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Automation Firefighter Car

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Disclaimer

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Abstract

Fires take a heavy toll, and there are often areas that firefighters can't get to quickly because of the flames. Therefore, we decided to implement a project to develop an automatic fire engine. The Firefighter Car project aims to design and implement an advanced fire detection and suppression system for firefighting vehicles. The system is equipped with a camera, Raspberry Pi and Arduino, enabling the vehicle to quickly identify fires and suppress them effectively. The technology of the project involves using computer vision to analyze real-time video frames captured by the vehicle's camera. The Raspberry Pi, with its computational power and small size, acts as the primary processing unit, executing fire detection algorithms. This allows for real-time monitoring and analysis of the video feed, enabling the vehicle to detect fire incidents instantly.

- There will be two modes to move the vehicle from the fire station to the destination: automatic and manual modes.
- We will install thermal sensors to confirm fire detection.
- In addition, we will add an ultrasonic sensor to detect any obstacles and avoid them if necessary.
- Stepper motor scanner with the camera He rotates until he finds fire, so we take the angle by a Gyroscope to move the car on it
- The Arduino microcontroller acts as an interface between the Raspberry Pi and various components, such as fire suppression mechanisms and motors. When a fire is detected, the system triggers the appropriate response, activating the mechanisms necessary to extinguish the flames.
- We will also install a water pump sensor to alert when the water is not enough and when it runs out. Moreover, we will develop a software that will provides us with live feed information from the vehicle using a wireless connection. Also, it will enable us to control the car.
- After the vehicle have finished extinguishing the fire, it returns to the fire station autonomously

1 Introduction

In many cases, many fires come to fire stations, which sometimes lead to the lack of fire engines or firefighters available at times of many fires, and in light of the great development that we are going through, it was necessary to make automation cars that can reach the places of fire in particular places which are dangerous to firefighters, these cars can be sent to reduce the risk of fire or to open an area for firefighters to work with much less risk

Therefore, we designed a car that saves the roads leading to any place in the city. It is provided with the location of the fire, so it goes by itself in an automatic way, then searches for the fire and extinguishes it.

1.1 Problem Statement

The main problem is the presence of large fires or in places that may make there a danger for the lives of firefighters, or there are more fires than the number of fire trucks available in a specific area

1.2 Objectives

The automatic fire Car aims to facilitate access to difficult fire areas and put out as much fire as it can in order to open the way for firefighters

1.3 Significance

The automatic fire car combines ease of use and control via mobile phone software and works without need any control from the user except for giving it the coordinates of the site where the fire is located..

2 Constraints and Earlier Coursework

2.1 Constraints & Limitations

1. The used motors were a major hindrance, as they needed a lot of electric current that could be obtained from any batteries of a small size of the car that fit or the capacity of the motors.
2. There were several problems between the Raspberry Pi and the Arduino Mega, as the Arduino often did not receive any information from the Raspberry Pi until it was ran before anything else.
3. We had a problem that the used motors needed an encoder, and these motors were not widely available, so we did not have 4 motors with the same RPM, so we had to use 3 motors with (250 rpm) and one motor with (220 rpm), and we reduced the speed of the three motors to suit Fourth engine.

The process of finding fire through the camera and the Raspberry Pi was giving a delay in time often, and this is due to the weakness of the Raspberry Pi processor

2.2 Earlier Coursework

1. Microcontrollers Course covering their fundamental principles and practical applications.
2. Electronics course that provides instruction in various aspects of electronic systems and technologies.
3. Critical thinking and scientific research teaching students skills such as reading scientific publications and utilizing modern technologies like LaTeX to produce research papers.

