Autonomous Fire Extinguisher Robot

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Autonomous Fire Extinguisher Robot

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***Abstract*— Fire hazard is a very common phenomenon in developing countries like Bangladesh which causes huge loss of lives and properties every year. Lack of detecting fire hazard in initial stage, delay in sending information to fire service authority and failure of taking primary initiative to extinguish or prevent spreading of fire increases the loss. This paper is concerned with developing of a microcontroller based autonomous fire extinguisher robot which is able to detect a fire hazard automatically when it occurs, sends information to fire service authority instantly and takes initiative to extinguish the fire. Three different sensors are used to detect the fire hazard. Microcontroller takes data from sensors and makes a decision of fire hazard analyzing the data. After a decision of fire hazard it used Bluetooth module as a serial data communication to alert trusted authority by sending SMS to multiple cell phone. At the same time, it runs to search the fire following a black track in the floor and throw water to extinguish the fire by activating a water pump when it gets a flame.**

Keywords*— *Microcontroller, Fire Extinguisher Robot, Bluetooth module, Line follower robocar.

I. INTRODUCTION

Fire safety has become a major issue in Bangladesh in the recent few years and is raising critical concerns. It is also a buzzing word in Bangladeshi garment factories. According to the analysis of Fire Risk Index (FRI) in Bangladesh, it was found that the mean FRI are 2.8 on a scale of 5.0 for the fire hazard condition, which indicates an extremely alarming condition [1]. Every year we are losing our important life and property. The use of modern technology in fire safety can reduce the enormous loss of fire hazard. That's why researchers are motivated to develop more reliable and intelligent fire detection and fire extinguisher system. A lot of researches have already been done to minimize the fire hazard as well to reduce the demolition in fire hazard [2]-[4].

In this paper, our objective is to build an autonomous fire extinguisher robot which can detect fire hazard automatically, inform about the hazard to the nearby fire service authority and takes initiative to stop the spreading of fire. Fire hazard is detected by sensing three parameters: temperature, smoke and flame. Three different sensors are used to measure these parameters. If temperature or smoke increases above a critical value the robot decides the event as a fire hazard. In this case, robot starts running through a predefined path to search fire by flame sensor. When flame sensor detects a flame, robot start throwing water, foam, gas, or other materials used extinguish a fire.

II. SYSTEM OVERVIEW

The block diagram of the system is shown in "Fig. 1". Microcontroller takes data from IR receiver transmitter to detect the track and drives two DC motors to follow the track. Temperature, smoke and flame sensor are used to detect fire hazard. Pump is used to spray water or any other chemical components to extinguish fire. Bluetooth module sends data to fire service through an android device and buzzer gives alarm to conscious the people about fire.

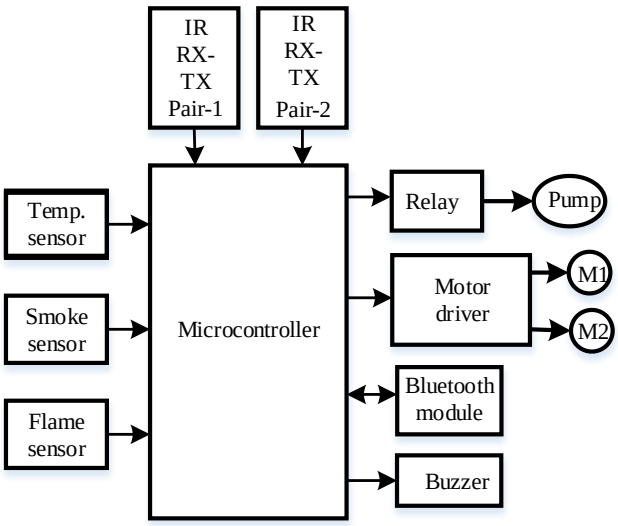

Fig. 1. System Block Diagram

III. METHODOLOGY

This section describes the methodology of developing the system. The development process includes data acquisition from different sensors, line following mechanism, sending data via Bluetooth, driving pump and finally the complete circuit diagram of the system.

