Low Cost Bluetooth Controlled Fire Extinguisher Robot Using Light Intensity Sensor

RACHAPUDI S N V M K SAI PAVAN KUMAR, Prof. SURESH NUTHALAPATI
saipavan.rachapudi@yahoo.com sureshnuthalapati@gmail.com

Abstract The Project is designed to develop a Low Cost firefighting Robot using Bluetooth technology for remote operation. Bluetooth HC-05 module is used for this purpose. The robotic vehicle is loaded with water tanker and a pump which is controlled over wireless communication to sprinkle water.

At the transmitting end using push Bluetooth app, commands are sent to the receiver to control the movement of the robot either to move forward, backward and left or right etc. At the receiving end three motors are interfaced to the microcontroller where two of them are used for the movement of the vehicle and the remaining one to sprinkle the water during the fire. A water tank along with water pump is mounted on the robot body and its operation is automatically detected by the photodiode based (Light Intensity) Fire detecting sensor, which is possible by LM393. The whole operation is controlled by an ATMEGA328 series microcontroller. A motor driver IC, L293D is interfaced to the microcontroller through which the controller drives the motors. .

Keywords: Low cost, HC-05, ATMEGA328, LM393, L293D

INTRODUCTION

There are many firefighting robots being constructed nowadays using different types of Microcontroller. However, these are just restricted for prototype purposes. There are several reasons for this, some of them are: due to high cost, lack of effectiveness, due to complex construction, due to lack of detection of fire (which will be explained further in the paper), etc. This project is designed to overcome these drawbacks and created a prototype which will be very close to implement it in real time.

The project is basically composed of two different segments: one is the Bluetooth module interface to move the Robot. The other segment is fire detection and passing the signals from sensor to microcontroller and signals from microcontroller to motor driver IC to start sprinkling the water.

The project construction is mainly done concentrating on the cost. So, the first segment for movement of the Robotic vehicle is done using Bluetooth module which is HC-05. As this is for the case of prototype, in real time implementation we can use Bluetooth range booster, which is cost effective comparative to the computer signals or any other IR signals or RF signal controlling. By using IR signal communication, it has to be in line of sight to obtain the effective communication, which is very much important for this project, as it is implemented in emergency situations, or else leads to the human lives loss along with financial loss. Hence, by considering all these cases, the usage of Bluetooth module is done. The controlling can be done by using any of the devices, here an android mobile is used, and as the availability of Bluetooth controlling apps is handy. Here for the prototype purpose we used an Bluetooth application downloaded from IOP Interoperability Profile. The further explanation is continued in later components of the paper.

The second segment is fire detection and its extinguishing, fire detection can be done using any of the following detectors: 1. Flame Detector 2. Smoke Detector 3. Heat Detector 4. Light Intensity Detector. By considering all the factors like efficient detection, cost, and real time implementation, Light Intensity detector is used in the project. There are disadvantages for every type of detectors, like smoke detector only detects if the smoke flows in the direction of the detector. Similarly there are disadvantages for other types of detectors, comparatively, temperature detector is better than the remaining. Still, considering the cost factor, Light Intensity detector is chosen. Light Intensity detector only needs the line of sight for the fire detection. The detected pulses are passed to the microcontroller, the microcontroller then processes the obtained signals, and make the driver IC to switch on the pump motor to start sprinkling the water. This process continues until there is an existence of line of sight of fire to the detector.

The remainder of the paper is organized as follows: section 2 describes the Bluetooth communication using android application, section 3 describes the hardware usage of both the segments, section 4 describes the software coding in the Microcontroller along with the interfacing of different components, section 5 describes the real time extension of this prototype, and finally, section 6 concludes the paper.

Bluetooth Module HC-05

Bluetooth is a de facto standard and specification for small-form factor, low-cost, short range radio links between mobile PCs, mobile phones and other portable devices. The technology allows users to form wireless connections between various communication devices, in order to transmit real-time voice and data communications. The Bluetooth radio is built into a small microchip and operates in the 2.4Ghz band, a globally available frequency band ensuring communication compatibility worldwide. It uses frequency hopping spread spectrum, which changes its signal 1600 times per second which helps to avoid

interception by unauthorized parties. In addition software controls and identity coding built into each microchip ensure that only those units preset by their owners can communicate.