3 Literature Review

Fire extinguishing methods have witnessed a great development in recent years, with the large number of natural disasters and technical problems that lead to huge fires that lead to the lives of many people. With the protection of many lives, The American authorities announced that the fires that destroyed thousands of homes last November in Malibu and Northern California, killing 88 people, caused material losses estimated to cost at least nine billion dollars, These fires destroyed a total of 100,000 hectares of green spaces and urban areas.

therefore we decided to make a smart firefighter car that processes the images it receives from the camera attached to it and puts out any fire it sees.

Our car will reach the fire site automatically by saving the map of the city in which it will be, which will help it reach the fire site without any manual intervention. It will search for the fire on its own and put it out.

4 Methodology

4.1 System Architecture

4.1.1 Polycarbonate Body

We designed the car body out of polycarbonate measuring 20cm x 20cm x 30cm. It is mounted on four DC motors and their wheels. Polycarbonate is hard to break and can withstand high temperatures, which is why it was chosen for our project.



Figure 1: Initial Design for Polycarbonate Body

4.1.2 Water Tank

We added a water tank behind the car, which is a plastic box with a capacity of 700 ml, connected with a water pump, and to install it, we used a plastic base with angles and screws.

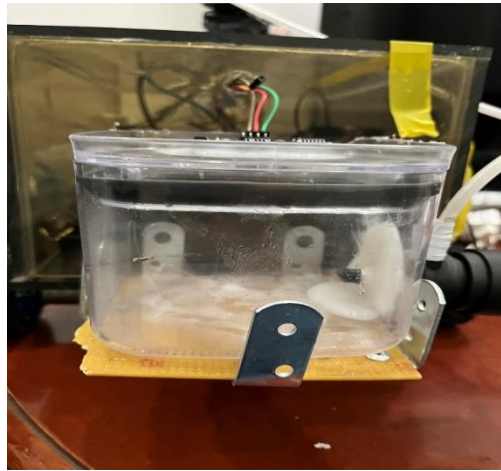


Figure 2: Water Tank

4.1.3 Fire Detection Mechanism

The Fire Detection Mechanism consists of a stepper motor, camera, water hose and pump. The stepper motor is located on top of the car in the front part and the camera is mounted on it. The water hose mounts on top of the camera and connects to the pump behind the vehicle and the stepper is mounted using angle irons.



Figure 3: stepper motor & camera

4.2 Processing Units and Used Devices

4.2.1 Arduino MEGA

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560[1]. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller.

We have used the Arduino mega to arrange the sequence of the project process and to control when and what part should run on each time

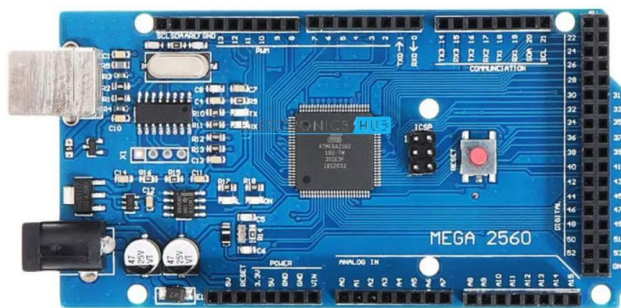


Figure 4: Arduino MEGA

4.2.2 Raspberry pi 4

The Raspberry Pi is a low cost, **credit-card sized computer** that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do .

we have used the Raspberry pi to make the fire detection mode by using image processing using "Python" .

