A Data Collecting Robot to Assist Firefighters

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***Abstract*— This paper proposes the usage of an innovative and yet simple robot to tackle fire incidents that has become a recurrent disaster in rapidly urbanizing cities such as Dhaka. The robot, which is to be controlled via a Bluetooth module, will be equipped with three sensors- the flame sensor, smoke sensor and temperature and humidity sensor- to detect the danger level of the fire and provide the necessary data required for firefighters to be properly equipped before they enter a burning building and thus avoid further injury. The robot does this by sending data that it gets from the sensors to a remote desktop monitor via Wi-Fi. As a result, the robot will help bridge the information gap between the time residents go out and the time the firefighters reach the scene.**

Keywords-Fire; Sensors; Remote Desktop; Bluetooth Car

I. INTRODUCTION

Whether it is man-made or natural, a fire can have disastrous effects including loss of property, fatal injuries and even death. An increase in rapid urbanization leads to an increase in fire incidents [5].With an annual growth rate of 3.262% of the urban population according to the UN [7], the need for fast and effective disaster management grows more in Dhaka. Yet, when it comes to managing fire incidents, the services are limited and any solutions proposed are far too expensive for a developing country like Bangladesh. According to Tishi [2015] [6], about 36% of the fire incidents that occur happens in residential areas in Dhaka, thus affecting residential buildings. Poor urban planning means that the buildings are far too close to each other [8], and so the fire has potential to spread really fast. Where lives are at stake, inhabitants often do not have the necessary resources to help out even if they want to and so are left helpless until the fire service arrives [9,10].

Several models have been proposed in the past to detect fire [1,2], extinguish fire[1,4] and also provide a safe evacuation route[3,4]. However, most of these models are for complicated fire situations and thus are costly models that can only be used commercially. For example, the robot presented in [1] consists of a fully autonomous operation, but also can be controlled via remote control. Both models in [1] and [2] use temperature and gas sensors, while [2] also uses smoke and CO sensors. [2] has a fuzzy logic system to calculate the probability of a fire using the readings from the sensor, which it can store in an Android application. However, [1] also has features that are not quite necessary, such as line following. Other works such as [3] and [4] both deal with situations that require attention after there is a fire. In [3] a RC servo motor and a camera is used to detect people in the fire site and lead them to the emergency exit. Sensors are also used to detect Carbon monoxide, Oxygen and smoke. In [4], an algorithm was used to cancel out noisy signals into the antennas from the surrounding obstacles like walls, etc. Multiple autonomous robots are used to extinguish fire, with a leader robot which the rest of the robots will follow into the building where a network switch is used to let the robots communicate. The follower robots were consisted of P3AT mobile robot, Wi-Fi connection, an onboard laptop and a servo device. On the other hand, the leader's transmitter included an omnidirectional antenna and a wireless access point, Ubiquiti Networks PicoStation M2-HP. The equipment on board were enough for medium-range communication distance. The whole purpose of [4] is to replace humans by using more mobile robots in a disaster scene. However, achieving accurate communication links among the robots with the use of antennas remains a challenge.

The main purpose of our proposed model is to collect necessary data before the firefighters enter the scene, thus allowing bystanders to help. Keeping the need for fast and affordable solutions during fire incidents in mind, the proposed model provides a relatively cheap alternative using elementary components that can be used by those who are not technologically adept. Quite often the inability to use all resources around, and not being able to properly tackle fire at an initial stage is what turns a fire into a deadly one. The proposed model will allow the fire service to be better prepared with the necessary equipment before going in, while simultaneously allowing firefighters to reduce the risk of their injury. The model can also be used to monitor one's house for fire even when one is away from their homes. The design is also neatly categorized into two units to allow assembling and detecting hardware malfunction more easily, thus making this easier to use.

The rest of the paper is organized as follows: Section II explains our proposed model, while Section III describes the details of the design and implementation of the model. Finally, Section IV provides a conclusion of the paper.

II. Proposed Model

The block diagrams in Fig.1 and Fig.2 shows a simplified version of the two separate units that make up our model. The robot uses three sensors to give an idea of the level of danger. The sensors are DHT11 Humidity Temperature Sensor, 1-Channel Flame Sensor Module and MQ-2 Smoke/LPG/CO Gas Sensor. The DHT11 Humidity Temperature Sensor measures the relative humidity and also contains an NTC temperature measurement component to measure the temperature. Relative humidity is the amount of water vapor in air compared to the saturation point. 1-Channel Flame Sensor Module is used to detect the flame and radiation. The MQ-2 Smoke/LPG/CO Gas Sensor can figure out if gases such as LPG, i-butane, propane, methane, alcohol, hydrogen and smoke are present. Together, they can give a decent estimation of what the conditions are. Not only does using three types of sensors makes it more reliable, but the process of detecting fire is also much faster than using just one type of sensor. The data is then sent to the Arduino board so that the data can be transferred to the Raspberry Pi so that it can be sent to the Remote Desktop from which people can see it. The Raspberry Pi of this unit is also connected to a Raspberry Pi Camera so that it can show the live feed in the remote desktop.

