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Autonomous, Surveillance Fire Extinguisher Robotic Vehicle with Obstacle Detection and Bypass using Arduino Microcontroller

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ABSTRACT
A robotic vehicle has to move autonomously avoiding the obstacles and at the same time finding and tracking flame sources and extinguishing them. In addition to that it has to send the live feed of the surrounding. For achieving this objective the implementation has been divided into various modules such as avoiding obstacles, fire detection, fire extinguishing and wireless transmission of the visual.

Keywords
Microcontroller, Flame Sensor, Ultrasonic Sensor, Motor Driver, IP Webcam

1. INTRODUCTION
The objectives of the project are to develop a vehicle that can run autonomously by avoiding the obstacles in its path. At the same time it should be able to track and find the fire source and extinguish without direct contact. Then the fire source can be extinguished. Apart from this live surveillance feed via the wireless camera to a PC will enable to view the surrounding. This project is an integration of various features:

1.1 Fire Detection
The fire is detected using 3 flame sensors, placed in three sides- front, left and right.

1.2 Fire Extinguishing
For the purpose of extinguishing the fire, a fire extinguisher can is used. It is controlled using a linear actuator.

1.3 Wireless Camera
The objective of the camera is to transmit the live feed to a workstation such as laptop or PC. The cost effective solution was to make use of an Arduino camera module with Wi-Fi module. As a result the camera feeds obtained could be transmitted anywhere.

1.4Avoiding Obstacle
On the way to the detected fire spot if this vehicle finds any obstacle, it can bypass that obstacle. This is achieved using ultrasonic sensors. After avoiding obstacles the vehicle reaches the exact spot.

2. HARDWARE COMPONENTS
2.1 FlameSensor
This Flame Sensor can be used to detect fire source or other light sources of the wave length in the range of 760nm - 1100 nm. It is based on the YG1006 sensor which is a high speed and high sensitive NPN silicon phototransistor. Due to its black epoxy, the sensor is sensitive to infrared radiation. In fire-fighting robot game, the sensor plays a very important role; it can be used as a robot eyes to find the fire source. When detected the flame the Signal LED will on and the D0 output LOW voltage level.

Features
- High Photo Sensitivity
- Fast Response Time
- Sensitivity adjustable

Specification
- Working voltage: 3.3v-5v
- Detect range: 60 degrees
- Digital/Analog output
- On-board LM393 chip
- Dimension of the board: 3.2cm x 1.4cm

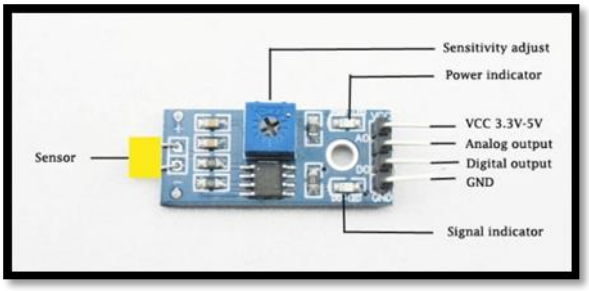

Figure 1: Flame Sensor

2.2 Ultrasonic Sensor HC-SR04
Ultrasonic sensor are also known as transceivers as when they both send and receive. They work on the principle similar to radar or sonar.
Active ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object. Passive ultrasonic sensors are basically microphones that detect ultrasonic noise that is present under certain conditions. The range of the target is determined by the "time lagging" between transmitted pulse and the received "echo". Generally microwave and ultrasonic frequencies are used in radars.HC-SR04 ultrasonic sensor works similar to the radar mechanism but in a simplified manner. This sensor consists of four pins as following:

Table 1: Pin details of HC-SR04

V_{cc}	Connect to 5V DC
Trigger	Pulse input that triggers the sensor
Echo	Indicates the reception of echo from the target
Gnd	Ground final

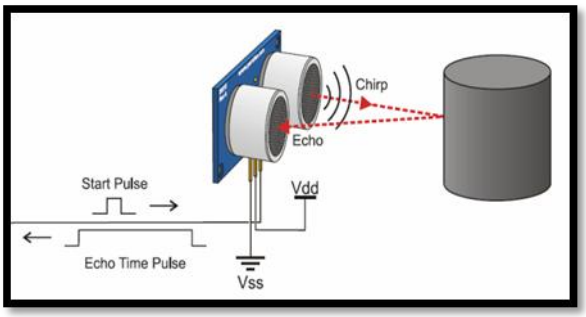

Figure 2: Ultrasonic Sensor

2.3 Motor IC

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction.

