

Manual and Autonomous Navigation Capable Fire Fighting Robot

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ABSTRACT: extinguishing a fire can be very difficult in areas inaccessible to human beings. These areas may or may not be visible to the fire brigade operators. This engenders a need for a robot that can be controlled wirelessly in case of visible inaccessible areas or can navigate itself autonomously in area blind and inaccessible to the operators. A robot with multiple modes of operation has been developed. The first mode of operation is designed to control the movement wirelessly using a Bluetooth module interfaced with arduino Uno, paired with a smartphone application. The second mode of operation is done by interfacing IR sensors with arduino for obstacle detection and temperature sensing using temperature sensing LM35 IC. A water pump is used as an extinguishing mechanism in both modes of operation. This robot is an effort to facilitate the operation of the fire brigade, by performing the operation of the fire brigade operator in the places of casualty, access to which is challenging to human beings.

KEYWORDS: multiple modes; manual; autonomous; Bluetooth; arduino; obstacle detection.

I. INTRODUCTION

The objective of the project is to show how we can wirelessly control the robot and get information from the sensors, placed on the robot for monitoring the surroundings by the use of Arduino Uno microcontroller. This project includes the use of a Bluetooth module HC05 for wirelessly navigating the robot. This is done with the help of a Smartphone application which is paired with Bluetooth module. The movement of the robot is achieved with the help of chassis wheel base and a LM392D motor driver IC interfaced with the arduino. Temperature sensors LM35 placed on the vehicle unit senses the temperature of the surroundings and the data is transmitted to the computer. The module detects obstacles with the help of an IR sensor that is interfaced with the arduino Uno and placed on the device. With the help of an Android Application Ardudroid, we can navigate the robot with the controls present in the application. The Bluetooth module is paired with the Smartphone and once this happens a screen containing the controls forward, reverse, right and left is obtained. The temperature sensor gives a reading to the computer from a simulated fire such as a candle. This value is used to start the extinguishing process which takes place with the help of a water pump placed on the robot. The robot can also move autonomously with the help of wheels and dc motor.

II. RELATEDWORK

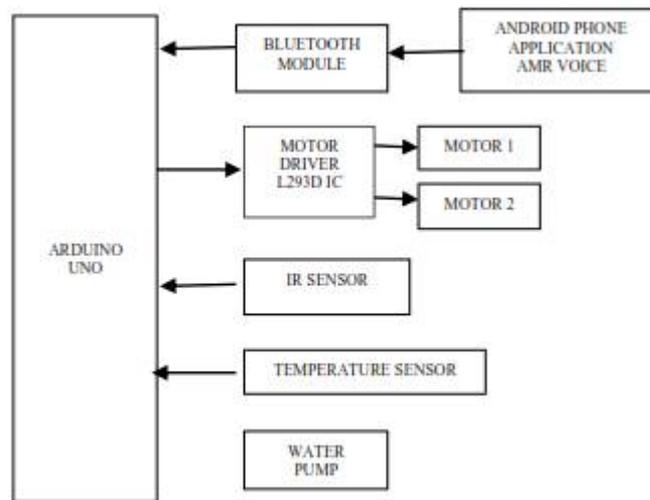
The necessity of fire fighting modules capable of autonomous navigation in areas inaccessible to human fire brigade is fairly palpable. This research paper develops a particular type of fire fighting prototype designed to have multiple modes of operation. Uno.U. Jyostna Sai Prasanna, M.V.D Prasad [1] have designed a fire fighting robot having multiple temperature sensors, sending warning message to the fire brigade personnel with the help of a GSM modem. Rohith Punuganti, Anusha Srinivas, Lakshmi F Savanoor, DivyaShree [2] have designed a fire fighting module that navigates autonomously and sends messages using GSM technology. Ting L. Chien, KuoLan Su, Sheng VenShiau, [3] have designed a system that makes use of obstacle avoidance, fire detection and remote supervision technologies to implement a multisensory fire fighting robot. Scott Dearie, Kevin Fisher, Brian Rajala, Steven Wasson [4] have implemented a autonomous fire fighting robot operated using environmental sensing, proportional motor control based on surroundings and differential drive control. The concepts in these references have aided us in designing and building a fire fighting robot with manual and autonomous navigation capabilities.

III. DETECTION METHODS

Fire extinguishing robot module basically uses two types of detection techniques- obstacle detection and temperature detection.