The specification has two power levels defined; a lower power level that covers the shorter personal area within a room, and a higher power level that can cover a medium range, such as within a home. It supports both point-to-point and point-to-multipoint connections and provides up to 720 Kbps data transfer within a range of 10 meters (up to 100 meters with a power boost). The technology uses omni directional radio waves that can transmit through walls and other non-metal barriers. If there is interference from other devices, the transmission speed decreases but does not stop.

With the current specification, up to seven slave devices can be set to communicate with a master radio in one device. This connection of devices (slaves and master) is called a piconet. Several piconets can be linked together to form scatternets which allow communication between other device configurations.

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH(Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. Hope it will simplify your overall design/development cycle.

Some of the software features regarding the HC-05 module is Default Baud rate: 38400, Data bits:8, Stop bit:1,Parity:No parity, Data control: has. Supported baud rate: 9600,19200,38400,57600,115200,230400,460800.
Few more features can be obtained from the datasheet, because discussing regarding those is beyond this paper.

The signals from the android application are passed to the HC-05 parallely, where this module receives and processes it serially, and passed it to the microcontroller accordingly.

The android application downloaded and can be edited the options in it from IOP, along with the background picture in the application. A sample edited application is as shown,

Here, different control options like forward, left, right, backward and stop are assigned from different number keys available in IOP application by default. We can connect any Bluetooth device which is compatible, The flow of control signals and its operation upon the hardware is given in the following section.

HARDWARE OVERVIEW

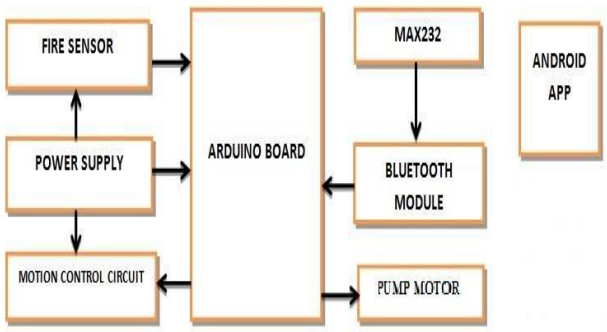
As mentioned earlier, the signals from both the segments are controlled and evaluated by Microcontroller. The signals from Bluetooth Module HC-05 are passed to ATMEGA. As the Arduino board is integrated by Bluetooth Module and also with MAX232 by default, the separate interfacing is not required. Hence, the signals from the HC-05 are directly taken and processed according to the code. The output signals from the Arduino board are passed to the Motor driver IC, L293D.Here we are using DC motors for the movement of the Robotic Vehicle. The alternative is the using of relays, However, We should use one relay for each movement, i.e. for the forward movement of each wheel, we need one relay, and similarly for the backward movement, we need one more relay. Which concludes the need of 4 relays for two wheels. Here we are using Caster wheel in front for the prototype purpose.

The interfacing between the DC motors and the arduino board is done by using L293D motor driver IC. The DC motors need 9V power supply, whereas the output from L293D Motor Driver IC is only 5V.Here, as the signal from the Arduino board is given to the Motor Driver to move forward, then the Motor Driver IC bisects the 9V power supply from the DC power supply to the DC Motors and make them given availability of power supply of 9V for the forward movement. Here, each motor will be composed of two inputs, so we can consider that a total of 4 motor control outputs has to be passed out from the L293D IC.

The second segment is about fire detection and its extinguishing. Here the hardware usage is similar to that of first segment. According to the process, First the sensor, detects the existence of fire by the light intensity factor. The core part of the project is this usage of LM393 IC as photodiode. Which in turn has more advantages than the remaining type of Sensors for the detection of light sensors. One of them is the cost factor and also the effectiveness in the detection, as it just needs the view of the fire, rather than

smoke towards the sensor, or heating up the surroundings of the sensor which in turn takes a lot more time than the present sensor. Which makes the equipment to start fighting against the fire far before than the alternatives.