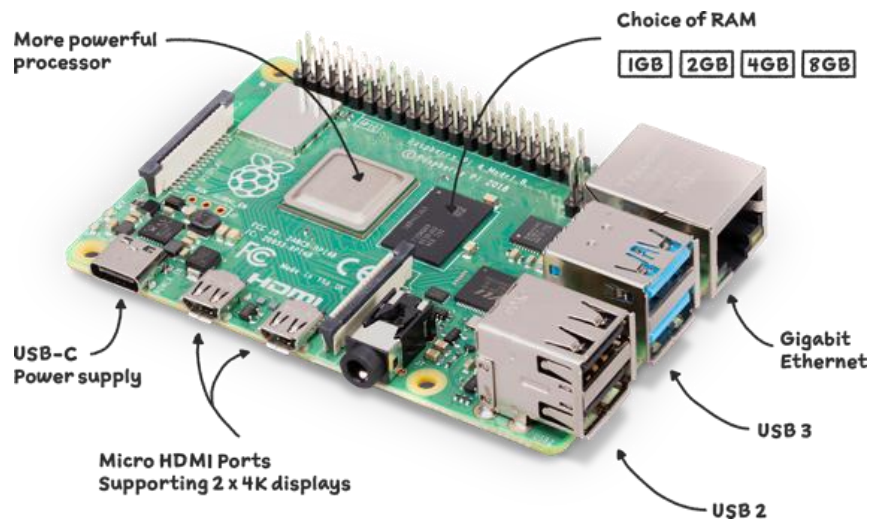


Figure 5: Raspberry pi 4

4.2.3 DC Motors with Encoders

We used 3 12V DC motors with 250 RPM and 1 DC motor with 210 RPM because there is fourth motor with RPM 250 so we have slow down the 3 dc motors with 250 RPM with a given equation

$$\text{PWM (for 210 RPM)} = \text{PWM} / 1.8 \text{ (for 250 RPM)}$$



Figure 6: DC Motor

4.2.3.1 Encodes in Dc motors

We used the encoders in order to run the vehicle for certain distances, in order to control its movement and directions, and to record the distances traveled in order to perform the automatic return process

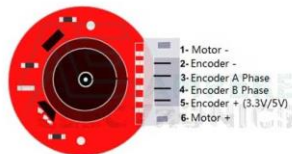


Figure 7: DC Motor Encoder

4.2.4 Motor Driver L298N (H Bridge)

This L298N motor driver module is a high power motor driver module for driving DC motors and stepper motors. This unit consists of a L298 driver IC and a 78M05 5V regulator. The L298N can control up to 4 DC motors, or 2 DC motors with both direction and speed control.

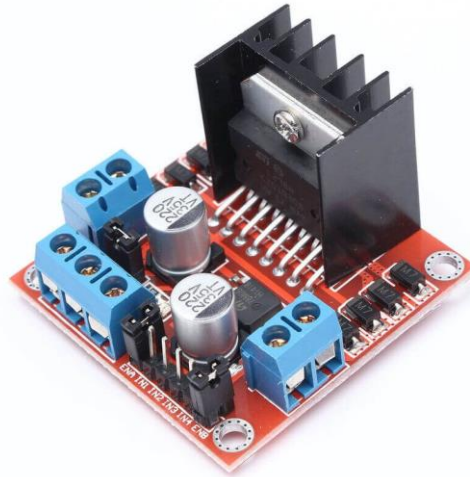


Figure 8: Motor Driver L298N

4.2.5 Camera

We used a web camera with 1080p that we usually use it in the computers , we use it to make a real time video and send the video data to the raspberry pi to make the fire detection operation



Figure 9: Web Camera

4.2.6 Water Pump

We used a 12 volt water pump to spray water on the fire area and control the water pump power with [I298N](#)



Figure 10: water pump

4.2.7 Stepper motor

A stepping motor, also known as a stepping motor or stepping motor, is a brushless DC electric motor that divides a complete cycle into a number of equal steps. The position of the motor to move one of these steps can be controlled and held without any feedback position sensor (open loop controller), as long as the motor is sized appropriately for the application in terms of torque and speed. We used the stepper motor In order to carry the camera and the fire

hose and move them to 180 degrees in order to cover all the area that the vehicle sees and spray water directly on the fire area

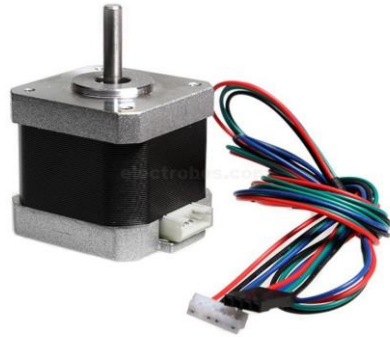


Figure 11: stepper motor

4.2.8 HC-05 Bluetooth module

HC-05 is a Bluetooth module which is designed for wireless communication, it is used for many applications like wireless headset, game controllers, wireless mouse, wireless keyboard, and many more consumer applications ,It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions. It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART).