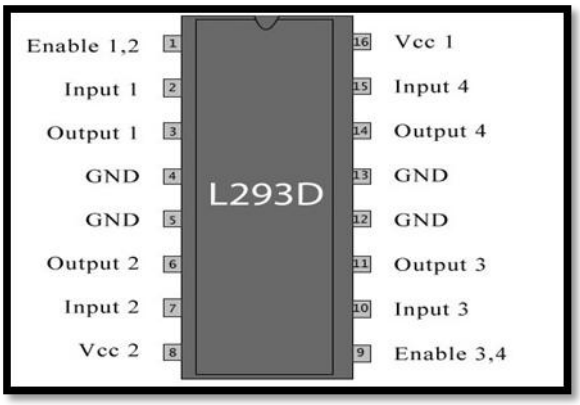

Figure 3. L293D Pin Diagram

The 4 input pins in L293D i.e. Pin 2 and Pin 7will regulate the rotation of motor connected across left side and Pin 15 and Pin 10 will regulate the rotation of motor connected across the right side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.
Consider a Motor is connected on left side output pins (pin 3,6). For rotating the motor in clockwise direction the input pins has to be provided with Logic 1 and Logic 0.

Table 2: Pin details of L293D

Pin 2	Pin 7	Rotation
1	0	Clockwise
0	1	Anticlockwise
0	0	Stop
1	1	Stop

In a very similar way a motor can also operated across input pin 15, 10 for motor on the right hand side.

2.4 DC Motor

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line.

Figure 4: DC Motor

2.5Arduino Microcontroller

The Arduino Mega is a microcontroller board based on the ATmega1280 (datasheet). It has 54 digital input/output pins (of which 14 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; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

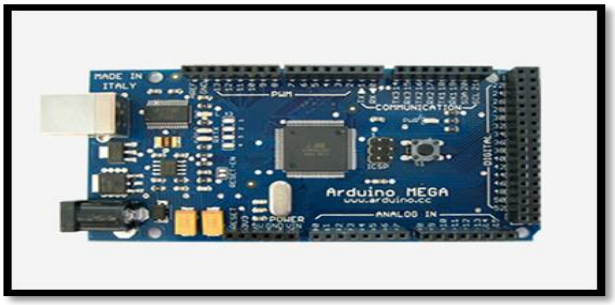

Figure 5.Arduino Mega 2560

2.6 Linear Actuator

A linear actuator is an actuator that creates motion in a straight line, in contrast to the circular motion of a conventional electric motor. Linear actuators traditionally have five wires. Two wires are for powering the motor and three wires go the internal potentiometer for reading position. The two relays are used to toggle the positive and negative power to the motor in order to determine the direction of piston travel. The analog potentiometer is wired to one of the analog inputs on the sensor shield for reading the current position. When a button is pressed the code reads the current position, then determines which direction to drive the piston to reach the goal position. Once the goal position is reached it shuts off the power to the motor.

Figure 6: Linear Actuator

2.7Arduino Camera Module

Arduino camera module, adopted the Surveillance cameras digital image processing chip-OV0706, specially designed for image acquisition and processing application, based on TTL communication interface, very convenient to connect with Arduino controller, able to read image and data via UART serial port, and then perform some image processing.

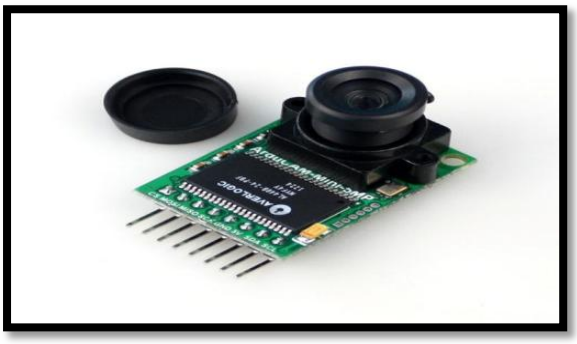

Figure 7: Arduino Camera Module

2.8WiFi Module

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of communicating with other microcontroller using TX, RX ports. Each ESP8266 module comes pre-programmed with an AT command set firmware. It connects to the internet using IEEE 802.11 b/g/n standard.

