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Design and Development of Smart Autonomous Fire Detector Robot

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Abstract: Now a days, in industrial, commercial and domestic world, automation assumes an essential part. It is really a planning of various components so as to control, sense, regulate and instruct itself to accomplish a wanted result. This study purposely designed to develop a smart multiple sensor based firefighting robot in our everyday life. So, a smart autonomous fire detector which deflects obstacle on pathway will be created with an extinguisher and some other important elements which controlled by a microcontroller. The system is cost effective has an extensive use. It can present effectively and good outcome during execution. It can be utilized purposely in commercial, domestic sectors and industrial uses which the condition of automatic job needed. If any fire detected, it will extinguish the fire using a water pump that gives to it. This system also able to avoid obstacles on its pathway by changing its direction of movement. This method is possible with the use of ultrasonic sensors. After extinguishing the fire it will move back to find another any presence of fire. It voluntarily senses and extinguishes fire without human guidance. This is mean to simulate the actual world process of robot executing a fire extinguishing task.

Key words: Rescue robot, Bluetooth, autonomous, system, executing, method

INTRODUCTION

These days, machinery and robotic construction turn into significant in serving humanity in multiple fields (Taher *et al*., 2016; Zulkefli *et al*., 2015; Ali *et al*., 2016; Harun *et al*., 2015). Most of the research support to create interest besides inventions in the robotics sector as functioning in a reasonable and possible ways to save a life and moderate damage of property. This firefighting robot able to sense and extinguish a fire automatically. It is about assembly systems with DC motors, flame sensors, ultrasonic sensor and water pump, along with major connections. With the innovation of such a device, human and property can be rescued at a much higher rate with moderate damage brought by the fire (Kapse *et al*., 2015; Punuganti *et al*., 2014; Bharathi and Prasad, 2013).

This robot executes the subsequent method such as environmental detection and corresponding motor control. This robot progress data from several sensors and key hardware features through the microcontroller. All types of signal got by the microcontroller will be managed and performed to achieve the mission of the robot. This robot can be stayed away from work region with obstacles in follow its mission to extinguish the fire.

The robot will observe the work region by executing undirected movements; it as an optional method utilized by humans, particularly the fire fighter to fight fire. In real life, a destructive burnt region frequently occurs without our understanding. Thus, this type of robot will need in the marketplace with high demand since it is helpful to the human along with the environment.

Search and rescue robot are very useful for search and rescue mission. It can be used to search for victims in all kind of area such as hazardous area, sea area and danger area. Mobile robot can be very efficient tools to speed up search and rescue operation (Annuar *et al*., 2016). This robot is designed to be small so that it can enter small gaps or hole that are impossible for human rescuers to enter. This can increase the chance

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to save more victims in a time. Robot is equipped with several features and can be control by human rescuers mobile devices in a close range (10 m). Robot can also move through rubbles and debris in collapsed structure to search for victims.

Shah *et al.* (2013) was discussed about the outline of a fire fighting robot utilizing embedded system. A robot composed and constructed with ability of fighting a simulated household fire (Shah *et al*., 2013). It is able to automatically explore through a demonstrated floor arrangement while effectively checking for a fire. The robot even can perform as a route guider in typical case and as a fire extinguisher alternatively. Robots intended to discover a fire, before it is going out of control. It is able to work with fire fighters who greatly decreasing the danger of damage of victims. The outcome result demonstrates that higher efficiency is in reality accomplished utilizing the embedded system.

According to Saravanan (2015), the design and implementation of the project are mostly based on handle Semi-Autonomous Mobile Robot (SA-BOT). The program direct 4 DC geared motors which are run via the ATmega 2560 besides managed automatically thru the navigation process which contains the infrared sensors and integrated ultrasonic sensors. The bot is equipped with wireless camera which catches the video and passes it towards the base station. The fire sensing system involves a temperature sensor and LDR, if a fire occurs, the sensors sense it and the bot will be going to the source and begins to extinguish. The extinguishing system includes a water container with a BLDC motor. The SABOT able to functioned manually for dangerous situations. It is have given a GUI support which the bot can managed from the base station.

Dhumatkar *et al.* (2015) was later defined about automatic fire fighting robot project used the electrical thermostat technology for managing the fire for 24 h. The system is financially beneficial has an extensive function which when executes It is can give a great and successful result. Synchronization of different hardware include in the system such as wireless remote and wireless android device, Wi-Fi enabled camera, thermostat sensor and water jet. This means to simulate the reality process of robot which executes a fire extinguishing task. Fuzzy logic gave a suitable result to the general complex task of scientifically determining an accurate model for the non-linear control system upon which straight forward method could be used (Dhumatkar *et al*., 2015).