We used this piece to control the vehicle through the phone program that we designed in order to issue commands to the Arduino and display the results on it

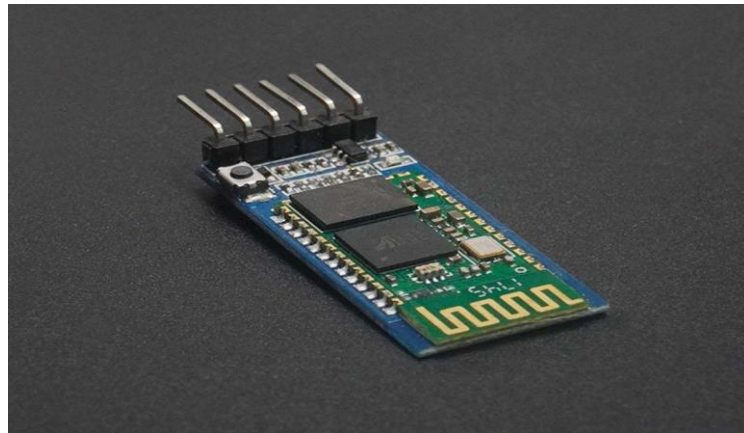


Figure 12: HC-05 Bluetooth module

4.2.9 Ultrasonic sensor

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasound sensor uses a transducer to send and receive ultrasonic pulses that transmit information about how close an object is, we used it to check if there is any impediment in the car way and if the car goes to the impediment closer than 15cm the car will stop and will bypass this impediment



Figure 13: Ultrasonic sensor

4.2.10 Water level sensor

A water level sensor is a device that measures the liquid level in a stationary vessel that is too high or too low. According to the liquid level measurement method can be divided into two types: contact type and non-contact type. The input type water level transmitter we call is a contact gauge, which converts the liquid level height into an output electrical signal. It is currently a widely used water level transmitter.



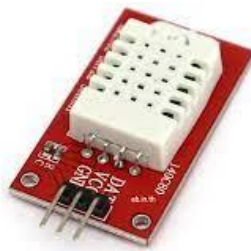
Figure 14: Water level sensor .

4.2.11 Heat sensor DHT22

This DHT22 is a digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed).

Compared to the DHT11, this sensor is more precise, more accurate and works in a bigger range of temperature/humidity.

We used the sensor to make sure that there is a fire not just a light



4.2.12 Stepper motor driver A4988

The A4988 is a complete microstepping motor driver with built-in translator for easy operation. It is designed to operate bipolar stepper motors in full-, half-, quarter-, eighth-, and sixteenth-step modes, with an output drive capacity of up to 35 V and ± 2 A. The A4988 includes a fixed off-time current regulator which has the ability to operate in slow or mixed decay modes.

We used the stepper motor driver to control the angel that we want the stepper motor to move
And to control run or stop the motor .