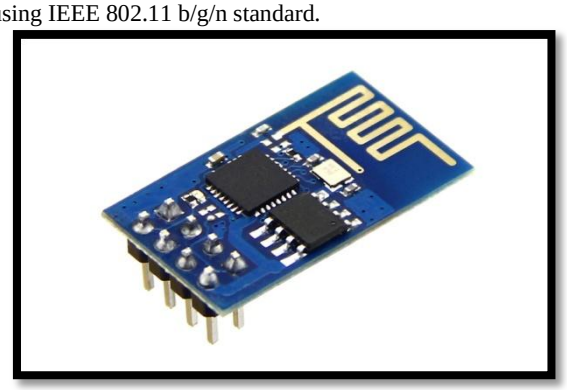

Figure 8: ESP8266 Wi-Fi Module

3. BLOCK DIAGRAM

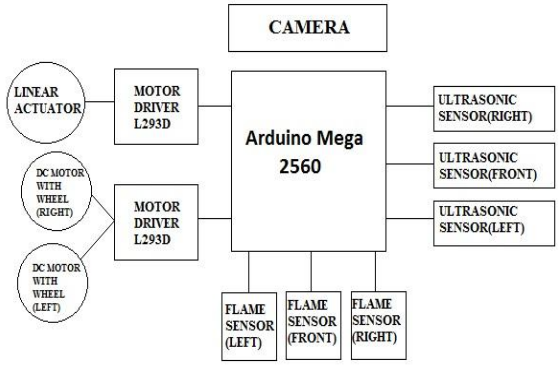

Figure 9: Block Diagram

4. FLOWCHART WITH ALGORITHM

For proximity sensor i.e. Collision Avoidance (CA)

1. *If there is no obstacle in front then the vehicle moves forward.*
2. *If there is an obstacle on the left, then the vehicle rotates right.*
3. *If there is an obstacle on the right, then the vehicle rotates left.*
4. *If the vehicle moves towards a wall diagonally then it should be able to correct its course and move forward along the wall.*

For flame sensor i.e. Flame Tracking (FT)

1. *The flame sensors are kept ON.*
2. *If there is no flame then the collision avoidance works normally.*
3. *If there is flame on the left then the vehicle turns left.*
4. *If there is flame on the right then the vehicle turns right.*
5. *If the vehicle is within 20 cm of flame then the vehicle stops and the fire extinguisher can sprays the foam to extinguish the flame.*

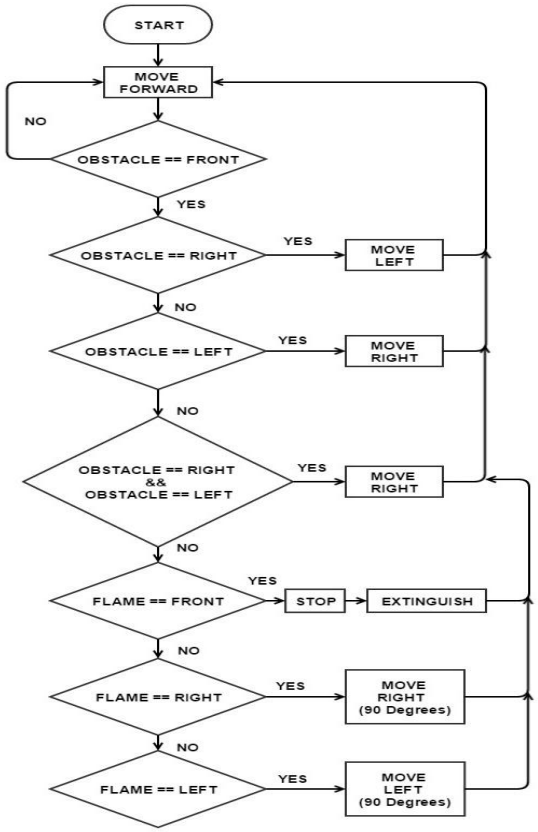

Figure 10: Flowchart of entire bot

5. CIRCUIT DIAGRAM

In this circuit, the microcontroller is connected to two motor drivers IC. One motor driver IC is used to control the DC motors attached to the wheel. Another motor driver IC is used to control the linear actuator. The three flame detectors are connected to the analog pins of Arduino microcontroller. Also the three ultrasonic sensors are also connected to the analog pins of the Arduino microcontroller.

