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Robotic Fire Extinguishing Vehicle with Rocker Bogie Suspension System

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Abstract*: *Fire safety is the set of practices intended to reduce the destruction caused by fire. Fire safety measures include those that are intended to prevent ignition of an uncontrolled fire and those that are used to limit the development and effects of a fire after it starts. The robotic fire extinguishing vehicle can be used as a vehicle which can extinguish the fire in a fire hazard zone. The advantage of using this vehicle is that it didn't need the direct presence of the fireman at the fire zone. Instead, this vehicle can be controlled by a user with the help of a laptop. These vehicles can be classified under AGV as the vehicle movements are purely automatic. The rocker-bogie suspension we are using is an another positive factor as this will help the vehicle to move easily over the obstructions in their path. The vehicle can be contained with sensors which help them in detecting the intensity of temperature in the zone and also the PIR sensors used will help them to detect the human presence inside the zone. Special cameras used will help them in having a view of the surroundings through which they move.

Keywords*: *Fire safety, Robotic, Rocker-Bogie Suspension, Ardunio, Extinguishing vehicle, Zigbee.

I. INTRODUCTION

Firefighting is the act of extinguishing fires. A firefighter suppresses and extinguishes fires to protect lives and to prevent the destruction of property and of the environment. In most of the cases when fire hazard occurs, the fireman will throw himself into danger for saving the lives of others. Also in all cases, they won't be able to reach direct where fire occurs. The direct presence of fireman will make their life is at risk in most cases.

With the introduction of an Automatic Guided Vehicle into the fire rescue, we could easily minimize the risks facing by the fireman. These AGV will make the rescue operations easier with minimum casualties. Robotics is an important field which can be effectively used in the field of fire and safety.

Robots are intelligent machines that can be controlled according to need. If a multimedia interface is provided, it further aids in the navigation of the robot. Making the robot wireless increases the effective area of operation, thereby making it possible to control the robot from a remote location. Keeping all the above factors in mind the, a robot capable of being remotely controlled through the Internet and possessing a multimedia interface was conceived and developed. The need for a device that can detect and extinguish a fire on its own is long past due. With the invention of such a device, people and property can be saved at a much higher rate with relatively minimal damage caused by the fire.

Another important part we are introducing to the fire safety is Rocker-bogie suspension systems. This system will provide the vehicle to move more easily over the path which is covered with obstructions. The way in which rocker bogie is built will help the vehicle to climb over the obstructions which are twice its size.

II. DESIGN CONSIDERED

There are multiple parts for this project. The main goal is to develop a robot with all of the aforementioned capabilities. The overall system design is divided into four interconnected subsystems as shown in figure 1. The four subsystems and their desired functions are:

1. Rocker Bogie Suspension System: The movement of the vehicle is made possible through Rocker-bogie suspension. This suspension system will help the vehicle to move into the fire hazard zone crossing over the obstructions in the quicker way. The term "rocker" comes from the rocking aspect of the links on each side of the suspension system. These rockers are connected to each other and the vehicle chassis through a differential. Relative to the chassis, when one rocker goes up, the other goes down [1]. The vehicle will be consisting of six wheels, with three on each side. One will be connected to the longer link and the other two will be on the shorter links. The power needed to rotate the wheels are provided using 12V DC motors which are connected to each wheel separately. The links used are made up of iron bars which are joined together using the nut and bolt arrangement. The suspension system gives the movement to the vehicle but the instructions for its movement are provided from the controlling system.

2. Controlling System: This system can be said as the brain of the vehicle. The controlling system will control all the activities going on the vehicle. The main components of the controlling system are Arduino and Zigbee, boards. The Arduino board is a type of microprocessor which can be used to give commands to the movement of the vehicle. This board is a programmable one and can able to change the instructions according to the user need. The commands needed for the movement and other activities are stored inside the Ardunio in form of computer program. The power needed for the working of the Ardunio is taken from the external power source and using a regulator to change the current to its need the Arduino will operate the vehicle according to the commands user gives through the laptop. A pair of Zigbee transmitter is also used in the controlling system. These boards are similar to the wi-fi in functioning which helps in transmitting commands from the receiver side to the vehicle. The normal range of Zigbee will be around 100m. The instructions will be given from the receiving system.

3. Receiving system: The receiving system consist of a laptop and a Zigbee board. The Zigbee board will be connected to the laptop using an USB data cable. Using the keys on the keyboard the user can give commands to the vehicle which will be transmitted from the Zigbee in the laptop to the board on the vehicle. By this process, the Ardunio will receive the necessary commands which are needed for the overall functioning of the vehicle.

