Fire Fighting Robot

ENEL-351

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Introduction : The main objective of this project is to design and build a fire fighter robot that can detect and extinguish fires using a combination of sensors and a microcontroller. The robot should be able to navigate through a hazardous environment and locate the source of the fire. The primary objective of this project is to design and build a firefighting robot that can detect obstacles, navigate around them, and detect high-temperature areas. The robot's design and construction were guided by the use of the STM32F103 microcontroller, which controls the movement of the robot and processes sensor data. The robot's ultrasonic sensors are used to change its path if there is an obstacle, and the analog temperature sensor is used to detect high-temperature areas, indicated by the red LED turning on.

In this report, I provide a detailed description of the design and construction of the firefighting robot, including the materials used and the techniques applied to build the robot. I will also discuss the programming aspect of the robot, including the programming language used, the algorithms used for obstacle detection and temperature sensing, and the code structure. Moreover, I will discuss the Pin configuration of the microcontroller. Additionally, I will present the testing process and the results obtained, including the metrics used to evaluate the robot's performance.

The development of the firefighting robot has significant implications for the field of firefighting, as it can reduce the risks faced by firefighters and increase the efficiency of firefighting operations. With this robot, it is possible to explore hazardous areas and detect fires or other sources of high temperatures without risking the lives of firefighters. Moreover, the robot's ability to navigate around obstacles makes it suitable for use in complex environments.

Background : Fires are one of the most dangerous and devastating disasters that can occur. Firefighters are responsible for controlling and extinguishing fires, and they face various risks and challenges in the process. In many cases, firefighters must enter hazardous areas to detect the source of the fire, which can lead to injuries or even death.

The development of firefighting robots is driven by advancements in technology, such as microcontrollers, sensors, and artificial intelligence. Microcontrollers, such as the STM32 microcontroller used in this project, provide a reliable and efficient way to control the movement of the robot and process sensor data. Sensors, such as ultrasonic sensors and temperature sensors, enable the robot to detect obstacles and high-temperature areas. Artificial intelligence techniques, such as machine learning and computer vision, can be used to enhance the robot's capabilities and improve its performance.

Design and Construction : The firefighting robot described in this report was designed and constructed using the following materials and components:

Materials:

- Car chassis plate (Acrylic material)
- Holder kit for 6V batteries
- Breadboard
- USB cable

Components:

- STM32 board
- L298N motor driver
- 2x Gear motor
- 2x 65mm wheel
- Mini servo
- Ultrasonic module
- Analog temperature sensor