Module 1: Arduino Microcontroller with Ultrasonic Sensors

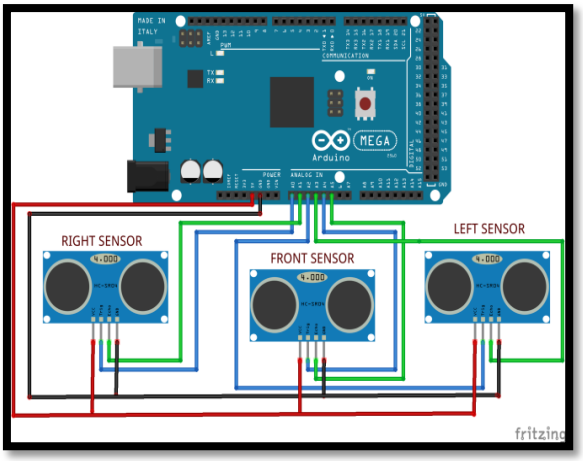

Figure 11: Arduino Microcontroller with Ultrasonic Sensors

Three ultrasonic sensors are used in front, left and right. The pin connections are as follows:

Table 3: Pin connection of Ultrasonic Sensors with Arduino Mega 2560

Sensor	Sensor Pin No	Arduino Pin No
Right	Trigger	A0
	Echo	A1
Front	Trigger	A4
	Echo	A5
Left	Trigger	A2
	Echo	A3

Module 2:ArduinoMicrocontroller with Flame Sensors

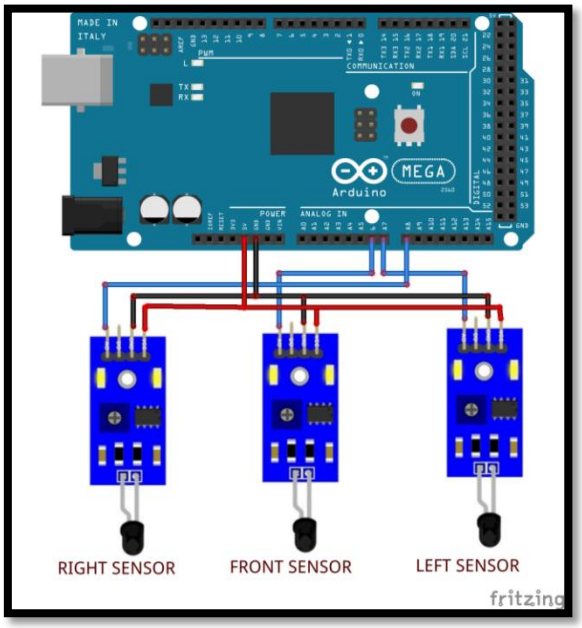

Figure 12: Arduino Microcontroller with Flame Sensors

Three flame sensors are used in front, left and right. Here the analog pin (A0) was used and the digital pin (D0) was left out. The pin connections are as follows:

Table 4: Pin connection of flame sensors with Arduino Mega 2560

Sensor	Sensor Pin No	Arduino Pin No
Right	A0	A8
Front	A0	A6
Left	A0	A7

Module 3: Arduino Microcontroller with motor driver and wheel

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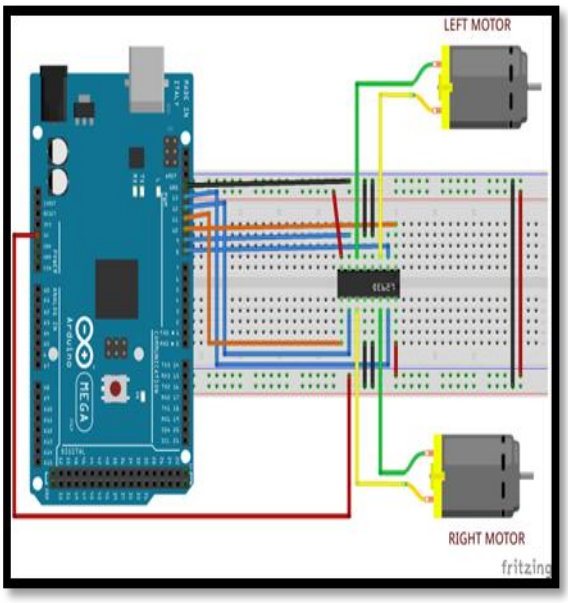

Figure 13: Arduino Microcontroller with motor driver and wheel.