4.3 How the system works?

4.3.1 Connection & choose the mode

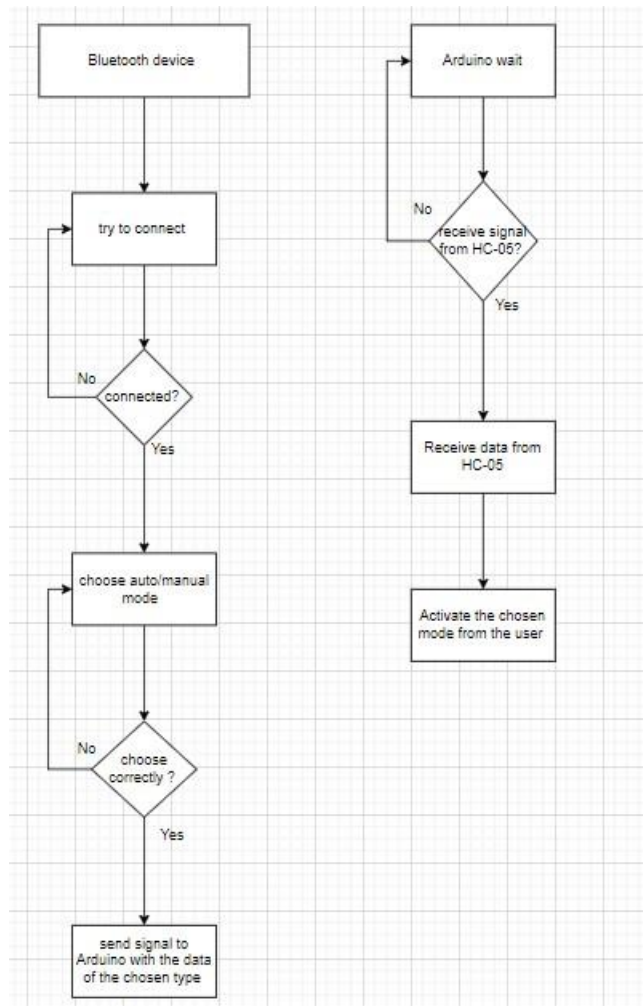


Figure 15: first state diagram

At first the user will connect to the bluetooth via the designed mobile application, then the arduino will wait until it receives the connection command from the bluetooth device, and it will wait until the user selects the working mode he wants