A. OBSTACLE DETECTION

One of the most widely used obstacle detection techniques is spotting obstacles with the help of Infrared radiation. The infrared radiation obtained from a suitable infrared sensor is transmitted along the direction of motion of the module. The IR radiation, encountering an obstacle is reflected back to the IR sensor module, where it is picked up by the receiver. When the range of the obstacle becomes paramount in the operation of the module, a different kind of sensor called the ultrasonic sensor is used. The high frequency (40 KHz) ultrasonic wave emitted from the sensor travelling at the speed of sound is reflected back to the sensor when an obstacle is detected. Path detection is achieved using the proximity sensors.



B. TEMPERATURE DETECTION

The major technologies used to detect fire in the fire fighting modules are the use of LM35 temperature sensor IC interfaced with a microcontroller and a thermocouple. The LM35 IC produces a high voltage output compared to a thermocouple and obliterates the need for amplification. It produces a voltage output that corresponds to the temperature in degree Celsius. It also draws very less current and has very low self heating capabilities. The thermocouple on the other hand, is made of two metals different in nature and maintained at different temperatures. The emf generated at the junction of the metals is used for temperature sensing and detection.

IV. SYSTEM ARCHITECTURE

The figure depicts the block diagram of the fire extinguishing robot. It uses multiple modules to achieve two modes of operation, manual and automatic. The core of the robot is the widely used microprocessor Arduino Uno, which implements the integrated code using interfacing. The manual mode is implemented using the motor driver IC LM293D, to rotate the wheels by interfacing a couple of pins with the Arduino. The output of which rotates the two DC motors as indicated. The robot is wirelessly controlled using the HC 05 Bluetooth module. This module is paired with a Smartphone application named AMR voice. This application makes use of Google Talk converting voice input to serial data to control the navigation of the robot manually. The automatic mode is achieved using the same motor driver IC and two IR sensors for obstacle detection as shown in the block diagram. The fire is detected using the LM35 IC, temperature sensor IC which gives an output, seeing which the chassis moves forward or backward. The fire extinguishing mechanism is done with the help of a water pump which is placed in the front of the chassis and interfaced with the Arduino.

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V. MODEL BUILDING

A. MANUAL MODE

The manual mode of navigation uses wireless communication to steer the fire fighting module to the area of casualty. It employs a Bluetooth module for this purpose. The Bluetooth module used in this prototype is the HC 05 Bluetooth module. It has an UART interface with a programmable baud rate and a range of 30 meters is recorded in the implantation of the module. Once the transmitter and receiver of the Bluetooth module interfaced with the microcontroller, it is paired with a Smartphone. The android application AMR voice is used for pairing and controlling the module wirelessly. The application uses Google voice feature to convert voice input to serial data. This is used to move the robot in the forward, right and left directions.

B. OBSTACLE DETECTION

The obstacle detection feature is used in the auto mode which is an extension of a manual mode operation. The voice command "auto mode" is used to activate the automatic navigation feature. It employs two IR sensors on the left and right side of the wheel base for obstacle detection. The detection is done by interfacing the sensors with the microcontroller and using the flow of operation described in the following section.

C. TEMPERATURE SENSING

Temperature is detected with the help of the LM35 integrated Circuit. Two temperature sensors are placed on the wheel base. The sensors when in close proximity to the fire record the temperature in the form of voltage proportional to the temperature in degree Celsius. This data is sent back to the microcontroller and the temperature floe depicted in the following section is implemented.

D. FIRE EXTINGUISHING MECHANISM

The mechanism used for extinguishing fire is a water pump connected to a motor driver IC fixed in the front of the wheel base. He motor driver IC controls the action of the motor present in the water pump. This is done in accordance with the automatic or manual mode operation flow. A more comprehensive approach to fire extinguishing would be the use of a fire extinguisher. The fire extinguisher is place in the front of the wheel base and its motion is controlled using a stepper motor.

