Which represents our research and any previous works of a similar nature.
- ➔ **Fourth chapter - Methodology:** Describes how we constructed this project to solve the problem, including how we built this robot, software tools, and hardware equipment.
- ➔ **Fifth Chapter - Results and Discussion:** Summarizes the collected data and its statistical treatment in detail, comparing outcomes to aims.
- ➔ **Sixth Chapter - Conclusion and Recommendation:** Summarize all of the project's major aspects and recommend practicable approaches to improve work performance and indicate future work, as well as identify some open problems.

2. Constraints and Earlier course work

2.1 Constraints:

- We couldn't find the type of wheel required to allow the robot to easily walk the inconsistent surfaces because we were forced to do the robot with a small size and lightweight so we could enter through the narrow vents, and we were limited to a few types of wheels that we chose from after several experiments.
- We had difficulty supplying the necessary power for all of the electronic components. For example, before the installation of the motors, the ESP 32 CAM module was successfully streaming video, but the addition of the wheels shut off the live streaming as the robot moved. The solution was to disconnect the camera's power supply from the wheel controller.
- The camera was very sensitive and had been damaged due to high voltages and even weak strikes; we had to replace it three times due to our lack of experience with these electronic pieces.

2.2 Earlier course work

We got enough skills from the Microcontrollers and Microprocessor courses to assist with the microcontroller aspect, reading the datasheet for each IC and determining the voltage and current required, as well as how to operate the hardware pieces via the micro-controller. CPU Lap assisted in connecting and troubleshooting the hardware components. The Microcontrollers Lab put theory into practice by working with I/O, serial connectivity, motors, and Arduino. In addition to earlier programming classes such as C++ for writing code on microcontrollers.

Part of the research: In the Critical Thinking Course, we learnt how to conduct professional searches and create papers. And shown how to collect data using past searches and generate reports correctly.

3. Literature Review

The goal of this study is to explain ways to use smarter technologies to make earthquake and war victim rescue more efficient and safer.

“The search and rescue robotics field is focused on designing robots that can help with post disaster efforts. When time and equipment are limited, the robots can be used for saving lives, eliminating the need of endangering human lives during the rescue operation. One of the most frequent disasters after which search and rescue robots are broadly used is the earthquake.”(Marton Gyarmati, Mihai Olimpiu Tătar, 2019)[1]

“The response conducted by emergency units after natural disasters, such as earthquakes, has to be coordinated, fast, and efficient in order to rescue and care for the victims, keeping all the population—and the units themselves—safe amidst the usual chaos. Outages in wireless networks, as well as fiber- or copper-based landline and Internet connections, are to be expected in these situations, so alternative communication solutions must be considered. To contribute in this duty, we propose a communication system that uses the LoRaWAN architecture to allow citizens to report their status to emergency units and public authorities with simple messages and interaction mechanisms. The purpose of this system is to keep people and first responders connected, and thus improve the capability to coordinate the evacuation activities”(MDPI AG, 2019)[2].

After reading about the methods of rescuing victims we decide to create the rescue robot so we read about the most important factors to be considered when designing a search and rescue Robot, so according to Locomotion Systems For Search And Rescue Robots Research made by Marton Gyarmati, Mihai Olimpiu Tătar: The dimension of a robot is very important because, depending on the situation, it can be an advantage or a major disadvantage, small sized robots are able to navigate through narrow or generally inaccessible spaces for human or canine personnel, while performing their tasks, search and rescue robots can encounter different terrain types and challenges, another important factor to consider when designing a robot is the locomotion system.

4. Methodology

4.1 Overview of The System:

A smart rescue robot was built in this study to safeguard the safety of earthquake victims and rescuers.

As controllers, the Esp 32 Cam module and the Arduino nano were used.

To complete the project, hardware and software were combined. Our goal was to make the robot easier to use for the rescuers because some components would be tough for them to use, so we utilized a simple mobile app instead.

4.2 Hardware Components

In this section, each IC that was used in the project will be identified:

4.2.1. ESP 32 CAM:

The ESP32 CAM microcontroller was used to create a video stream under rubbles, and it was also used to show the robot's mobile app using its IP in order to control the robot and read sensor values.