By analyzing the several studies, it is determined that fire fighting robot utilizing Arduino system is not yet studied. So, the intention of this study is to design a fire fighting robot using the arduino system. It will be made by references of previous projects which will utilize the Arduino board, robot platforms, flame sensor, ultrasonic sensor, motor, driver circuit and fire extinguisher.

MATERIALS AND METHODS

The system development should be cost effective, has an extensive use which can present effective and good outcome during execution. It can be utilized purposely in commercial, domestic sectors and industrial uses which the condition of automatic job needed. The fire sensing system utilizing flame sensors that constantly observe the presence of fire. If any fire detected, it will extinguish the fire using a water pump that gives to it. Fire fighting robot also able to avoid obstacles on its pathway by changing its direction of movement. This method is possible with the use of ultrasonic sensors. After extinguishing the fire it will move back to find another any presence of fire. It voluntarily senses and extinguishes fire without human guidance. This is mean to simulate the actual world process of robot executing a fire extinguishing task.

Figure 1 indicates the block diagram for this robot. This block diagram indicates how an autonomous fire fighter robot executes. Inputs such as flame sensor and ultrasonic sensor control by microcontroller. Using this input, main board sets the references and uses this information to relating to its output such as DC motor and water pump.

Software an AutoCAD Version 2012 was used to design the hardware of this project. Using a specific parameter, the chassis of this project was designed followed by other component parts. Figure 2-4 shows some views of this project.

The steering method is the significant element that should give attention in the robot task of searching and extinguish the critical burnt zone. These strategies assist the autonomous fire fighter robot to accomplish the mission to completely extinguished fire. Table 1 displays the DC motor settings with relative robot movements. Table 2 shows the case by case operation of obstacle detection and Table 3 shows the robot movements based on the flame sensor besides the pump operations.

The whole process of a smart autonomous fire fighting robot is simply explained through the flow chart in Fig. 5. The initial position of the robot is in OFF state. Once the switch is ON the robot it will start its mission of extinguishing the fire followed by several features.