In this module a motor driver is used to the control the two DC motors attached to wheels. The pin connections are as follows:

Table 5: Pin connection of L293D IC with Arduino Mega 2560

Motor	L293D Pins	Arduino Pins
Left Motor	1 (enable pin)	10
	2 (input 1)	8
	7 (input 2)	9
Right Motor	8 (enable pin)	11
	12 (input 3)	12
	13 (input 4)	13

Module 4: Arduino Microcontroller with Camera Module

In this module the camera is interfaced with Arduino mega microcontroller. The pin connections are as follows:

Table 6: Pin connection of OV0706 IC with Arduino Mega 2560

Camera Module	Pin	Arduino Pin No
TX	TX	2
RX	RX	3

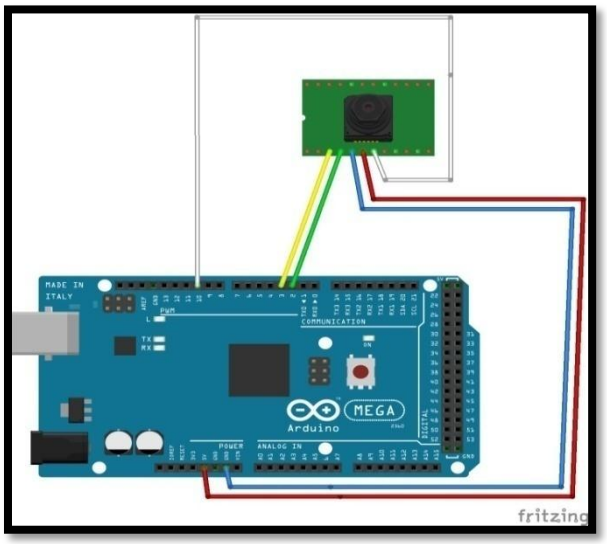

Figure 14:Arduino Microcontroller with Camera Module

Module 5: Arduino Microcontroller with Wi-Fi Module

In this module the ESP8266 is used for Wi-Fi connectivity. The pin connections are as follows:

Table 7: Pin connection of ESP8266 with Arduino Mega 2560

ESP8266 Module	Pin	Arduino Pin No
TX	TX	14
RX	RX	15

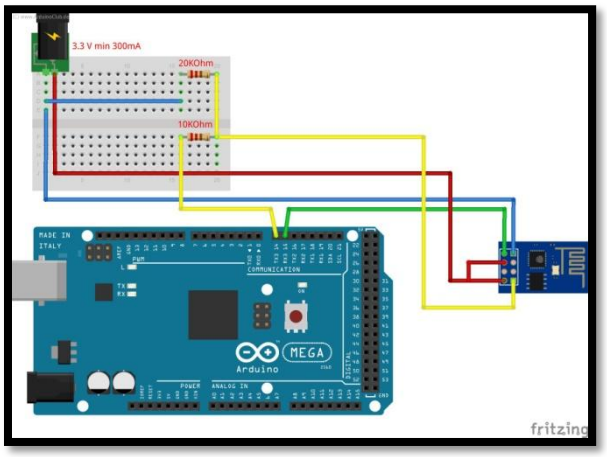

Figure 15:Arduino Microcontroller with Wi-Fi Module

6. CONCLUSION

This paper illustrates the theoretical concept of construction of a fire fighting autonomous robot with the capability of live surveillance feed. The autonomous capability of the robot can be introduced by the use of proximity sensor. The flame sensor detects the flame and the fire extinguisher can sprays the foam to extinguish the flame. The collision avoidance module and flame tracking module function simultaneously.

The live surveillance feed is obtained using a wireless camera. The feed from the camera is provided to an interface on the PC.

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