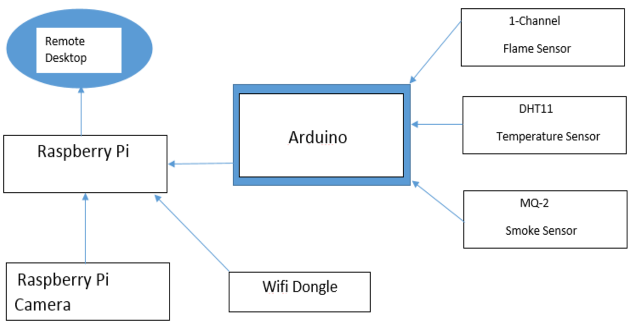

Figure 1. Sensor Input and Display

The other unit consists of the working of the car which will carry the sensors. The car is driven by a motor driver which is connected to another Arduino. It acts as an interface between the DC geared motors and the Arduino board. An android application is used to control the car. This is possible due to the Bluetooth module that is connected to the Arduino. Fig.2 consists the working of the car.

As a result, one would be able to see the disaster scene from a safe spot due to the Pi camera and with the Bluetooth connection they would be able to control the motion of the robot-car. The robot will contain the sensors that will get readings from the disaster scene and it would send the data to the remote desktop, thus allowing people to get a better idea of the situation in the disaster scene.

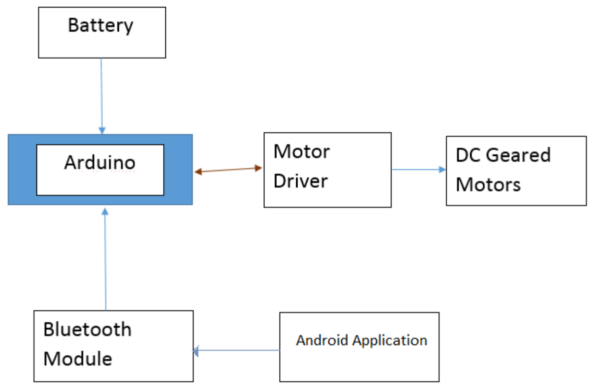

Figure 2. Block Diagram of RC Car

III. Design and Implementation

A. *Making RC-controlled Car*

The Arduino Uno R3 is used to build the prototype, specifically because it is easy to work with. An AtMega 328p micro-controller is used in Arduino UNO R3. The HC-05 bluetooth module wirelessly connects the Android application to the Arduino and receives instructions from the application through its RX pin and transmits the data to the Arduino via its TX pin. The RX pin of the HC-05 bluetooth module is connected to the TX of the Arduino while the TX of the Bluetooth module is connected to the RX of the Arduino. This is done by defining the pins in the Arduino code. The L298N Motor driver is used to create an interface with the DC geared motors on the robotic chassis and the Arduino Uno, thus letting us control the direction in which the wheels will move. When the Arduino receives instructions from the Bluetooth module, it sends the required instructions to the L298N motor driver, which then causes the DC-geared motors to move accordingly. The motor driver consists of 4 input pins and 4 output pins in order to control the 2 DC geared motors attached to the robotic chassis. Module output 1 connect to the DC motor A, while Module output 2 connects to the DC motor B. Module IN1, IN2, IN3 and IN4 of the motor driver connects to the Arduino's 7,6,8 and 9 Digital I/O pins, respectively. Fig.3. shows the connections involved.

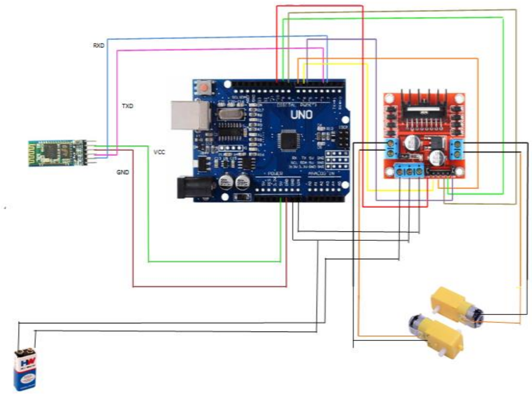

Figure 3. Circuit Diagram of Android Controlled Car

B. Getting live feed

A Raspberry Pi Camera is attached to the robot to get the live feed from the disaster scene. The Raspberry Pi camera (5MP) is first connected to the Raspberry Pi and the terminal in the Raspbian OS is then coded to show the live feed. This makes navigating the car easier but it also allows people to see exactly where the fire is and how intense it is.