Autonomous Firefighting Vehicle

start



BLUETOOTH CONECTED

Manual Mode	Automatic Mode
	○
	>

Figure 16: connection & choose mode screen

4.3.2 Manual Mode

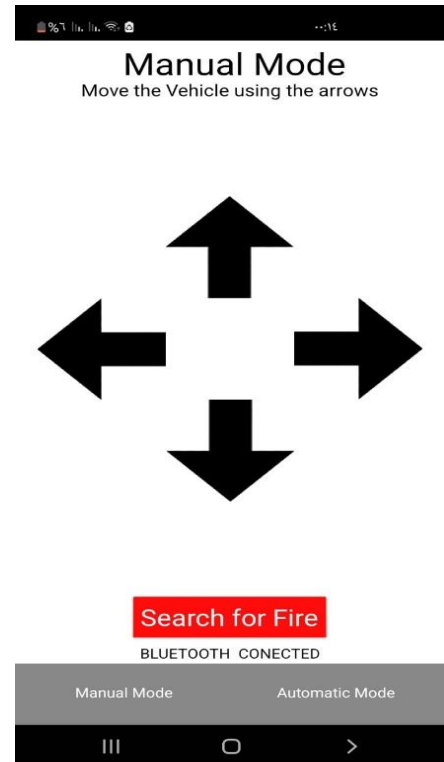
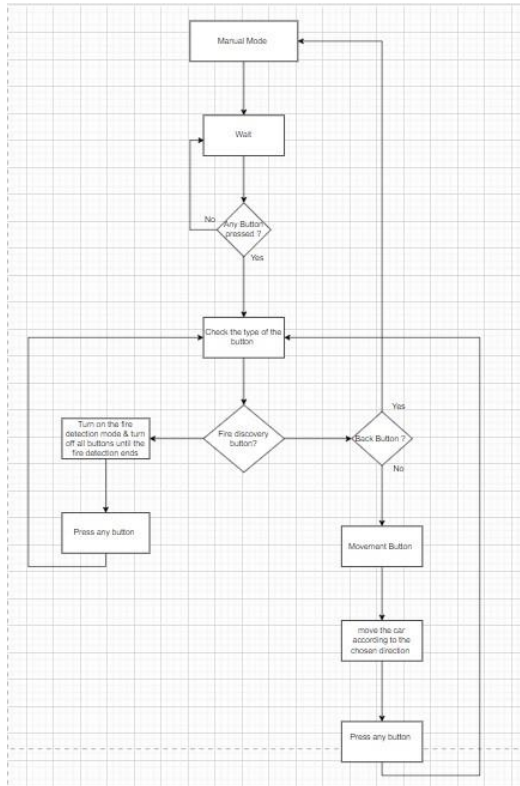
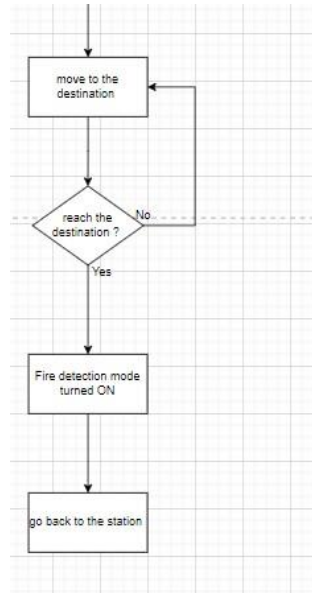
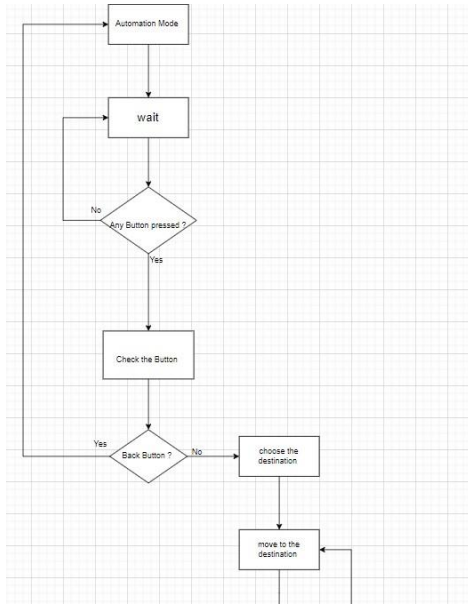


Figure 17: Manual mode

When the user choose the manual mode that will open a new page with 6 buttons so when the user press on any button the mobile application will send a serial data to the HC-05 witch connected to the Arduino and the process will run As positioned in “Figure 17”

4.3.3 Automation Mode



Automatic Mode

start

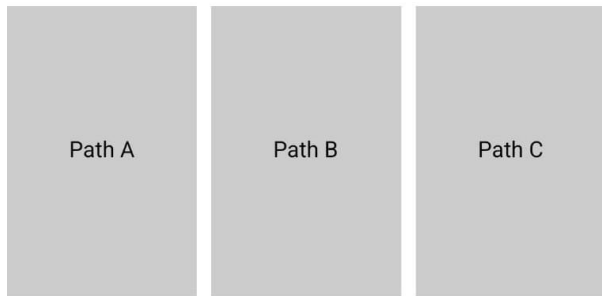
Figure 18: Automation mode

In the Automation mode the user just need to choose the saved destination on the mobile application and the car will go there and make a fire detection test then it will returned to the station after it finished its work , and after each step the car will send a feed back where it was