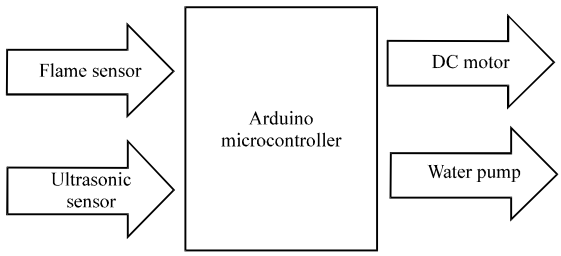

Fig. 1: Block diagram of autonomous fire fighting robot

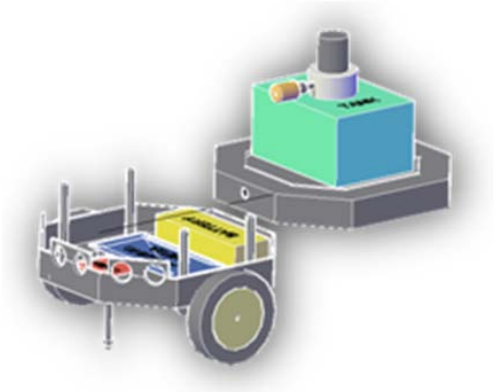

Fig. 2: Front side view of AutoCAD design

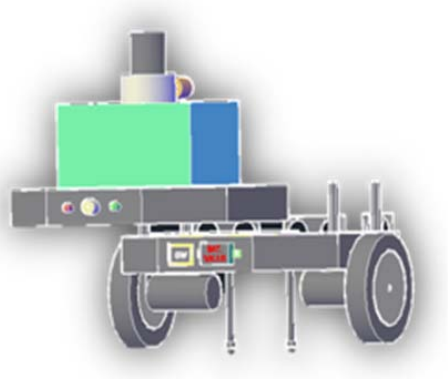

Fig. 3: Back side view of AutoCAD design

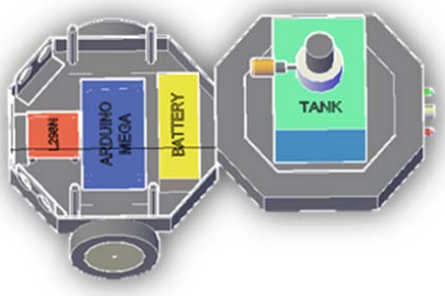

Fig. 4: Top view of AutoCAD design

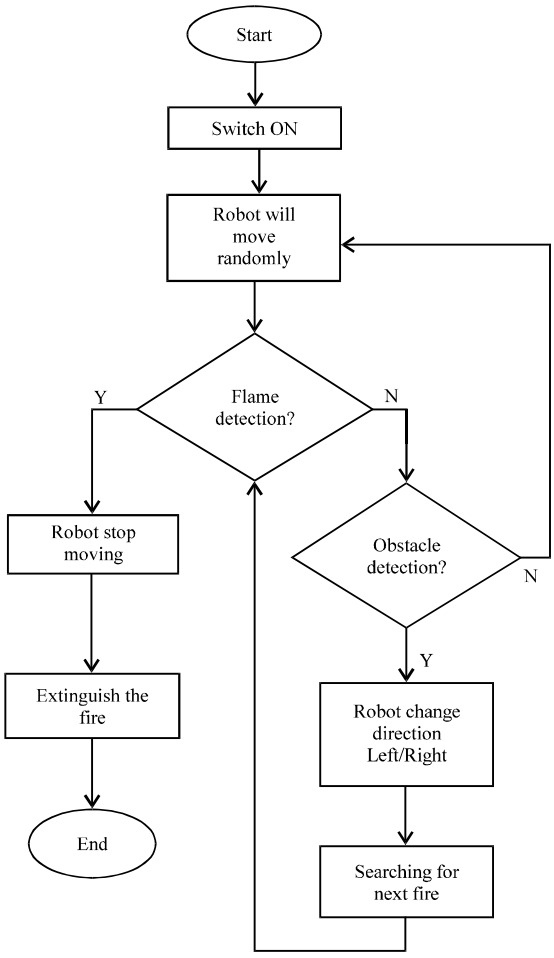

Fig. 5: Whole process flowchart of fire fighting robot

Table 1: DC motor settings with relative robot movements

Left motor	Right motor	Robot movements
Forward	Forward	Forward
Backward	Backward	Backward
Forward	Backward	Turn right
Backward	Forward	Turn left
Stop	Stop	Stop

Table 2: Case by case operation of obstacle detection

Case	Left sensor <15	Left sensor distance> right sensor distance	Middle sensor <15	Right sensor distance> left sensor distance	Right sensor <15	Robot movements
1	0	0	0	0	0	Forward
2	1	0	1	10		Turn right
3	0	1	1	0	1	Turn left

Table 3: Pump operations based on flame sensor

Flame sensor	Pump operation	Robot movements
1	Active	Stop
0	Deactivate	Forward

RESULTS AND DISCUSSION

In this study, all the results and analysis have been discussed. The data are taken from different types of

Fig. 6: Final looks of the project

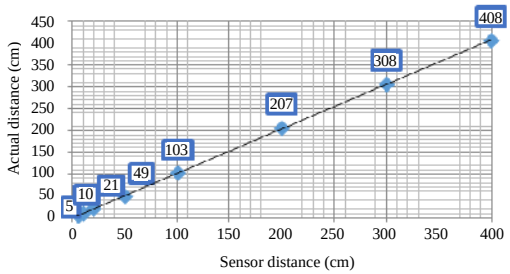

Fig. 7: Graph of ultrasonic sensor distance vs. actual distance

Table 4: Comparison of ultrasonic sensor reading and actual reading

Sensor reading (cm)	Actual reading (cm)
5	5
10	10
20	21
50	49
100	103
200	207
300	308
400	408

analysis and measurement in order to examine the accuracy and consistency of the robot. Figure 6 shows the final looks of a smart autonomous fire detector which deflects obstacle in the pathway. The project fully assembled with all the main components which stated in the methodology. The tank can be filled up maximum to 350 mL.

Analysis of ultrasonic sensor reading: The actual readings were measured by using measuring tape. The first 5 readings which range between (5-100 cm) are almost same actual reading (Table 4 and Fig. 7). Above than that there is a bit changes between actual readings and sensor readings. Maximum of 8 cm different when compare sensor readings with actual readings.

Analysis of flame sensor: Initially the threshold value is 1023 when there is no any flame detected. But when the fire detected the threshold value starts to decrease. When the distance between fires and the robot is getting closer, the threshold value also will decrease simultaneously. It means that the intensity of flame is high. The analysis carried out using candles as a fire source. Figure 8 shows the relationship data experiment between distance and threshold value.