A. Data Acquisition from sensors

The output data of all the three sensors are analog. As microprocessor cannot work with analog data, so they should be converted into digital by an analog to digital (A/D) converter. The microcontroller used in this project has inbuilt A/D converter of 10-bit resolution [5]. There are six analog channels in this microcontroller i.e. 6 analog data can be multiplexed to the A/D converter input line through a multiplexer. "Fig. 2" shows the acquisition of analog data from sensors by A/D converter. The temperature sensor is

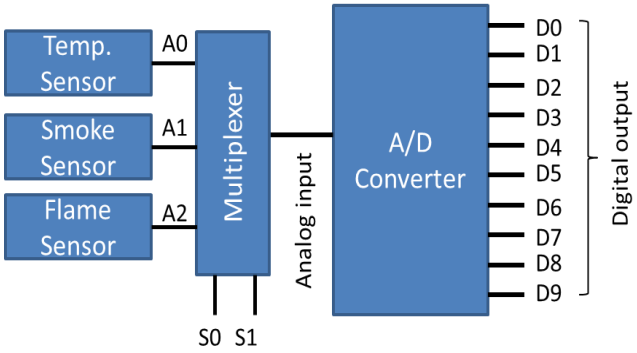

Fig. 2. Data acquisition from sensors.

connected with channel A0, smoke sensor with channel A1 and flame sensor with channel A2. All the analog data are converted into 10-bit digital data.

B. Line following mechanism

The robot follows a predefined path in the floor to search the fire. The path is a black line in white surface. The robot can trace the path by IR sensor pair as shown in "Fig. 3" and "Fig. 4". In "Fig. 3", it is shown that the IR transmitter (IR-Tx) sends IR which is absorbed in the black surface. So, IR receiver (IR-Rx) don't get any IR and it act as an open circuit i.e. no currents flow from node A to B. Normally the voltage at node A is 4V. Node B is pulled LOW through R3 resistor, so the voltage at node B is 0V. Node B is connected to the non-inverting terminal of comparator LM741 and the voltage at inverting terminal is adjusted to 2.5 by variable resistor R5. In this case, as the voltage of non-inverting terminal is less than the voltage at inverting terminal so output of comparator is LOW.

In "Fig. 3", the IR transmitter (IR-Tx) sends IR which is reflected in a white surface towards IR receiver (IR-Rx). When IR falls on IR receiver, it allows current to flow from node A to node B. As a result, voltage of node B rises to 3.01 V approximately. In this case, voltage of inverting terminal is less than the voltage of non-inverting terminal, so the output of comparator is HIGH. By this way, the robot can determine whether the IR sensor pairs are in black surface or not.

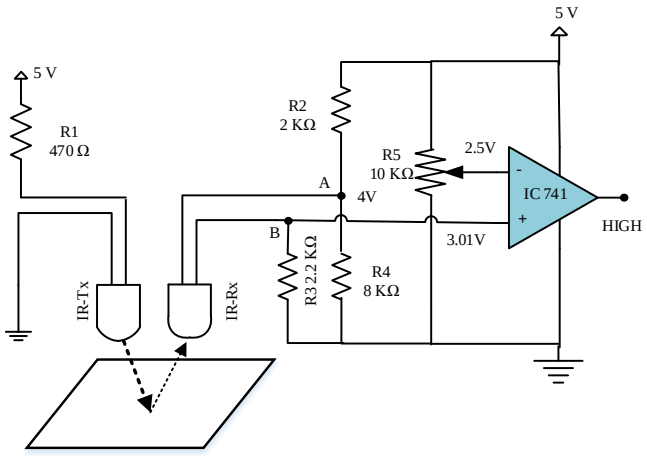

Fig. 3. Output of comparator is HIGH when IR gets white surface.

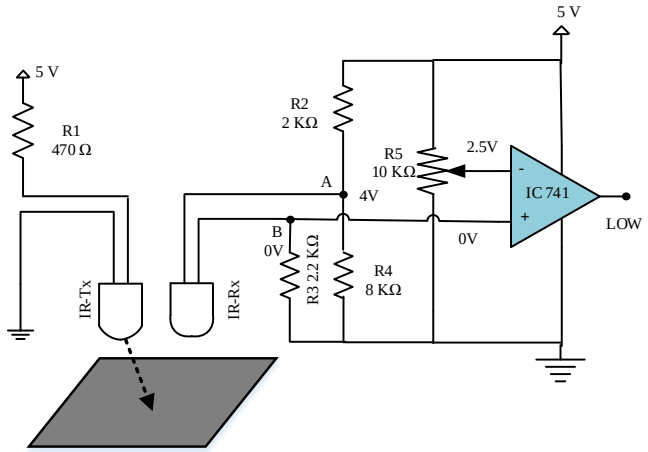

Fig. 4. Output of comparator is LOW when IR gets Black surface.

