International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 03 | Mar-2018 www.irjet.net p-ISSN: 2395-0072

Multi - Purpose Fire Fighter Robot

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Abstract - *The Multi Purpose Fire Fighter Robot has three main objectives for fire extinguish and rescue operation. The design was made as an all-terrain robot, for easy locomotion. A robotic arm with a gripper at its end will be used to remove debris from damaged building parts during fire accidents. The design has a water tank at its back, the water outlet is attached to the tip of the robotic arm for fire extinguishing with 360 degree scope. Some sensors like IR receivers and flame sensors are used for automatic fire detection. Ultrasonic sensors works as obstacle detector and PIR sensor acts as a human detector to save lives during automatic operation of the robot. The entire robot can also manually operated using Bluetooth remote interface. With all such functionalities, the robot helps not only civilians but also firemen during fire extinguish and rescue operation. This was designed as a Final Year project and to online publication as a journal through IRJET. The main objective was to help fireman in dealing with fire accidents more easily.*

1. INTRODUCTION

The fire fighting robot was made to sense fire using multiple sensors fitted on all sides. Once the different fire locations are obtained, the arduino is coded to run a sensing algorithm according to which the robot moves towards the nearest fire spot. After assessing the fire spot by flame sensor modules on the sides of the robotic arm, the water outlet hose fixated on the base of the tip of the robotic arm gripper is made to extinguish the fire. The navigation of the robot is achieved by IR sensors and ultrasonic sensors. The PIR sensor allows tracking of human beings. The deployment of the extinguishing device is implemented with a custom arm controlled by servos. The design of the robot was made as simple as possible, considering all the sensors, motors and drives used. All the important topics about the robot are explained in detail below.

1.1 Software Design

The software for the robot was coded in Embed C, as it reduces complexity in comparison with assembly language and provides a far decent view of understanding the program for viewers. Since our Arduino supports Embed C, it was easier to code the entire program. The total program was divided into the three main parts, 1.Automatic 2.Manual 3.Security. Upon the robot initialization, the [1] Automatic mode runs as default. When the robot senses a fire accident, there will be two cases. If the robot can solve the emergency itself, the mode is set to [3] Security. But if the situation becomes complex for the robot to handle during both the fire extinguishing and pick and place operation, the mode is set to [2] Manual, where the user controls the robot using the Bluetooth remote interface, normally using an android device.

1.2 Sensor Synchronization

Sensor synchronization included reading an ultrasonic transducers and interpreting distance for obstacle detection, and with the robot locomotion. Multiple power LEDs are used to signify the current operation of the robot. The most programming sensitive sensor was the ultrasonic and analog IR receivers. The ultrasound expects an initial trigger pulse, which is projected out and upon striking the object it reflects back until an echo is received. The length of time that the line is held is proportional to the distance that the sensor is reading. The IR receivers are set to read all analog values, and upon reading the values of flame detected, arduino will process the fire extinguishing operation. The Bluetooth module was coded to receive certain key codes. Each key code transferred will cause the robot to perform a different operation. The Coding was done with multiple conditions, as read from the sensor. Once a condition becomes true, the corresponding operation is executed by the robot

2. Mechanical Design of Robotic Arm

The Custom made Robotic arm has 4 main parts 1. Base 2. Shoulder 3. Elbow 4. Gripper. All the robotic arm and robotic gripper were designed and cut out of mica rather than 3d printed parts. This is to ensure low cost with high endurance. The entire design uses just 4 servo motors as it provides better accuracy and precision. We used 3 SG90 servos and one MG995 servo. MG995 is used because of its high torque; it is housed in the base of the shoulder, managing the shoulder movements.

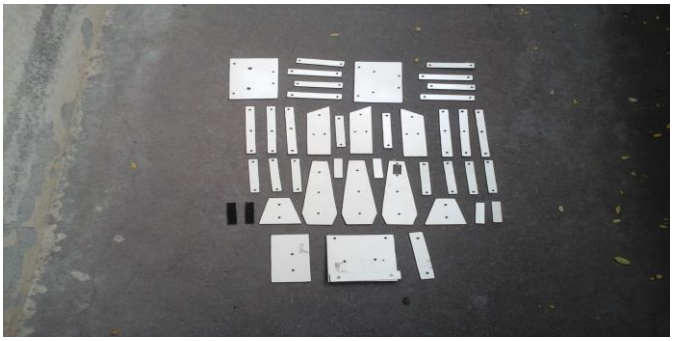

Fig -1: Mica pieces after cutting and drilling

2.1 Robotic Arm Base

The base is a rotating platform such that the entire platform is placed upon a sg90 servo motor, such that the motor itself is firmly fixated onto the metal chassis. The sg90 servo motor allows 180 degree rotation of the robotic arm base.