As power we used 5v generated from the motor driver.

The ESP controls the motos by taking the needed move from the mobile app and sending it to the arduino by serial communication.

Figure 1: ESP32-CAM

4.2.2. Arduino nano:

We used the arduino to control the motors by taking hardware serial (from the ESP connected to pins rx, tx) or software serial (from the Bluetooth module connected to pins 7,8) and giving it to the motor driver. We connected the ultrasonic sensor to detect any obstacle and stop moving before hitting it.

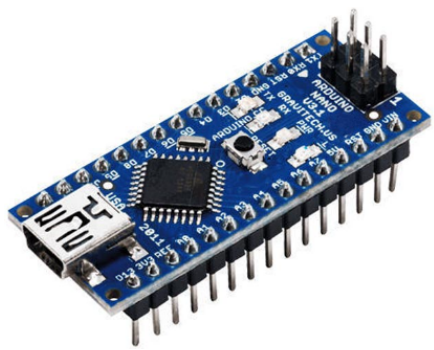

Figure 2: Arduino nano

4.2.3. DC - Motors with gearbox:

We used two motors to convert the electrical energy coming from the batteries into mechanical energy to move the wheel of the robot we connected the motor wires with the driver

Figure 3: DC - Motor

4.2.4: L298N Driver (for DC-motors):

The easiest and affordable way to control the motors is to interface the L298N motor driver with the Arduino nano. It can control the spinning direction of two JGA25 motors.

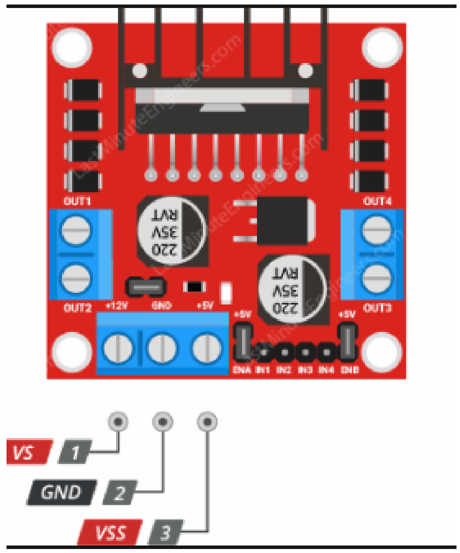

Figure 4: L298N motor driver

4.2.5: MQ 05 Gas Sensor :

It was used to sense building's high carbon dioxide ratios and thus help rescuers assess the risk of asphyxiation to confined victims.
the digital output pin is connected to pin 12 of the ESP to show the value in the mobile app

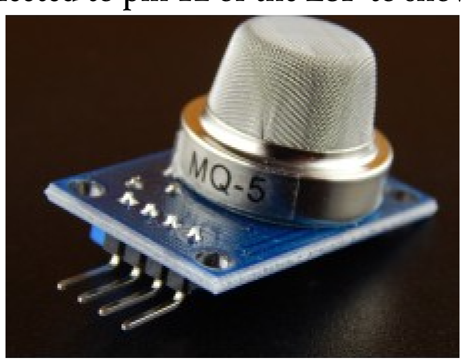

Figure 5: MQ 05 Gas Sensor

4.2.6: Flame Sensor:

Used for detecting the occurrence of a fire or flame and as a gas sensor its importance is helping rescuers assess the risk of asphyxiation or burning to confined victims.

The digital out pin is connected to pin 13 of the ESP module to show its value in the mobile application.

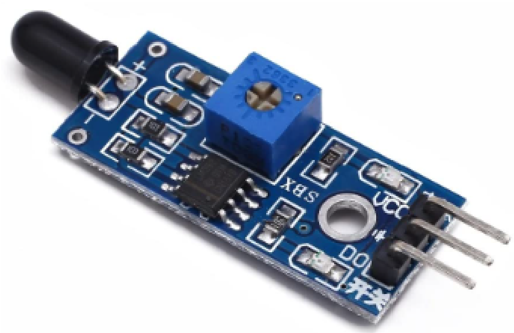

Figure 6: Flame Sensor

4.2.7: Ultrasonic Sensor:

Ultrasonic Sensor is employed to measure the distance between the robot and the objects in front of it and stop moving when the distance is 400-500 cm.