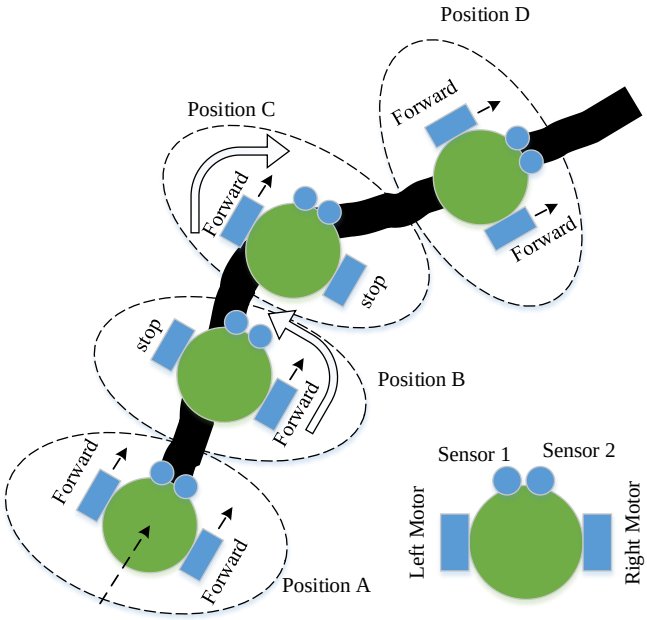

Fig. 5. Line following algorithm.

"Fig. 5", shows the line following algorithm of a line follower robot. At position A, both the sensors are in black surface. So, left motor and right motor should rotate forward to run the robot in forward direction. At position B, Sensor 1 is in black surface but sensor 2 in white surface. So, left motor remains stop and right motor rotates in forward direction to turn the robot in left direction for restoring the track. Similarly, in position C the robot turns right to reestablish its track.

C. Controlling DC motor

The microcontroller used here takes data from IR sensor pair and controls the two DC motors accordingly. Because of the internal structure of microcontrollers, the I/O pins of microcontroller cannot supply enough current and voltage (i.e. Power) needed to run a motor directly. Therefore, an external driver circuit is required to deliver the electrical power to a motor under the control of the microcontroller. Such a driver circuit can be as simple as a single transistor or as complicated

as an integrated chip with some additional components attached [6]. Here, two H-bridge motor driver circuits are used to deliver electrical power to the motors under the control of microcontroller. It is L293D, called Dual H-bridge Motor Driver integrated circuit (IC) which is embedded by two H-bridge motor driver circuit as shown in "Fig. 6".

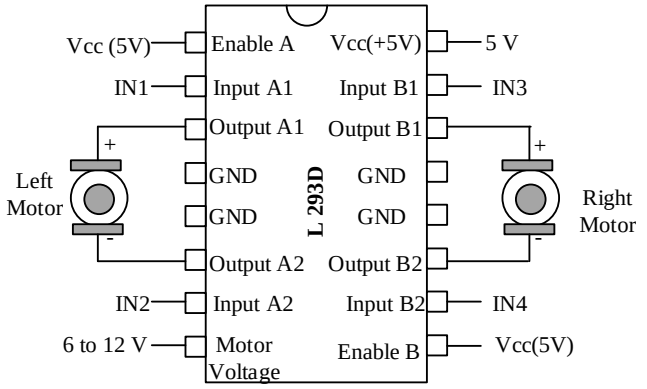

Fig. 6. Dual H-bridge motor driver IC.

D. Sending data via Bluetooth

Bluetooth module is connected using UART serial communication interface with the microcontroller. UART stands for Universal Asynchronous Receiver Transmitter. This sort of communication is asynchronous, which means that a special line for transferring clock signal is not used [7]. Here, the baud rate is set at 9600 bps. The microcontroller sends data to an android cell phone via Bluetooth. The cell phone then sends SMS to some authorized phone number using BlueAct mobile application.

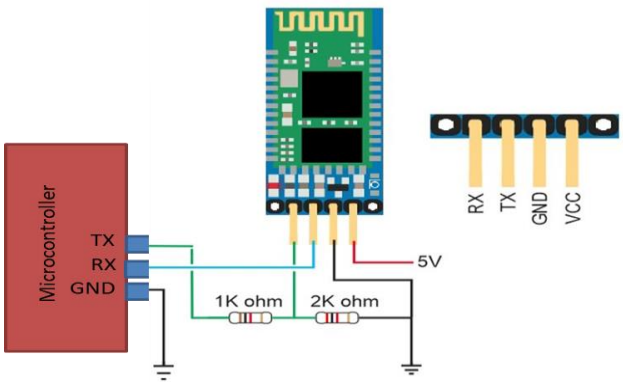

Fig. 7. Interfacing Bluetooth module with microcontroller.