As the fire detected and then the signals from the sensor are passed to the Arduino board. Where, the ATMEGA makes decision and drives the Motor Driver IC to bisect the 9V voltage to the Pump Motor, and for which the water tank or the foam is attached. The process is similar to the first segment, except the receiving input is from the sensor and the output is driven to the Pump Motor. The block diagram can be shown as below:



ATMEGA328P description is as follows: Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller.
In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- LED: 13. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analogReference().
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Communication

Arduino/Genuino Uno has a number of facilities for communicating with a computer, another Arduino/Genuino board, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). The Arduino Software (IDE) includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows serial communication on any of the Uno's digital pins.
The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino Software (IDE) includes a Wire library to simplify use of the I2C bus.

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino/Genuino Uno board is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino Software (IDE) uses this capability to allow you to upload code by simply pressing the upload button in the interface toolbar. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.
This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data

when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.
The Uno board contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line.

SOFTWARE OVERVIEW

The Software work is about coding the Arduino according to the requirements and also the interfacing of different modules available. The code can be written using convenient language. The different variables assumed are for Bluetooth Module, Fire Sensor, and output for the Motor Driver IC boards, from which a total of 4 outputs from one L293D, and 1 output from the other, which is for Pump Motor. The code can be written according to the need, for forward movement, the positive terminals of both the DC motors can be given High voltage,i.e.9V, and Low Voltage to the negative terminals. And vice versa for the Backward Movement. For Right and Left Movement. Alternative terminals for both the DC Motors has to be given high and others as Low. For Stop signal received from the Bluetooth Module, the Power supply to the Motors is stopped. For Pump Motor, as it is only one output, when there is a detection of Fire from the LM393 sensor is happened, then the Pump Motor is given High Power, and when the detection signal from the Senor is stopped, the power supply to the Pump Motor is also stopped.

REALTIME IMPLEMENTATION

The major asset of this project idea is, the real time implementation is more feasible. The communication to the Robotic vehicle is done used Bluetooth for which range is below 100m, For the real time implementation, its range can be increased by using Bluetooth range booster. By which its signals can be error free and secured. The cost of this firefighting robot is also comparatively very less than the other types, which can be easily affordable by a common man. As the operation of this Robot is by using the android application, which is not a complex mechanism to understand. The operation as mentioned earlier is only for the controlling the movement of the Robotic vehicle, not needed for the operation of water or extinguishing material, to switch on or off, which is taken control automatically, which is an advantageous for the implementation in real time. As a normal person can operate, no need for pre operation training, etc. This project construction is done for the implementation as an emergency kit, rather than mostly concentrating as a fire department equipment. It can be used even as such, however only after slight changes in the project. The changes may include the controlling the direction of the pump motor, As the operation is in hands of a fire department expert, then there is no need of automatic fire detecting, using the sensor. For which the total implementation of this project changes. Hence, further discussion regarding this can be considered as beyond the scope of this document.

CONCLUSION

This project can be further extended in many other ways, one of the possible way is by including the camera, which helps in recording the circumstances during the fire accident and the live video of the places can be viewed lively on the phone, through which we are controlling the vehicle. By this there are too many advantages, some of them are: Viewing of the places where human entrance is not possible. As, the live video can be seen through phone lively, the operator can move the vehicle carefully towards the places where still fire is existing, there can be no wastage of the extinguishing material, as the extinguishing material will be sprinkled only when there is existence of the fire.
This project can be further extended by including many other sensors, like Gas sensor, through which the existence of the gas leakage can be notified as an notification to the mobile phone, through which we can avoid the occurrence of the fire accident. By implementing in such a way, this project can be used as emergency avoidance and clearance.
Hence, we can conclude this document by noting the usage as follows: this project can be used as an emergency kit, where there is no need to wait for the arrival of the fire department, or an expert to start using the fire extinguishers to clear the fire. As the cost of the implementation of this project is also very less, this can be utilized in all the offices, households, every public places. Comparing to the present implemented fire detectors like smoke detectors, flame detectors, gas leakage detectors, etc. and the extinguishing equipment, this project, consisting of both the detecting and the fighting against the accident is very cost effective and operating is very easy compared to the existing equipment.

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