The output pin (Echo) connected to pin 2 of the arduino and the input pin (Trig) connected to pin 3 of the arduino.

Figure 7: Ultrasonic Sensor

4.2.8: IR Sensor:

We used it to detect if there was any human in the place and didn't appear in the live stream in order to make search operation more easy and efficient.

Figure 8: IR Sensor

4.2.9: HC06 Bluetooth Module:

It used to connect the mobile application with motors via bluetooth in order to control the robot and moving it by say one of the following moving commands to make controlling easier and more quickly.

moving commands:

- "start moving forward"
- "start moving backward"
- "move to the left"
- "move to the right"
- "move left then go forward"
- "move right then go forward"
- "stop"

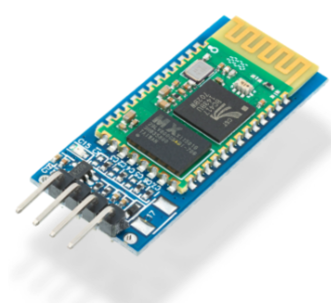

Figure 9: HC06 Bluetooth Module

4.2.10: Robot Chassis:

We used a piece of wood to put the components on it such as ESP Cam, Arduino nano, motors ,battery base , dc driver.

Figure 10: Robot Chassis

4.2.11: Wheels:

We used 5 wheels inside chains to move the robot on rough surfaces.

Figure 11: wheels

4.2.12: 12V dc Battery:

We used 8 - 1.5 volts batteries to supply the L298N Driver with 12 volts.

Figure 12: 12 V dc Battery

4.2.13: 9V dc Battery:

We used 6 - 1.5 volts batteries to supply the Arduino with 9 volts.

Figure 13: 9 V dc Battery

4.2.14: Arduino Uno:

We used this arduino to program the esp32Cam.

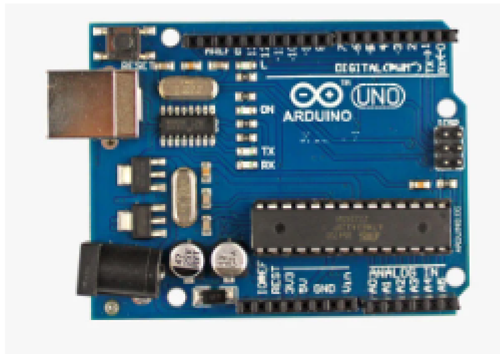

figure 14: Arduino uno

4.2.15: Wires:

To connect the components, wires of various lengths and types were used.

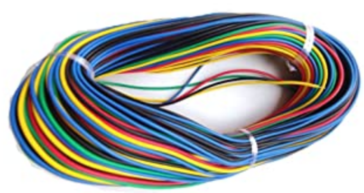

figure 15: Wires

4.3 Software:

We used a simple android mobile application to control the robot's movements, access the sensors readings, control the strengthening of the camera flash and watch the stream video of the camera.

The App consists of a single page, easy to use and user friendly, the mobile connected to the robot with wifi for video streaming, movements and sensor results and for the microphone and speaker it is connected with bluetooth to control the robot by talking.

4.4 Technical Choices:

4.4.1 Mobile Application:

The following figure depicts the mobile app page, which includes the following components:

The results of the flame sensor (0: no fire, 1: fire) and the co2 sensor (0: low co2, 1: high co2) can be found at the top of the page.

The video streamed by the esp camera is then visible.

Following that, there are four buttons that allow us to move the robot forward, backward, left, and right.

Under the buttons, there are two lamp symbols that turn on/off the camera flash, and four other buttons that control the flash strength.