2.2 Robotic Arm Shoulder

The Shoulder also a 180 degree rotating servo motor but with higher torque of 10kg/cm, the servo motor is a MG995 model. The shoulder needs higher torque motor, due to the gripper's weight and the weight of the object (obstacle/debris of buildings considering a practical fire brigade). The entire movement and weight load falls upon the shoulder, hence Tower pro MG995 is preferred.

2.3 Robotic Arm Elbow

The Elbow consists of two sg90 servo motors; one is fixed at the bottom, while the other is fixed at the top. The bottom one enables movement of the elbow, while the top one enables rotation of the robotic arm gripper, as the application needs.

2.3 Robotic Arm Gripper

The gripper consists of 2 rotary gear, and one worm (screw) gear. The worm gear is attached to the shaft of a 12v geared dc motor, on forward and reverse running of the motor, the gripper hands made out of mica will close in gripping the object, and on reverse loose free the grip over the object.

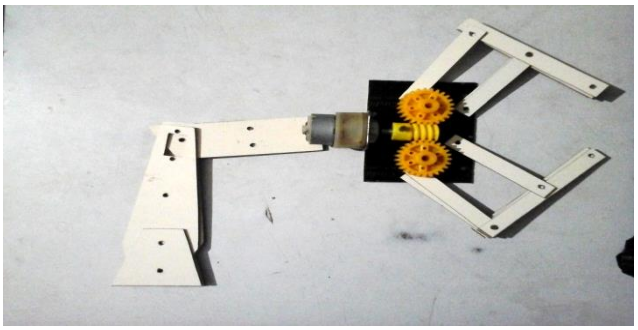

Fig -2: Partial Attachment of robotic arm

3. Mechanical Chassis Design

The Chassis is double layer metal design made of steel metal of thickness 3mm. The bottom of the lower layer consists of screw holes for metal clamps for attaching wheels and motors. The layers are set to have a hollow gap of 7cm in between them, it is in this region all the circuits are placed upon, and it is such that during fire extinguishing operation, the circuitry should not be disturbed or damaged by water drops and to prevent any physical damage that might happen during the operation. Proper holes and cuttings are made on certain spots, for exact and smooth fixing of different components.

Fig -3: Disassembled version of robot chassis

4. Motor Drive System

The motor drive system consists of a motor controller, motor driver and geared drive DC motors and servo motors. Using a motor controller and geared drive motors is a great improvement over modified hobby servo solutions in reliability, speed, noise, and power consumption in terms of vehicle locomotion. This solution is about twice the initial cost of using servos, since a separate motor controller is used. But, the servos are used to produce positional movement of robotic arms, which is essential for identifying the angle of the fire spot from the robot. However, the longevity of geared DC motor over a modified hobby servo is the advantage for robot movement.

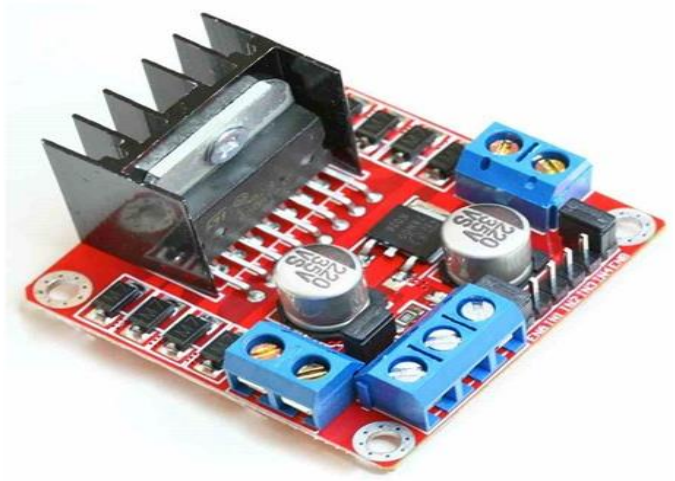

Fig -4: Motor Driver ST L298N (5 Amps Peak)

4.1 Motor Driver

Double H driver module uses ST L298N dual full-bridge driver, an integrated monolithic circuit in a 15- lead Multi watt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

5. Sensors

A Sensor is simply a device that is used to detect or sense certain events and changes that happen in the environment around the sensor. It reads environmental values and provides it as an electrical signal for further processing needed for the project.

5.1 Flame Sensors/Modules

The flame sensor is simply an Infrared Receiver, it reads all values in its range, and provides an analog output. The analog output is fed to the arduino system, such that the arduino uses these values to predict the flame regions.
The secondary version of these Infrared Receivers are the flame sensor module, the module consists of certain circuitry that the module itself detects the flame. Upon detection, it provides a digital HIGH to the arduino microcontroller.

Fig -5: Flame Sensor Module

5.2 Ultrasonic Sensors

An Ultrasonic sensor is used to detect objects (obstacles) in front of it. The sensor sends an audio signal of 40 kHz, commonly called as trigger. This signal traverses through space and on collision with an object, get' s reflected back on to the sensor, commonly called as echo. Determining the time taken for sending and receiving the signal, the distance of the object from the robot can be easily measured. This helps the robot in automatic locomotion, for fire detection.