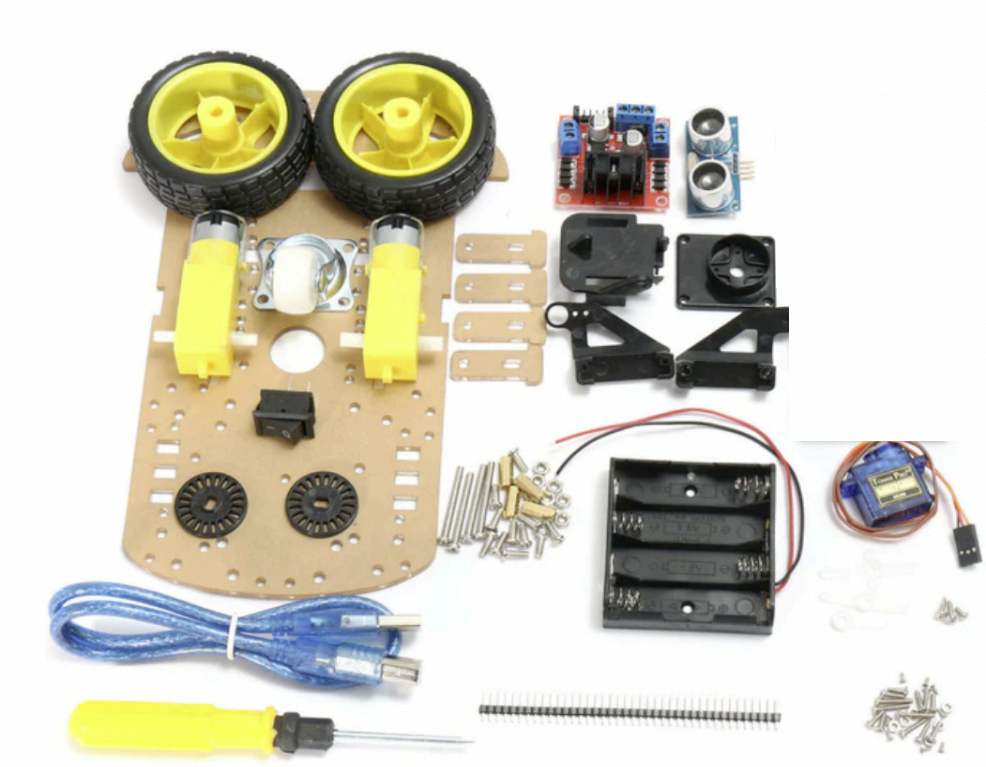
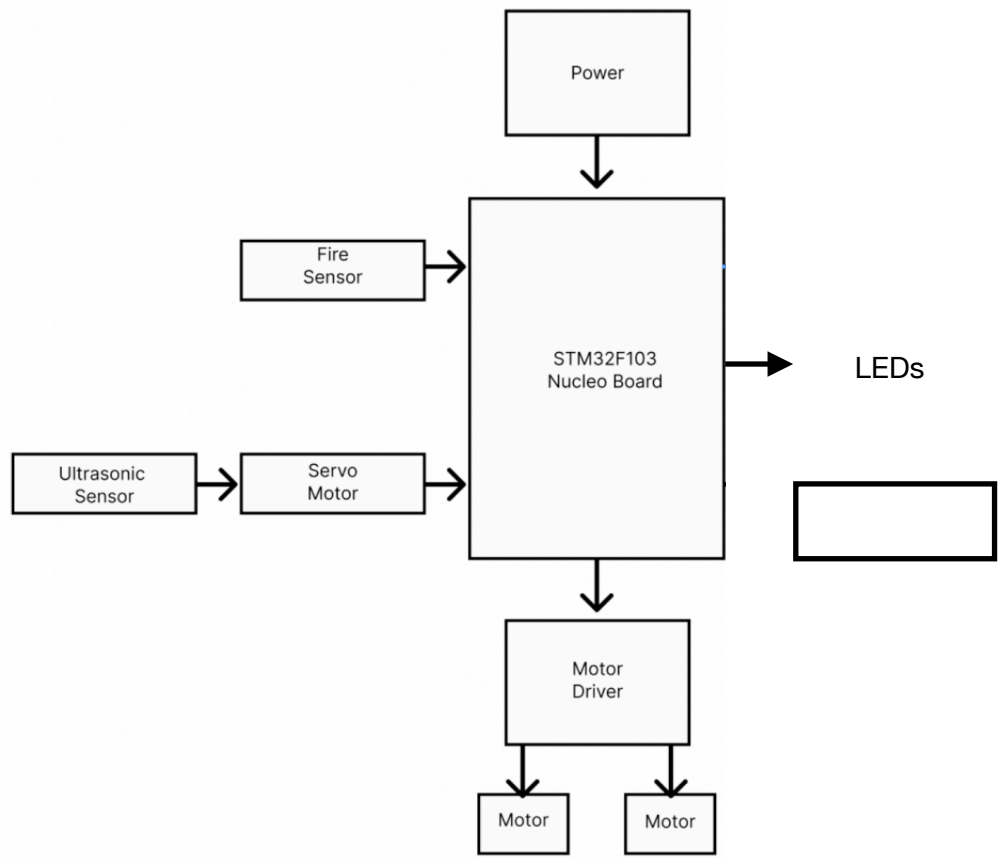