VI. WORKING METHODS

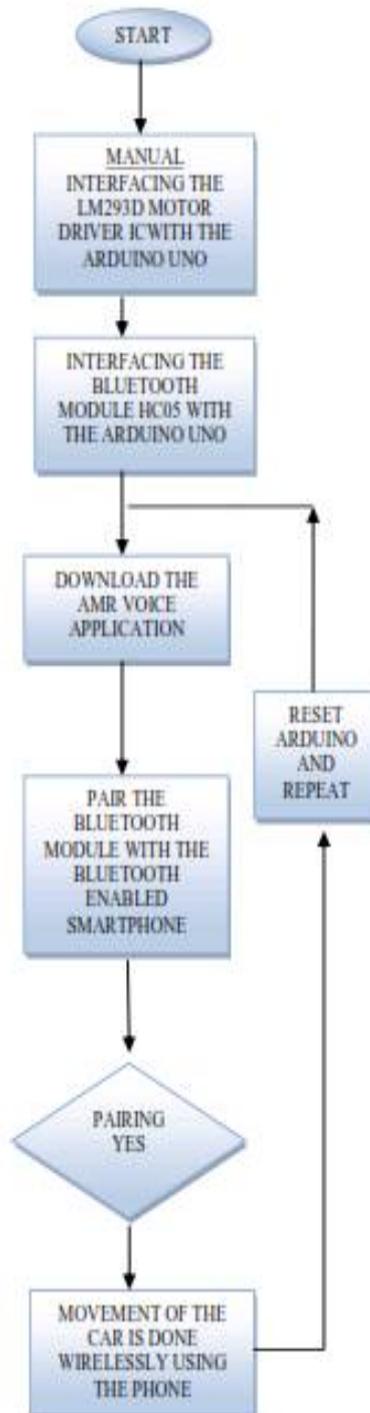
A. OBSTACLE DETECTION- AUTO MODE

Obstacle detection is implemented by allocating the pins for IR sensors and motors and interfacing with the arduino uno. IR1 and IR2 states are initialized to "0". The robot moves forward under this condition. When an obstacle is detected by the second IR sensor, motor "1" stops and the robot moves towards right. Similarly, when an obstacle is detected by the first IR sensor, motor 2 stops and the robot moves towards left. When an obstacle is detected by both the IR sensors the robot stops moving

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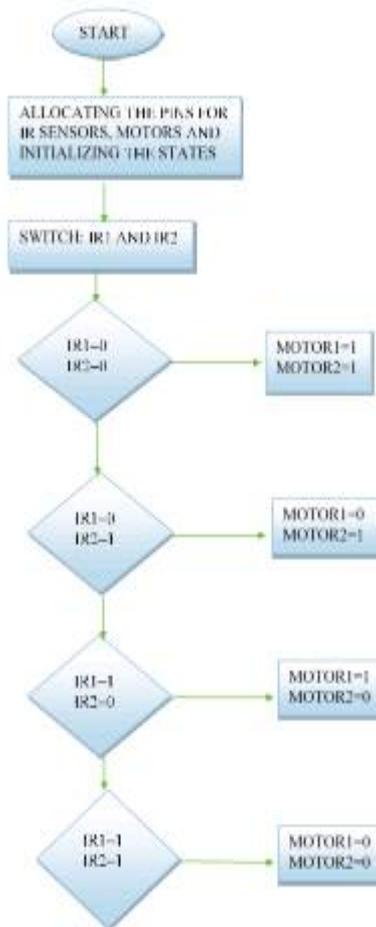


Figure 2: Obstacle flowchart

B. TEMPERATURE SENSING- AUTO MODE

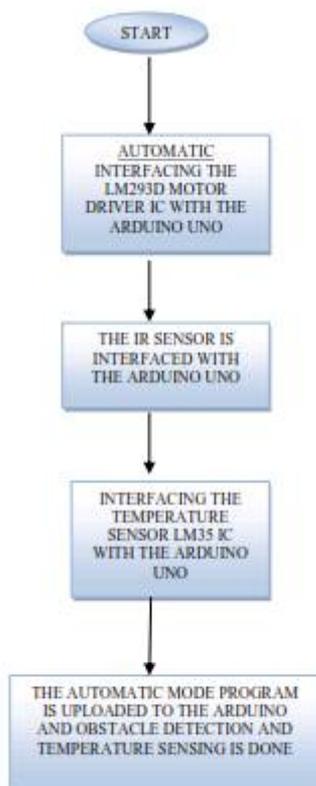
The temperature is detected using LM35 IC. The initial temperature and the temperature while moving is noted. If the change in temperature is by a single digit, then the chassis moves forward.

If the change in temperature is by two digits, then the chassis moves forward. If the temperature change is by three digits, then the chassis stops and deploys the fire extinguishing mechanism.

C. MANUAL MODE IMPLEMENTATION

The flowchart depicts the operation flow of the fire extinguishing robot. There are two modes of operation; Manual mode and Automatic mode. In manual mode of operation, the motor driver LM293D and the Bluetooth module HC50 are interfaced with Arduino Uno. An android application, AMR voice is downloaded from play store which can be used to control the robot manually with the help of voice to serial data conversion. It makes use of the google voice feature for its operation. Then the Bluetooth module is paired with a smart-phone using its MAC address. The car can be controlled wirelessly using the phone. If the pairing is unsuccessful, Arduino is reset and the above step is repeated.

D. AUTOMATIC MODE IMPLEMENTATION



In automatic mode of operation, we use IR sensors to detect obstacles and temperature sensor IC LM35 to detect the temperature. These are interfaced with Arduino Uno and a code is uploaded to the board for automatic movement of the robot. Fire extinguishing is done using a water pump which is interfaced with the Arduino.