E. Interfacing Servo Motor

The servo motor is used to achieve precise angular positioning of water nozzle. A servo motor has three terminals: Vcc, GND and control signal [8]. The control signal is a pulse width modulated (PWM) wave of frequency 50Hz i.e. time period of the PWM wave is 20 ms. By changing the width of PWM we can change the angular position of the servo shaft. A pulse of 1 to 1.5 ms turns the servo in clockwise (CW) direction, pulses between 1.5 ms to 2.0 ms makes it to turn counterclockwise (CCW) and a pulse of 1.5 ms turns the servo to its center as shown in "Fig.8".

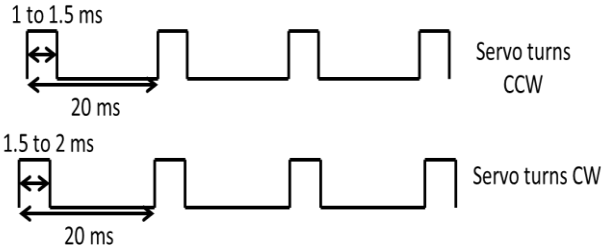

Fig. 8. PWM signal provided to servo motor.

F. Complete Circuit Diagram

The complete circuit diagram of the system is shown in "Fig. 9". An 8-bit microcontroller Atmega328P is used in this project. The IR sensor pairs are connected with first two I/O pins of PORTB (pin number: 14 and 15). Three analog channels ADC0, ADC1 and ADC2 are used to get data from temperature, smoke and flame sensor. Bluetooth module shares data with microcontroller by TX and Rx pins. Two DC motors are interfaced with microcontroller through L293D. Pins 4 and 6 (PD2 and PD4) controls 1st DC motor and pins 6 and 11 (PD4 and PD5) controls the 2nd DC motor. The servo motor which adjusts the angular position of water nozzle is connected with pin 12. The switching operation of pump is controlled by pin 13.

IV. Programming and Implementation

This section represents the programming algorithm and practical implementation of our system.

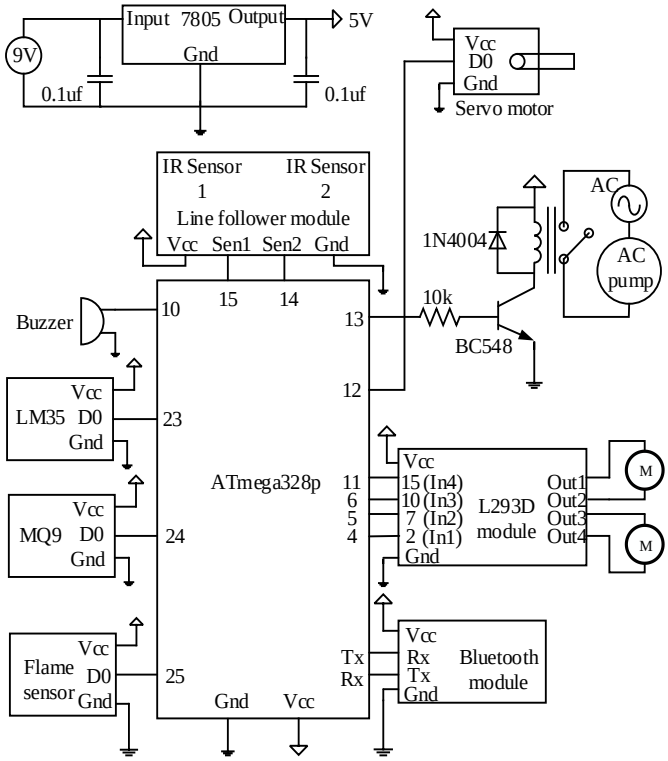

Fig. 9. Complete circuit diagram of the system.

