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Fire Fighting Robot With Obstacle Detection

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# Overview

The job of a firefighter is one of the most dangerous jobs in the world. They have to face risky situations while rescuing victims or extinguishing fires. The jobs of these fire fighters can be made a lot easier if there can be a robot which itself can extinguish small fires automatically. A robot can also reach places which are not easily reachable by a human. Also in households, a robot which automatically detects fire and extinguishes it can be a blessing, as it can extinguish a small house-fire before it spreads and becomes a life-threatening one.

# Goals and Deliverables

The main aim of our project is to deliver a model that will be beneficial in times of fire crisis and for its management. The robot will roam around in the room following zig-zag pattern and avoiding obstacles in between while continuously detecting the fire in left, middle and right. As soon as it will detect that in any direction, the robot will reach to that location and will automatically extinguish it without any human interference by spraying water onto the candle fire continuously.

Apart from using such robots as autonomous fire extinguisher, they with their obstacle detection mechanism can also be used for other household purposes like vacuum cleaning ,surveillance, or mobile robot navigation.

# Equipments Required

* Arduino Uno
* Ultrasonic Range Finder Sensor - HC - SR04(3)
* Motor Driver IC - L293D
* Robot Chassis
* Bottle spray
* Servo
* Servo Holder U-shaped
* Servo Bracket
* Metal Horn
* Fire Sensors (3)
* Geared DC motors (2)
* Battery - 9V (4)
* DC Adapter / Lithium Battery
* Voltage Regulator
* Buzzer
* Wheels(4)

# Circuit Diagram & its Working

The above is the circuit diagram.

Robot is moving with use of 2 DC motors which is controlled by l293d motor driver IC. IC’s 2 and 7 number pins are connected to arduino’s digital pins 8,10 which are controlling the left motor. While IC’s 10 and 15 number pins are connected to arduino’s digital pin 11 and 12 which are controlling the right motor. From these pins, we can control the clockwise or anti-clockwise motion of both motors independently which can be used to change the direction of the robot when it confronts an obstacle or detects fire.

The robot will roam around in the room following zig-zag pattern and avoiding obstacles in between while moving. It uses 3 ultrasonic range finder sensor which are connected to the arduino.They are provided with 5V power supply and ground each. The left Obstacle Sensor has its echo and trigger connected to Digital pin 5 and Analog pin A1 respectively. Similarly the right Obstacle Sensor has its echo and trigger connected to Digital pin 6 and Analog pin A2 respectively. And the last middle Obstacle Sensor has its echo and trigger connected to Digital pin 3 and Analog pin A0 respectively.

We are using 3 fire sensors to detect the fire in all 3 positions : left, middle and right. The purpose of using three fire sensors is to find accurate direction of fire. Fire sensors have three pins - 5V power supply, ground and output pin. Output pin can be used as analog or digital output. We are using it as analog so it is connected to analog pins A3, A4and A5 of arduino. Where, A3 is output pin to middle sensor, A4 is for left while A5 being for right sensors respectively.

When fire is detected by fire sensor,the robot will turn into that particular direction(left or right whatever it may be) and will move further in that direction and after reaching a specific distance from fire, will stop and the buzzer at digital pin 13 of arduino buzzes indicating robot has detected fire and is now ready to extinguish it. To extinguish fire we will be using a spray bottle. It’s handle will be connected to a combination of servo, it’s holder and lastly it’s bracket(U-shaped) which will be attached to the spray bottle. The servo data pin is connected to the digital pin 9 of arduino. Servo is powered by 3 batteries which are connected in parallel to each other. When buzzer buzzes, servo bracket will swing inside constantly causing the copper wire connected to the handle of the spray bottle to press itself which in turn would spray water on the candle fire. The spray bottle is supported by the wedge made out of cardboard.

**Algorithm**

The robot will continuously roam around the room following a zigzag pattern. For this, we have used a variable nextTurn indicating the next turn of the robot. When the robot reaches a wall in its front, it will turn in the direction indicated by nextTurn. It will go forward a bit and then turn in the direction indicated by nextTurn again, making it a U-turn and continuing on its zigzag path.

When the robot detects an obstacle in front (if the value of the front ultrasonic sensor is less than 20?), it will check the value of the ultrasonic sensor of the direction indicated by nextTurn(eg. right). If there is no obstacle in that direction, it will turn in that direction(right) and move forward a bit. After moving forward, it checks in the other direction(left). If it detects an obstacle, it will treat it whole as a wall and turn again (right), making it a U-turn. If however there is no obstacle there, it will take a turn in the other direction (left), move forward for some time and take another turn (left), move forward again, and then take a turn in the other direction(right), thus avoiding the obstacle in front and continuing on its path.

If the robot detects an obstacle in front and there is also an obstacle in the direction indicated by nextTurn(eg. right), it will check the value of the ultrasonic sensor on the other side(left). If there is no obstacle there, it will follow the same pattern above for that direction(left).

If the robot detects an obstacle in all three directions (if the values in all of the ultrasonic sensors is less than 20?), then it will move backward a bit and then check for obstacle in the direction indicated by nextTurn, and then follow the same algorithm above.

If the robot detects fire in its front(the range measured in the front fire sensor is less than 4?), it automatically means that there is no obstacle in the path between the robot and the fire, so it will move forward and get closer to the fire. If the robot detects fire in left or right direction, it will turn in that direction while simultaneously searching for fire in the front sensor. When it detects fire in the front, it will follow the same algorithm as if it detected the fire in front, going closer to the fire. When it gets close enough(the range measured in the front fire sensor is 0?), the buzzer will buzz and the robot will spray water on fire using the servo motor and servo bracket until the fire is extinguished(value in the front fire sensor is not 0?). After extinguishing the fire, the robot will avoid that area treating it as an obstacle and continue on its zigzag motion, searching for another fire.

**Problems during the project**

* The robot chassis which we got for the robot was a bit crooked, so the wheels were not aligned with each other properly. As a result, the robot was taking turns inconsistently. We fixed this by bending the chassis a little and by applying rubber band on one of the wheels.
* The fire sensor used in front was a lot more (powerful?) than the ones in the sides. Originally we unknowingly placed it on the right side and because of that, the readings from the right sensor were inconsistent with the readings from the left sensor. After changing that sensor to the front, we got same range readings from left and right sensors. Also, we adjusted our code a little to accommodate the more (powerful?) front sensor.
* Originally, we planned to have two more ultrasonic sensors(front left and front right) to figure out if there was enough room for the robot to go on, but one of those sensors was not working properly, causing the robot to go to some other direction than expected, so we removed those two sensors altogether.
* Considering a big chassis, four wheels and a bottle full of water on the top, the robot was too heavy. As a result, the 9V battery we used to run it would only last us about 10 minutes. We got around that by using a DC adapter at first, and then using a Lithium-ion battery.
* The Spray bottle which was to be used to extinguish the fire had to be kept a bit bent towards the ground than its actual alignment to spray it perfectly onto the fire rather than allowing it to spray parallely to the surface! For that, we made a wedge which could now support the spray bottle and joined it with the upper area of the robot for keeping it glued with

**Limitations**

* As this is a small scale project, our robot will only be able to extinguish small fires.
* In our algorithm, we have not considered the case of a thin but long obstacle as it made the code a bit too complex. If such obstacle is placed in the path of the robot, it will crash into it.
* Due to faulty ultrasonic sensors, we have not considered a case where there are no obstacles in the robot’s path but the path itself is too narrow for the robot to go through.