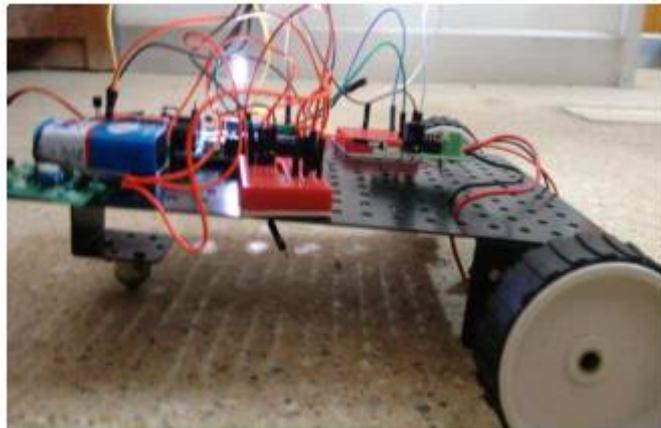


Figure 5:IR sensors placed in the front of the wheel base

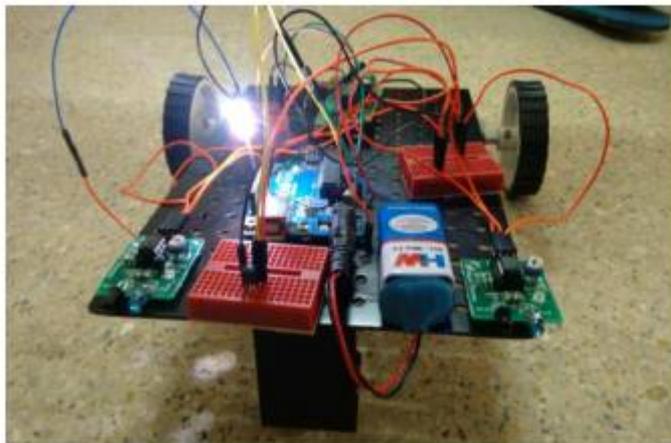


Figure 6: Bluetooth module interfaced the arduino Uno

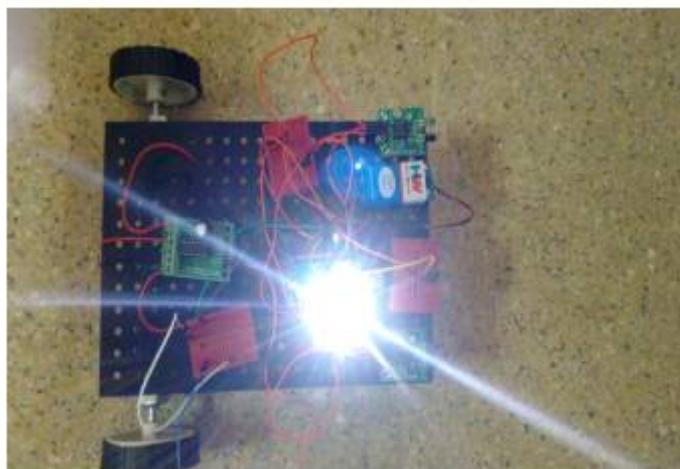


Figure 7: Final implementation

VIII. APPLICATIONS AND FUTURE WORK

This proposed system gives an exposure to design a simple robot that can be used for multiple purposes. With the ubiquity of smart phones today, any phone (whether Android or IOS) with Bluetooth feature can be used to wirelessly navigate the robot. This setup is an idea that can be used in fire fighting and forest fires scenario. In places too small, this vehicle unit can be sent out to find any distress call, by monitoring the video from a remote laptop. With the addition of either an ultrasonic sensor or an infrared sensor, the obstacles can be detected and act as a sign of warning when too close to an object not visible to the line of the camera. If the temperature is very hot in that region, the fire fighters can pin point to that location and signal the operators. Some of the future work of the module can be detecting Gas leakage and intruder detection. Gas sensor detects the presence of bio hazardous gases like LPG, iso-butane, propane, LNG and alcohol, and the PIR sensor detects only the living organism (Intruder). This robot can also be used for navigation on water or air, where the wheels can be replaced by fans with the base placed on a floating material or with the use of brushless DC motors connected to a fan for navigation in air like that of a quad copter.

IX. CONCLUSION

The autonomous navigation capable fire fighting robot successfully manages to do the operation of fire brigade operators efficiently in areas cumbersome to access. It is capable of navigating both on its own and with the help of the voice command of the operators. The fire detection can be done using multiple methods; a simple method is implemented in this prototype. This prototype is perfectly capable of extinguishing fire in a simulated environment. Practical implementation is possible by using enhancements such as GPS and web camera features to this module.

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