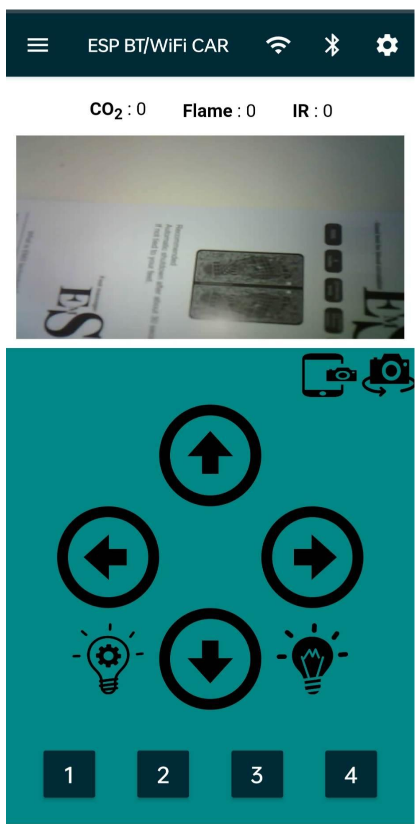

figure 16: mobile app page1

To control the robot by audio we have to connect to the bluetooth and then we will have the first page from left, then we choose "Voice Control" so it will be connected and ready for receiving move commands:

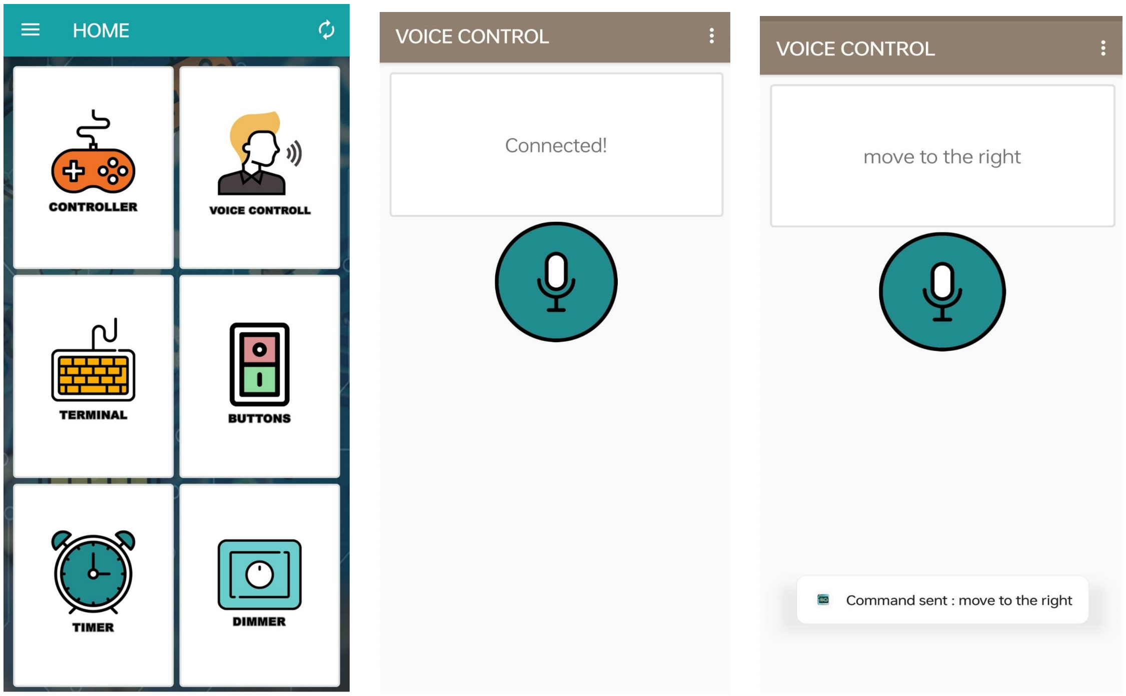

figure 17: mobile app page 2

4.4.2 Process of work

Design the robot:

We started our work by designing the robot body to suit its purpose, we searched for similar robots and searched about the best design. The design chosen is a small, light and strong robot which can move in narrow places and rough surfaces.

in the following picture some designs for robots we inspired from.

figure 18: similar robots

Decide Features:

After researching methods of rescuing earthquake victims and discovering the most common problems that rescuers face, such as the risk to their lives when entering under rubbles, we attempted to solve as many problems as possible by developing this robot equipped with risk detection sensors to go under rubbles instead of rescuers and to provide a contact way between rescuers and victims by the video stream.