C. Using Sensors to provide data regarding fire

Since Arduino Uno works well with a wide range of sensors, we used a separate Arduino board to which the three sensors were connected. For fast results, we used the sensors 1-Channel Flame Sensor Module, MQ-2 Smoke/LPG/CO Gas Sensor and DHT11 Humidity Temperature Sensor. The flame sensor can detect wavelengths of 760nm-1100nm from as far as 20 m, thus making it ideal for our project. The gas sensor module uses a LM393 chip and ZYMQ-2 gas sensor to detect smoke levels. The module is very sensitive and long lasting, two features that are very much required for the purpose of our project. The DHT11 Temperature and Humidity sensor can detect temperatures from 0-60 degree Celsius, and relative humidity of 20 to 90% RH. Each of the sensors is connected to the Arduino. The smoke sensor is connected to pin A1, the flame sensor to A3, and the temperature and humidity sensor to A0, of the Arduino's digital I/O pins. The details of the connection are given in Fig-04.

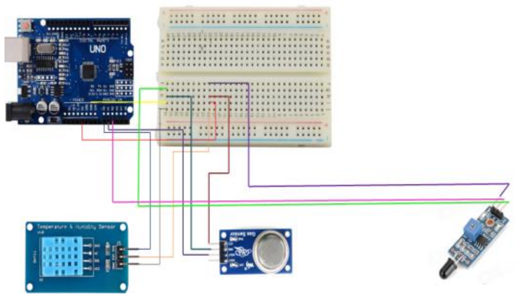

Figure 4. Circuit Diagram of Arduino and Sensors

D. Sending Data to Remote Desktop

Since the sensors are connected to the Arduino board, the first task was to transmit the data from the Arduino to the Raspberry Pi. This is done over a USB cable using python code in the terminal. The Raspberry Pi needs to be powered separately using a power bank, while a 9V battery is added to the Arduino to power the Arduino and the sensors. To allow the data to be seen in a Remote desktop, internet is needed, whether it is Wi-Fi or Ethernet. However, in our project we are using the Wi-Fi connection. First, the terminal emulator puTTy is used to enable the SSH. The remote desktop is then downloaded in Windows, and then tightvncserver and xrdp are installed in raspberry pi, which are remote desktop clients. Finally, this will allow us to see the data from the sensors into the remote desktop. The reason for using Remote desktop is that it would allow us to see the data anywhere provided we have prior connection set up. Further uses of this feature can be to directly even send it to the fire-station or use it for monitoring the house when away from home. Moreover, the project may be extended to using an IoT platform to display the sensor readings.

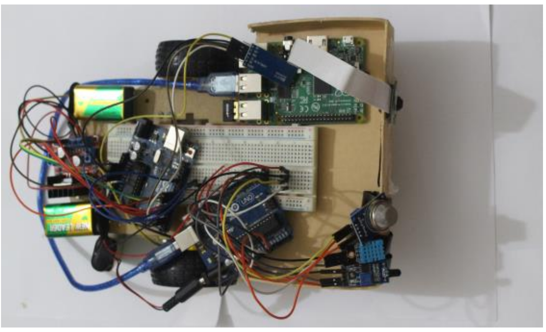

Figure 5. Final Design of Firefighting Assisting robot

IV. CONCLUSION

This paper presents a model of a robot that allows constant monitoring of fire situations. While the RC controlled car allows mobility, the three sensors-flame sensor, smoke sensor, and temperature and humidity sensor- provides a reliable fast method to monitor the situation. The data which is sent to a remote desktop via Wi-Fi helps the firefighters analyze the situation and prepare accordingly. Our prototype will have a fibreglass covering to protect the sensors and also to allow the robot to withstand high temperature. The sensors can pick up data in real time and can immediately send it to the remote desktop. This means that in terms of speed, our model does quite well.

Using caterpillar track instead of wheels would allow the model to move vertically across floors along stairs. Using Raspberry Pi NoIR camera will allow the model to work at night and even if there is too much smoke. However, the gas sensor can only detect upto 20000 ppm methane. These limitations mean that the most important improvement would be to include sensors of higher accuracy and larger range into the model so that the results are more reliable.

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