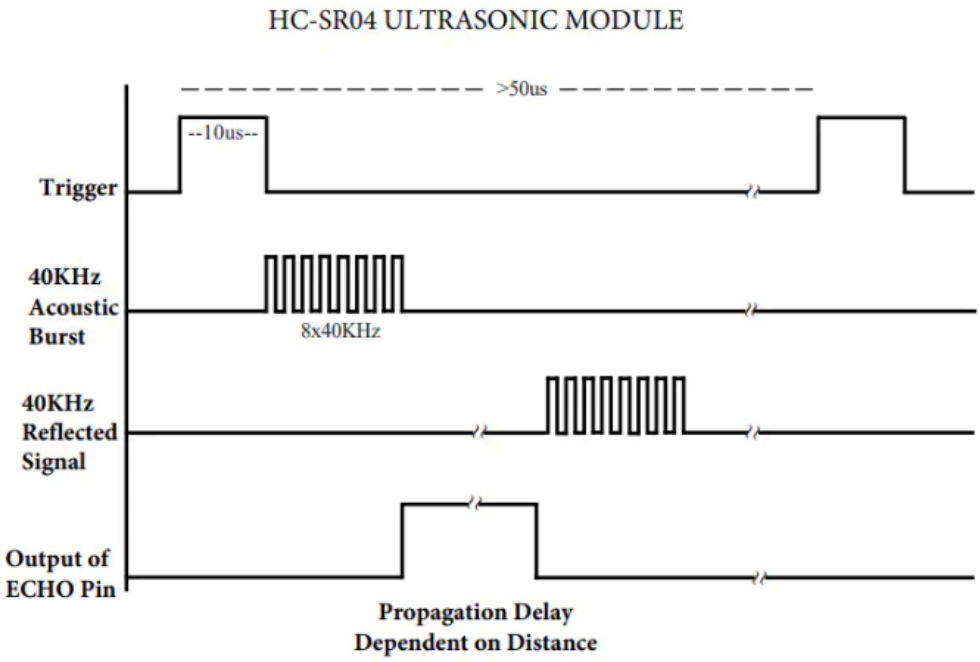
Diagram and Updates : Initially, in the project proposal, I proposed a Fire Robot that detects the fire and spray water where the origin is. However, we can not use fire and water in the lab demo. To overcome this problem, I did minor changes to my project as following :

- The fire detector module is replaced by the temperature sensor which will operate when the temperature rises to a certain point.
- Instead of spraying water in the source of fire, I will turn on a red LED which means the temperature has risen above to the programmed value.

Here is the block diagram of the project :



Ultrasonic Sensor : It has 4 pins, namely the VCC, GND, Trig (Trigger Pin), and the Echo pin. The purpose of this sensor is to calculate the distance between itself and objects placed in front of it. This is achieved by sending 8 bursts of 40KHz signals through the transmitter. After these signals are emitted a timer is started. Now, when these signals encounter an object they reflect back and are detected by the receiver. The time taken by the signal to travel back to the sensor helps determine the distance from the module to the object.



Mathematical Calculations :

- Time = ((Clock Cycles x 0.0625 x 0.000001)/2)
- Distance = (340*100)xTime

Temperature Sensor : This module is based on the working principle of a thermistor (resistance varies with temperature change in the environment). It can sense temperature change in its surrounding and send the data to the analog IO in the STM board. All we need to do is to convert the sensor output data into degrees Celsius temperature via simple programming, finally to display it. Mathematical Calculations :

- Voltage = ((ADC_vale / 4095) * Vin) , Temperature = (Voltage - 0.5) * 100

Pin Configuration :

Component	Pin Number	Connections
STM32 Nuclei F103RB	5V,GND	Connected to power supply
Ultrasonic Module	VCC, GND	Connected to power supply
Ultrasonic Module	Trig	PA0
Ultrasonic Module	Echo	PA1
Temperature sensor	VCC, GND	Connected to power supply
Temperature sensor	Signal	PB0
Servo Motor	VCC, GND	Connected to power supply
Servo Motor	Signal	PA6
L298 Motor Driver	VCC, GND	Connected to power supply
L298 Motor Driver	IN1	PA9
L298 Motor Driver	IN2	PA8
L298 Motor Driver	IN3	PB8
L298 Motor Driver	IN4	PB9
Red LED	VCC	PA7
Green LED	VCC	PA5

Programming : The programming aspect of the firefighting robot was done using the C programming language, which is commonly used for microcontroller programming. The code was structured to control the movement of the robot and process sensor data. The algorithms used for obstacle detection and temperature sensing were designed to enable the robot to navigate around obstacles and detect high-temperature areas. The algorithm is as follows :

- The ultrasonic sensor will detect the if there is any obstacle in front (set to 1 feet). As long as there is nothing in the front, both tires will move forward.