Fig -6: Ultrasonic Sensor

5.3 Passive Infrared Sensors

These sensors shortly called as PIR sensors, are mainly designed to detect human movements. If a human is supposed to move across the sensor, the PIR detects the human presence, and the digital circuitry within the sensor, produces a digital HIGH, for easy usage of the sensor. The common usage of these sensors is for Burglar alarm. But in our project, we used it to detect immobilized humans during the autonomous operation of the robot. Such that, if a human is detected, proper actions can be considered to save the person because it is tough for a fireman to get in to hot air regions around the fire accident location.

Fig -7: Passive Infrared Sensor

6. Bluetooth Remote Interface

The robot can also be manually controlled using Bluetooth technology. For this, the Bluetooth module HC- 05 is used, due to its good compatibility. The Bluetooth uses short wavelength UHF radio waves in the ISM band from "2.4 to 2.485 GHz" from fixed and mobile devices, and building personal area networks (PANs). The range of this Bluetooth module is 10m (30 feet) maximum. The HC-05 is connected to the in-build Bluetooth of an android device. On pairing the devices, the robot can be fully controlled using a virtual joystick provided by some android applications. Depending on the values sent from the applications, the arduino is coded accordingly.

Below are images of HC-05 Bluetooth Module and the corresponding Bluetooth app.

Fig -8: HC-05 Bluetooth Module

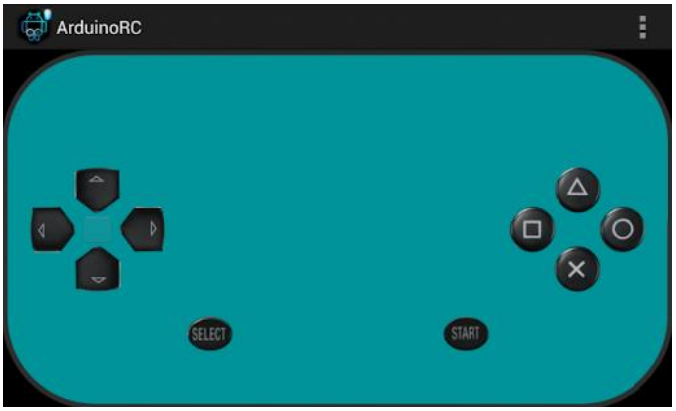

Fig -9: Android Bluetooth Application Sample Image

7. Arduino Mega 2560 R3

The Arduino MEGA 2560 microcontroller was primarily designed for projects and as improved version of Arduino Uno with more input and output terminals, more sketch memory and RAM. With 54 digital I/O pins, 16 analog inputs, a USB port for dumping the sketch, a power jack, an ICSP header and a reset button with more space for storing the code. The Arduino platform helps in projects due to its simplicity in embed C coding language and easy circuit connections using the header pins. The Arduino Mega 2560 is programmed using the Arduino Software (IDE); it also has a serial display to check the operation performed by the arduino

Due to the above specifications, arduino mega was selected out of all arduino microcontroller models. Arduino Mega 2560 serves as a great development platform for 8-bit microcontroller projects. The additional I/O and serial ports and plentiful code space in the Mega provide significant advantages over the Uno or other previous-generation Arduino boards. What is great about the Mega, and the Arduino family as a whole, is the ability to transport your code from one hardware solution to another and even beyond to your own custom PCBs. Once you run out of resources on one of the smaller boards, and with only minimal code changes and a simple board selection in the Arduino IDE, you can be up and running on the Mega with ease.

Fig -10: Arduino Mega 2560 R3 Micro Controller

8. Working of Robot

The Robot uses its multiple sensors all sides of its body, such on detection of fire; it runs an algorithm to identify the nearest fire spot, and moves towards it. Using the flame sensors on the robotic arm, the robot pin points the flame spot, and runs the motor pump to extinguish the flame. The outlet of the pump is fit tightly with a hose, and the other end of the hose is attached to the tip of the Robotic arm gripper. The ultrasonic sensor will help in identifying obstacles in front of the vehicle, and the robot changes direction and pace accordingly, if it's a small obstacle the robotic arm removes the obstacle and continues forward. The robotic arm also helps in clearing the debris during fire accidents thus helping firemen. The entire mechanical design was made strong enough to defend fire intrusions unto the vehicle. Since it is autonomous, it helps in firemen safety. In case of serious real life situations, all parts of the robot can be controlled by using Bluetooth remote interface. A similar image of the motor pump is shown below.

Fig -11: 12v dc Submersible Water Pump

9. CONCLUSIONS

The Multi-purpose Fire Fighter robot helps in clearing the debris of buildings during fire accidents, extinguishing the fire spot with pin point accuracy and allows detection of humans within debris using PIR, and allows easy locomotion in and around the area by its all-terrain vehicle design. The robot not only helps civilians, but also firemen during fire accidents.

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