Automatic Mode

You have reached the desired destination



Automatic Mode

I returned to the station



Figure 19: Automation mode mobile application

4.3.4 Fire detection work

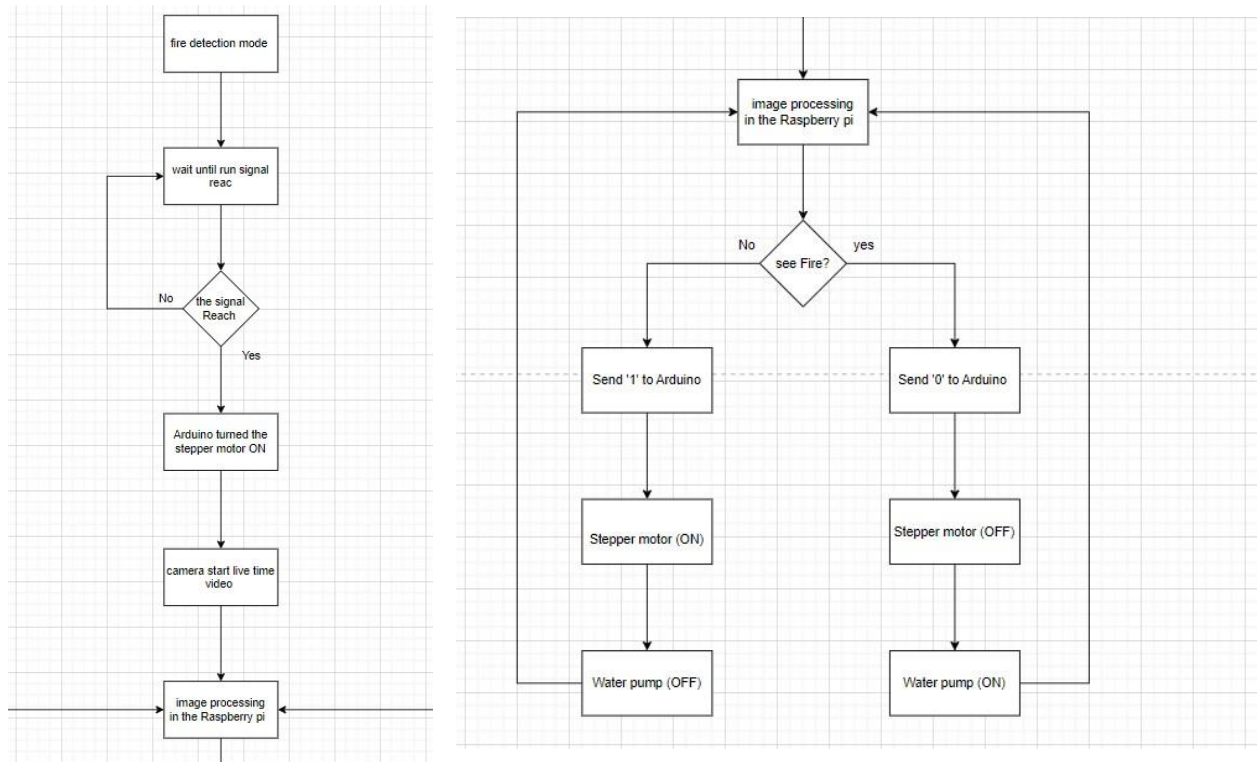


Figure 20: fire detection work

The fire detection mode work is done through a joint action between the Arduino and the Raspberry pi. When the camera sees the fire and the Raspberry pi analyzes it, the stepper motor will stop and the water pump will be turned on. Then, when the car extinguishes the fire, the stepper will run again and the water pump will stop.

5 Results & Discussion

5.1 Results

The system provides us with a multi-purpose fire truck that can be used manually or automatically. It can be used when there are fires that are difficult for humans to reach, or when there are no firefighters available. A mobile application has also been provided to control it.

5.2 Discussion

It provides us with a modern idea that can be developed to benefit from it to save the lives of more people. It can be a solution to many fire problems that are difficult for humans.

6 Conclusion & Future Work

6.1 Conclusion

In conclusion, we believe that this idea could be the beginning of reducing the danger to firefighters in particular and helping many people to preserve their lives in general, and it could be a starting point for large projects that help people overcome some disasters.

6.2 Future Work

- Automation drones put out the fire
- GPS system to reach to the care if it lost or changed its direction