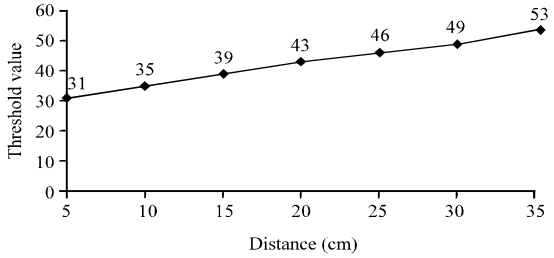

Fig. 8: Graph of relation between distance and threshold value

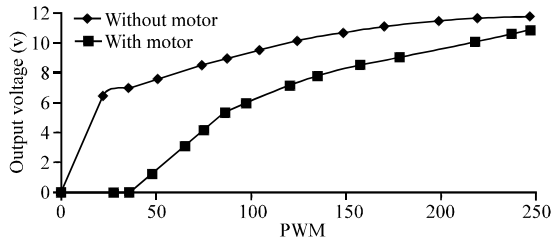

Fig. 9: Graph of L298N PWM vs. output voltage

Analysis of l298N motor driver: The results were tested into 2 conditions. One is with the motor and another one is without the motor. The output voltage values are totally different between these 2 conditions. When the motor driver is not connected to the motor, the output voltage drastically increases once PWM increase. But when the motor driver is connected to the motor, the output voltage slowly and gradually increase once PWM increase. Table 5 and Fig. 9 shows the data experiment value.

Analysis of pump speed: This analysis carried out to identify the time taken to empty the water tank. The water tank is filled with 200 mL of water. The pump speed is converted from PWM to percentage. Then, time taken is decreased when the pump speed is increased. If the pump operated at high speed, it makes the motor driver heat quickly which let to malfunction of the pump. Table 6 and Fig. 10 shows the data experiment taken.

For future improvements to the current development, extra features can be integrated onto the system. Improvements can be done in the fire extinguisher system as well as the fire sensing system. In the current situation

Table 5: Analysis of L298N motor driver output voltage

Variables	PWM	L298N driver output Voltage (V)
Without motor	0	0
	23	6.43
	36	6.95
	52	7.56
	76	8.41
	90	8.89
	108	9.45
	128	10.02
	154	10.64
	176	11.06
	206	11.47
	227	11.65
	255	11.77
With motor	0	0
	28	0.11
	37	0.13
	50	1.2
	67	3.13
	78	4.15
	89	5.33
	101	5.99
	125	7.12
	140	7.75
	163	8.47
	185	9.04
	226	10.04
	246	10.53
	255	10.73

Table 6: Analysis of pump speed

Pump speed (PWM)	Pump speed (%)	Time taken (msec)
51	20	0.243
102	40	0.100
153	60	0.081
204	80	0.053
255	100	0.033

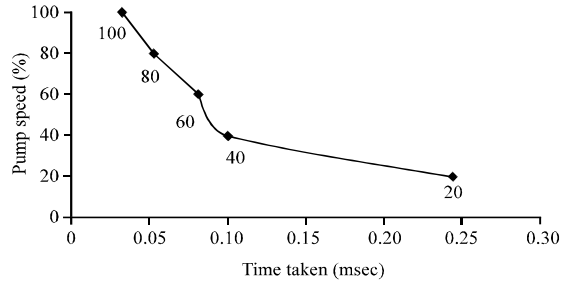

Fig. 10: Graph of pump speed vs. time taken

the fire fighting robot can extinguish the fire only in the way and not in all directions. It can be extended to an actual fire extinguisher by exchanging the water with a carbon dioxide. By adding more flame sensors, the sensing range of all directions can be increased. Thus, it can extinguish fires of all directions by modifying the program code. An addition of a temperature sensor can be integrated to enhance the distance determination from a fire. The limited water supply because of the dimensions of the tank may overcome by design a direct connection from a water source.

The robot cannot run over the batteries without frequent charging. Use of renewable source of energy such as solar power to recharge the battery could maintain the battery level without external charging required. General improvements on wheels may help the robots to navigate on uneven surfaces and able to climb staircases. Currently, the robot movements are controlled by itself and it takes time to locate the fires. By adding the wireless remote control modules on robot might easily for an operator to communicate and control the robot from the base station. Moreover, the robot can be enhanced with breath sensors for identification of live people.

CONCLUSION

Fires can happen at any place and any time and it quickly spread that can lead to destruction. The robot can be utilized in homes, labs, offices, commercial enterprises, shopping centers, work bands and any other places. They deliver more efficiency to detect the fire and extinguish before it becomes uncontrollable and threat to life. Through this can conclude that a robot can reduce the risk of life of the fire fighters. In conclusion, the entire objective stated at the beginning of the report has been achieved with the help of the firefighting robot. The wide usage of microcontrollers provides the integration step to be easier. There were still few troubles at integration step but they were fixed well because troubleshooting can be done at every stage. So, the final model of the robot can successfully reach the fire by avoiding the obstacles on the pathway. During the project, the technical knowledge was placed into practical usage and hence gains several technical skills.

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