4 Sensor System: As the vehicle is being used in a fire hazard zone, the need for sensors is very crucial. The use of sensors will help the user to know the surrounding temperature through which the vehicle is moving. Also, the temperature readings will be helpful for the user to know the intensity of heat present in the zone. Also, a PIR sensor is used which serves the purpose of detecting human presence in a fire accident zone. This helps the user or fire man to know the human presence inside the accident zone which helps in starting rescue process. The camera is also used in the front part of the vehicle which provides visuals in front of the vehicle. The visuals captured by the camera is transferred to the user laptop through the internet as a medium.

5. Pumping System: This system consist of the parts which are needed for the vehicle to extinguish the fire. The main parts come under this system is a servo motor, a storage tank to store water and a piping system which connects the tank and servo motor. With respect to the command using a DC, motor water is pulled from the storage tank to the outlet of the pipe. The directions into which the water is pumped can be controlled using the servo motor.

Each subsystem is individually designed and tested. A comprehensive part evaluation for each subsystem was performed and suitable components were chosen which are reliable and also cost-effective. The components of each subsystem and their functions are:

A. Microcontroller

The key component of the vehicle is Ardunio. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++.

For our project purpose, we had been used Ardunio Atmega 8. This boards are user-friendly and can be reprogrammed according to the user need. At reset, Arduino initializes all other subsystems. The Arduino takes digital data from USB dongle and stores it in an array for further processing. The firmware then takes these data packets and parses them to obtain commands which make all activities of the vehicle being possible. This part is further explained in the software section. A computer program was developed on Ardunio software which helps the board to control the motions of the vehicle and all other activities. The signals coming from sensors are also connected to this board. The command keys for the activities of the vehicle using the laptop is programmed which enable the vehicle to move as per keys.

This component is an essential part of Robotic Fire Extinguishing Vehicle. This board will be the brain which makes the vehicle an automatic guided one.

The features of using this board are it provides separate pins to receive signals as analog and digital. A comparator module is integrated into the IC that provides comparison facility between two voltages connected to the two inputs of the Analog comparator via External pins attached to the microcontroller. As we are using sensors the need of receiving feedback on analog signals is very essential. The programming made on this board is easier to understand while comparing to the other software. It also has a two wire interface. It allows designers to set up a commutation between two devices using just two wires along with a common ground

connection, As the TWI output is made by means of open collector outputs, thus external pull-up resistors are required to make the circuit.

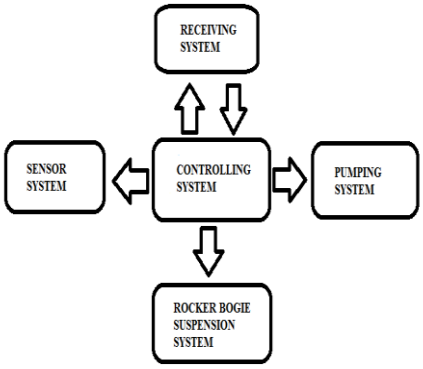

Figure 1: Interconnected Subsystems

The Ardunio being the central part will give commands to the movement of the vehicle and also will operate the dc motors which are helpful in the movement of wheels and also for pulling the water from the storage tank. It also receives the analog signals from the sensors and by internal computation converted into digital values. The signals and data collected at the Ardunio are transmitted to the user for further actions. The main keys used and action assigned to each key are shown below

Key	**Action performed**
F	Vehicle moves forward
B	Vehicle moves backward
L	Vehicle moves left
R	Vehicle moves right
O	the motor on to pump water
N	Motor stops pumping water
1	Servo motor moves pipe up
2	Servo motor moves pipe down
3	Servo motor moves pipe left
4	Servo motor moves pipe right
T	Shows temperature reading
P	Detect human presence

B. PIR Sensor

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors. All objects with a temperature above absolute zero emit heat energy in the form of radiation. Usually, this radiation isn't visible to the human eye because it radiates at infrared wavelengths, but it can be detected by electronic devices designed for such a purpose. The term *passive* in this instance refers to the fact that PIR devices do not generate or radiate any energy for detection purposes. They work entirely by detecting the energy given off by other objects. PIR sensors don't detect or measure "heat"; instead, they detect the infrared radiation emitted or reflected from an object.

In our vehicle, this sensor are used to detect the presence of humans inside a fire hazard area. This sensor can capture the heat emitted from the humans and send this to the Ardunio board in form of analog signals. The use of this sensor will help the vehicle to detect the human presence inside the room and send information to the user. This will help the fireman to initiate rescue operations inside a room which caught fire.