Implementing the Robot:

We started by connecting the ESP32 camera and testing the video stream on the built-in website page. After that, we moved on to connecting the DC motors to the driver and wheels and attempting to make it work. At this point, we encountered a problem where the video stream would stop each time we moved the wheels. After days of testing and searching, we realized that we needed to separate the power of the camera from the power of the motors.

When our supervisor saw our work, he suggested that we use an Arduino to control the motors and leave the camera for video streaming, but when we tried that, we ran into power issues again, so we increased the voltage to 12 for the motors driver and took regulated 5 volts for the ESP camera and 9 volts for the arduino.

We used the esp cam controller for the flame, gas sensors and the arduino controller for the ultrasonic sensor and motor control, so the two microcontrollers functioned as one.

We built the project by adding features one by one and testing each one separately without other features. When each one worked, we edited the main code by adding this new feature code, then tested the entire code again and repeated this process.

After we finished the project, we decided with our supervisor to add some new features, so we added a motion sensor to detect if there are victims who do not appear in the video stream or to know if they are okay, a new way to control the robot by audio with connecting the app to bluetooth mode, and finally, we decided to use a mobile app rather than the built-in website to specialize our project.

To make that we connected an IR sensor to the ESP module and the Bluetooth module to the Arduino and used the pin 7 and pin 8 as Rx, Tx.

Project internal circuit:

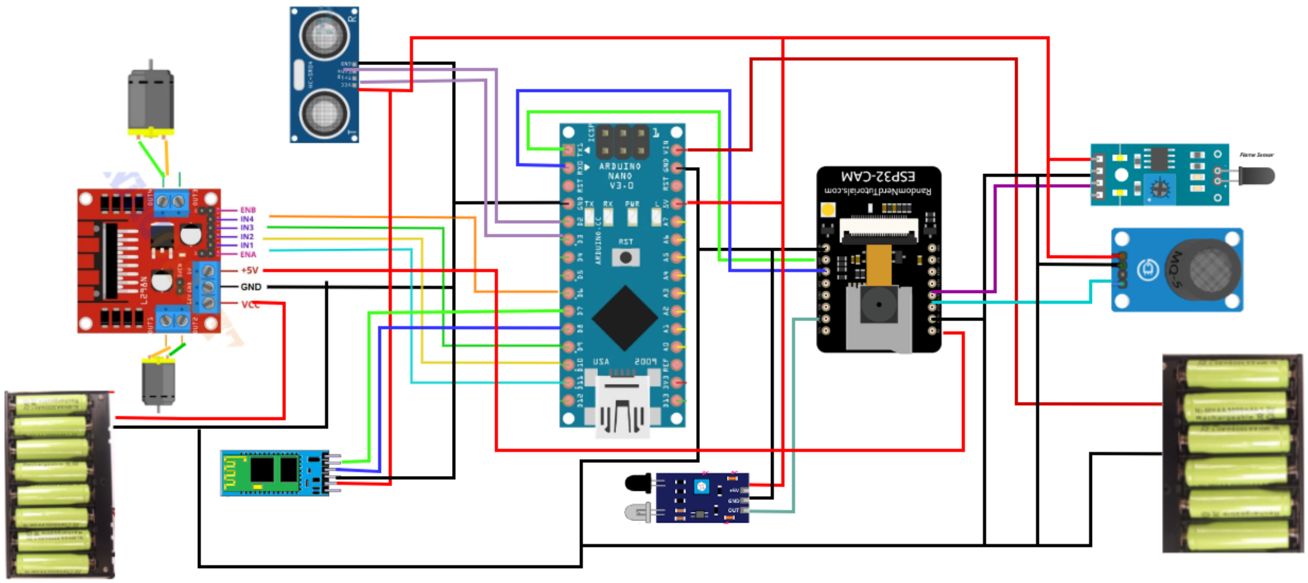

figure 19: Internal circuit

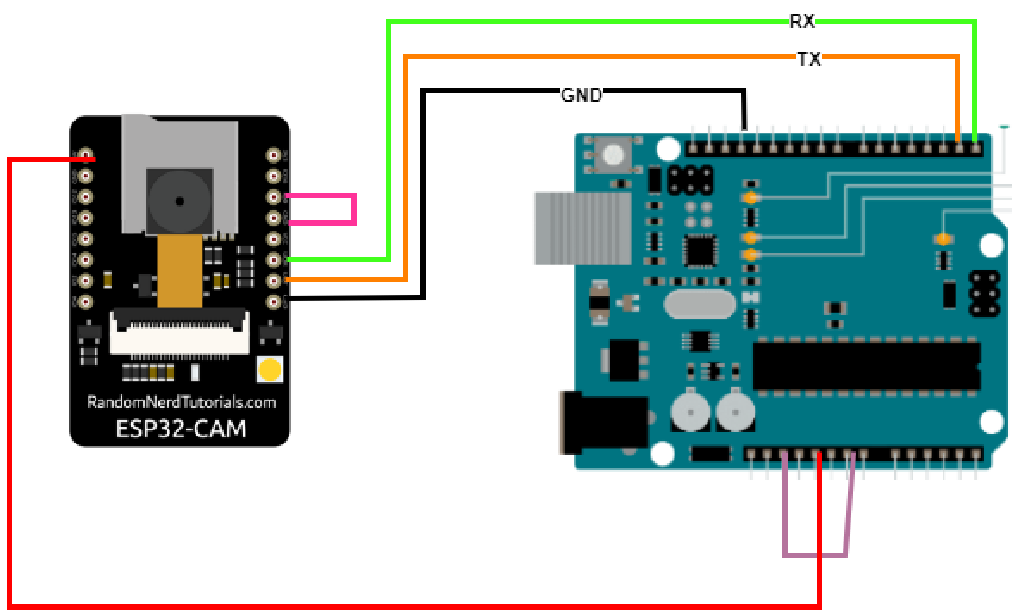

figure 20: ESP Programming Circuit

5. Results and Analysis

The final project is a smart search and rescue robot used mainly in earthquake cases but It can also be used in cases of wars, explosions, and house demolitions, which we live a lot in Palestine, unfortunately.

This robot will search inside rubbles for victims and provide outside detection for any risks in the area such as burning and asphyxiation via flame and gas sensors. Also, the motion sensor and video streaming help rescuers find the best way to take the victims outside by moving the robot inside the place and using the camera flash with different levels of light to see all sides safely without the risk of a crash because of the ultrasonic feature that stops the robot in the event of an obstacle.

Following some pictures for our resulted robot:

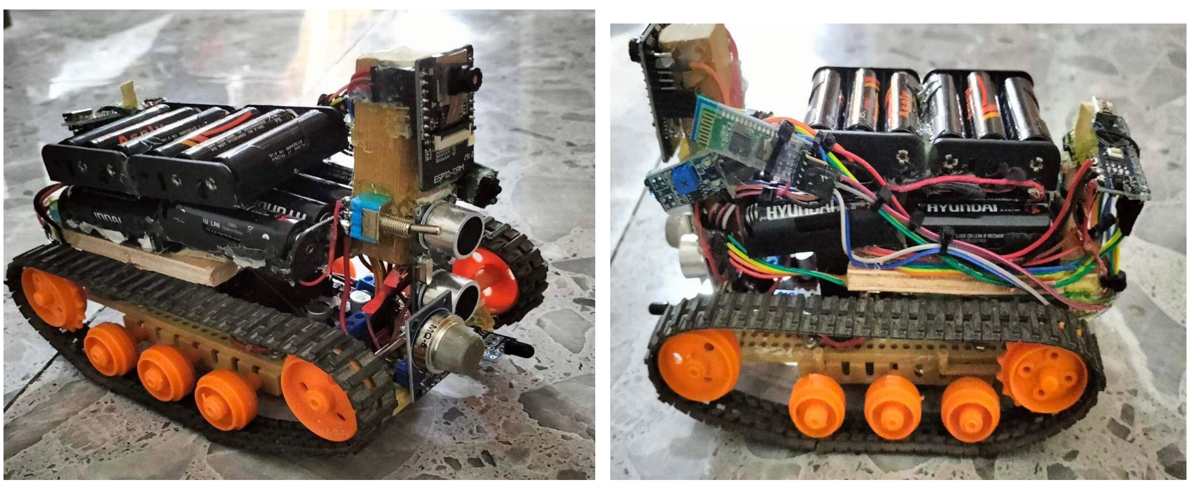

figure 21: resulted device

6.Discussion

6.1 Testing

- ☑ The ESP32CAM was powered by 12 V DC, and once the code was uploaded, the ESP Wi-Fi successfully connected to the network. This was repeated several times with different networks at home and at university to ensure that the code is correct and the Wi-Fi module is operational.
- ☑ For auto-stop mode, the DC motors are powered with eight 1.5V batteries to achieve 12 volts, connected to the driver, and connected to the Arduino. When an obstacle is within 400-500 cm of the robot, it perfectly stops.
- ☑ The flame and gas sensors were tested in various locations, both indoors and outdoors, at various times of day and in various weathers to see if it detected fire and co2. We used candles, lighters, and placed the flame sensor near a real fire and for co2 we used real gasses sources like cooking gas and lighter gas , and it worked very well.
- ☑ We used various types of surfaces to test movement performance, such as We used tile-free, earthy, and rough surfaces, and the robot moved easily on all of them thanks to the type of wheels we chose.
- ☑ To adjust the angles of turning left and right we tried different delays until we found the delay which gives us almost 90 degree which is (900)

6.2 Learning Curve

even being confused and a little stressed at first due to our lack of experience with hardware components and the fact that this was our first time creating a complete hardware project, the learning process was aided by taking main guides from our colleges who completed this project, searching for similar ideas, and watching YouTube tutorials for how we must deal with each component before adding it to the project. Making such a project required us to learn about new hardware components that we were unfamiliar with and had to learn from the ground up. Technical Engineers from whom we purchased the components assisted us in selecting the best one for each feature; on the other hand, we maintained contact with our supervisor, and his recommendations were extremely helpful.

The knowledge gained supported the creation of a simple and effective method to assist rescuers in finding and saving earthquake victims.

7.Conclusion and Future Work

As previously stated, our project is aimed at governments and human rights organizations, so it can greatly assist them in protecting their citizens and reducing deaths in the event of natural disasters such as earthquakes or wars. We hope to expand on this project by implementing it with more accurate and higher quality components and a stronger body, such as changing the type of wheels to suit the difficult environment, such as making the robot capable of climbing over the accumulated stones without difficulty.

For future work, we intend to improve our robot to hold assistance to victims such as food, water, and blankets to help them withstand conditions longer, giving rescue teams a chance to save more people, connect software system which contains addresses of all harmed houses and victims names, so that after rescuing a home, the names of victims will be deleted, making the process easier and the rescue teams will know which houses are done and which are not and as hardware we are planning to add GSM system to provide contact way between the victims and outside so the can talk to the rescuers and give them information about their state of health or talk to their families and loved ones outside to reassure them.

References

[1] Marton Gyarmati, Mihai Olimpiu Tătar. "Locomotion Systems for Search and Rescue Robots". In: Technical University of Cluj-Napoca (2019).

[2] Roger Pueyo Centelles, Felix Freitag, Roc Meseguer, Leandro Navarro, Sergio F. Ochoa, Rodrigo M. Santos. "A LoRa-Based Communication System for Coordinated Response in an Earthquake Aftermath". In: Department of Computer Architecture - Universitat Politècnica de Catalunya, Department of Computer Science - Universidad de Chile, Department of Electrical and Computers - Universidad Nacional del Sur(2019).