A. *Program Algorithm*

Microcontroller takes data from temperature, smoke and flame sensors and converts them from analog to digital. The length of digital data is 10-bit wide i.e. the converted parameters may vary from 0 to 1023. If temperature is greater than 65degree Celsius and the digital data from smoke sensor is greater than 250, microprocessor identifies this case as fire hazard. Microcontroller sends signal to an android cell phone via Bluetooth which further sends SMS to others. Also robot starts running to search flame. If the digital value obtained from flame sensors falls lower than 60, robot stop running and pump starts to spray water positing the nozzle by servo motor. The sequence repeated continuously as shown in "Fig. 10".

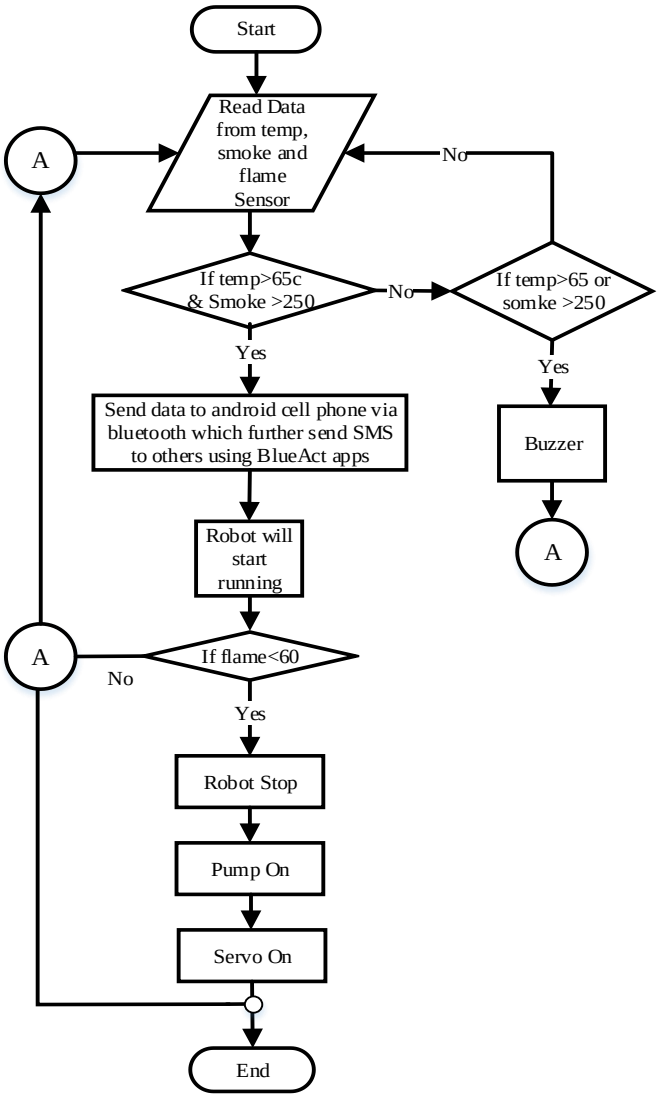

Fig. 10. Program algorithm.

B. *Implementation*

A prototype of the system is implemented as shown in "Fig. 11". The system is tested to detect and extinguish fire of a candle.

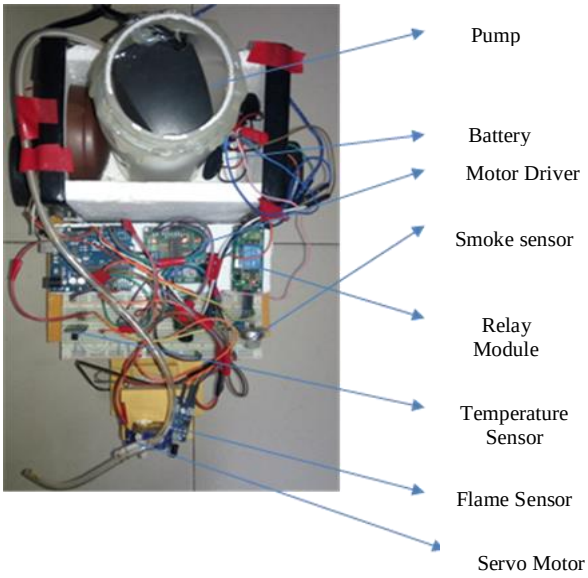

Fig. 11. Implemented prototype.

V. CONCLUSION

Since this robot is built as a prototype it has various limitations. More research should do to improve the current robot. In the present condition it can extinguish fire only in the room where it is placed but that can be solved by placing sensors in different rooms which will alert the robot as soon as it detects fire. The robot will then go there to extinguish the flame. The water carrier can also be replaced by more efficient fire Extinguisher.

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