C.Zigbee

Zigbee is a low-cost, low-power, wireless mesh network standard targeted at the wide development of long battery life devices in wireless control and monitoring applications. Zigbee devices have low latency, which further reduces average current. Zigbee chips are typically integrated with radios and with microcontrollers that have between 60-256 KB of flash memory. Zigbee is used for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for

home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need a wireless connection. The technology defined by the Zigbee specification is intended to be simpler and less expensive than other wireless personal area networks (WPANs), such as Bluetooth or Wi-Fi. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range low-rate wireless data transfer. Zigbee can have a normal range of data transmission from 50m to 150m.

In our vehicle, one Zigbee is installed on the vehicle to receive the signals from the user laptop. The normal voltage range needed to operate the Zigbee is 3V the other Zigbee is connected on the laptop using an USB cable. The commands or signals from the software application X-CTU is transmitted to the microcontroller on the vehicle through the Zigbee.

D. DC Motor

A DC motor is a mechanical device which helps to convert the electrical energy to mechanical energy. in our vehicle there are seven DC motors are used. The voltage needed for the operation of this DC motors are 12 V. The power is provided from an external power source. In this motors, six of them are used on each wheel which help the wheels to move more independently. This helps the rocker-bogie movement possible. The other motor is used below the storage tank to pull the water from the tank to the outlet of the pipe.

E. Servo motor

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity, and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors .A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft.

The servo motor is used in our vehicle as a component of the pumping system. Using this servo motor the pipe movement is controlled. The use of servo motor will give the pipe an 180-degree movement both horizontally and vertically. The user can control the movement of the pipe in all four directions using this servo motor. The servo motor usually works in a voltage of 6V. Using this servo motor the user able to fire in the direction where the fire is present.

III. IMPLEMENTATION

The power source used for our model is the 230V AC supply. The power from the main source will first reach through the microcontroller. The regulator with the microcontroller will regulate the flowing current from 230V AC to 5V DC. This is the current needed for the microcontroller to operate. When the user gives a command on the laptop, the Zigbee board will transmit this command to its pair on the vehicle. The Zigbee which is connected with the microcontroller will receive this command in form of signal. The microcontroller will perform the work which is specified for the corresponding key user used. For example, if the user had pressed the key 'F' on the keyboard, the microcontroller will receive that command. The controller will make the vehicle move in the forward direction as per the way the keys assigned.

The DC motors used will be the one which gives necessary power for both the movement of the vehicle and to pump the water from the storage tank. LM35 Temperature sensors are used which will read the surrounding temperature readings and transmitted it into the microcontroller. The controller will receive this signals in analog form and convert them into a digital signal. Similarly, a PIR sensor is also used which will detect the human presence in fire hazard zone. Servo motors as per the command will be helpful in controlling the direction through which the water pumps by the vehicle. Using the servo motor the pipe can able to move both in horizontal and vertical directions. Camera used on the front part of the vehicle will capture the visuals of the path through which the vehicle moves and sends it to the user laptop through the help of internet. In our case, we had used IP camera software to capture the images in front of the vehicle with help of a mobile phone. The visuals can be visible to the user at the same time with help of the internet and IP camera application. The frame of the vehicle is been covered with a wooden frame to protect the internal components from the fire.

Figure 2 Rocker Bogie Base Frame

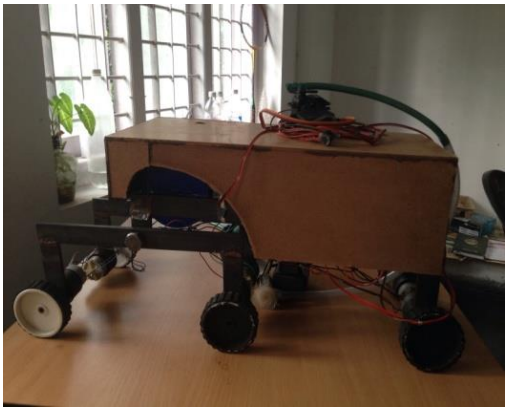

Figure 3 Fabricated Prototype

CONCLUSION

The robotic vehicle we are introduced is a better way to ensure safety to both the fireman and people who got affected by the accidents. This vehicle can be controlled by using a laptop by a user so that the fireman can extinguish the fire without reaching the fire zone by its own directly. The sensors used in them will help the fireman to know whether people are trapped inside a fire zone. This helps them to initiate the rescue operations to those who trapped inside.

The current importance of this vehicles is very high as the people nowadays chooses to live in more compact places. When many people live in a single building, the chances accidents places like this will be very high. This vehicle can be efficiently used in this case which is helpful in saving people lives in quick way possible.

The materials we had to choose for fabricating the prototype are easily available materials. The real model using the industrial grade materials can be more effective as they will have a better life and withstanding power.

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