- If any obstacle is detected in front, robot will stop. The servo motor will move the ultrasonic sensor to 180 degree to detect the left side of the robot. If nothing is detected, the robot will take a eft turn and start moving forward.

- If any object is detected on left hand side, the servo will move the ultrasonic to 0 degree which is right hand side of the robot. If nothing is detected, robot will take right turn.

- If there are obstacle on both side, robot will move backwards.

- All this time, the temperature sensor will detect the temperature around it. If the temperature is lower than certain level a green LED will be ON which means OK, however, a red LED will be turned ON if the temperature rises unto certain value.

Testing and Results : The firefighting robot was tested in several scenarios to evaluate its performance in detecting obstacles and high-temperature areas. The tests were conducted in a controlled environment to ensure consistent results. For the obstacle detection test, the robot was placed in front of a wall, and various obstacles were placed in its path. The ultrasonic sensors were able to accurately measure the distance to the obstacles, and the robot was able to change its path accordingly. The mini servo was able to detect the direction of the obstacles, and the robot was able to move around them.

For the temperature detection test, the robot was placed in an area with a known high-temperature source. The analog temperature sensor was able to accurately measure the temperature of the surrounding area, and the red LED was able to turn on when the temperature threshold was reached.In addition to the individual tests, the robot was also tested in a scenario that combined obstacle detection and temperature sensing. The robot was able to detect and navigate around obstacles while also detecting high-temperature areas and indicating their presence with the red LED.

Overall, the testing results indicated that the firefighting robot was able to effectively detect obstacles and high-temperature areas, and navigate around them. The use of the ultrasonic sensors and mini servo enabled accurate obstacle detection and direction sensing, while the analog temperature sensor allowed for precise temperature measurement. The robot's ability to combine both obstacle detection and temperature sensing made it a useful tool for firefighting and rescue operations.

Conclusion : The firefighting robot designed and built in this project has demonstrated its potential as a useful tool for firefighting and rescue operations. The robot is equipped with ultrasonic sensors and mini servo to accurately detect obstacles and their direction, while an analog temperature sensor allows it to detect high-temperature areas. The robot's ability to combine both obstacle detection and temperature sensing provides an effective solution for navigating through hazardous environments.

In conclusion, the firefighting robot designed and built in this project has the potential to be a valuable asset in firefighting and rescue operations. The robot's ability to accurately detect obstacles and high-temperature areas, and navigate around them, makes it a versatile and effective tool for hazardous environments. With further development and improvements, the firefighting robot could become a standard tool in the firefighting and rescue industry.

Future Works : The firefighting robot designed and built in this project is a promising tool for firefighting and rescue operations. However, there is still room for improvement and future development. Some of the potential areas for future work are discussed below:

- Improvement of obstacle detection: While the current design of the robot allows for accurate obstacle detection and navigation, there is still room for improvement. The addition of more sensors could help to improve the accuracy of obstacle detection.
- Fire Extinguisher : An water pump or compressed nitrogen can be installed to extinguish fire.
- Fire Sensor : The robot should only operate when the fire is detected which will need fire sensor.

References

- Nanoti, R. A. (2022, January 22). *Interfacing an ultrasonic sensor with the STM32F407 Discovery Board using bare-metal programming*. Embedded System Projects. Retrieved April 9, 2023, from https://ruturajn.hashnode.dev/interfacing-an-ultrasonic-sensor-with-the-stm32f407-discovery-board-using-bare-metal-programming

- YouTube. (2018, August 29). *How to make Arduino obstacle avoiding robot car | under $20*. YouTube. Retrieved April 9, 2023, from https://www.youtube.com/watch?v=4CFO0MiSlM8&list=LL&index=9