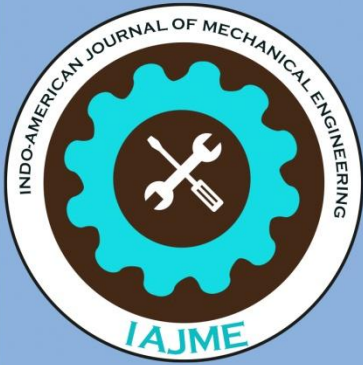




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FIRE FIGHTING ROBOT

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ABSTRACT:

Fire fighting is an important but dangerous occupation. Robots are designed to find a fire, before it rages out of control, could one day work with fire fighters greatly reducing the risk of injury to victims. Fire Fighting Robot Competition is a contest purposely to simulate the real-world operation of an autonomous robot rescuing 10 victims (table tennis balls) and stop 5 fires (emergency candles) in a house within three minutes. The robot development is consisting of three elements which is the hardware, electronic, and programming. The robot have three DC motor, two for driving system and another single DC motor for ball suction subsystem and the fire blowing subsystem. Various sensors are also interfaced with PIC16F877A as a feedback to the robot such as photoelectric sensors, fiber optic sensor and RGB color sensors. LCD display also gives the graphical information of the robot status to the user. For the programming part, C language is used to determine the robot action gain from the sensors input.

Keywords: Fire fighting robot, wall follower, MUROC

1. Introduction

Fire fighting is the act of extinguishing destructive fires. A firefighter must be able to stop fire quickly and safely extinguish the fire, preventing further damage and rescue victims to a safer location from the hazard. Technology has finally bridged the gap between fire fighting and machines allowing for a more efficient and effective method of fire fighting. Robots were designed to find a fire, before it rages out of control. The robots could one day work with fire fighters in reducing the risk of injury to victims.

To simulate the dangerous fire fighting works, the Fire Fighting Robot Contest 2010 that was organized by University Malaysia Perlis (UNIMAP) in the first Malaysia University Robot Contest (MUROC). Fire Fighting Robot is a game based on an imaginary firefighter rescuing the victims and stops the fires.

The Fire Fighting Robot will autonomously move around the house (field) as in Figure 1 to rescue the victims (table tennis ball) as much as possible and

stop the fire (standard emergency candle) in the given time.

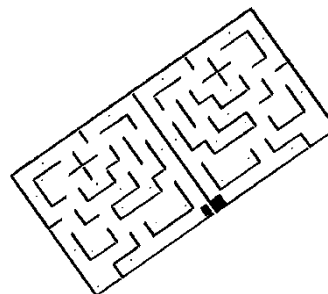


Fig. 1 The Fire Fighting Robot game field

2. Design Concept

To make sure the robot capable to complete the entire task and achieve “rescue”, the robot need to be design by following the MUROC’s rules. According the rules, the size of the robot is limited to a volume of 40cm x 15cm x 15cm and the maximum weight is 5Kg [1]. On top of that, the robot is needed to suck table tennis balls into the designed robot and able to stop five fires with the minimum and maximum height of standard emergency candle from 2inch to 6inch respectively. The robot also needs to navigate itself in the maze without problems [2].

This project is divided into three sections. The

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first section of the project is the mechanical part, followed by electronic part and the final section is the programming part.

3. Mechanical Design Structure

Before starting the robot construction, the robot was design and simulated using the CAD drawing using the Solid Work software, this important to analyze the advantage and disadvantages of the design. Other than that, by using CAD it also helps to reduced time and cost because there will be less prototype fabrication.

To make sure the structure of the robot is durable and the weight is not exceeding 5kg, the main used materials for building this robot are the PCB board for the main structure and transparent Perspex for the tennis ball container. These materials are lightweight and easy to shape.

3.1 Main structure

The robot need archive “rescue” within less than 3 minutes. Thus, the robot needs to travel fast in the maze without problems. To ensure that the robot move perfectly when moving straight, and taking turn smoothly inside the maze, the robot need to be built in “disk” shape with 15cm in diameter. The completed fire fighting robot’s structure is shown in figure 2. The wheels are mounted at the middle of the disk but this will make the robot to be unstable because it tends to fall to the front or to the rear side. To overcome the stability problems, several trans-wheels mounted around the robot’s base [3].



Fig. 2 Fire Fighting Robot

3.2 Ball suction and fire blowing system

The fire blowing system is use to stop the fire from the emergency candle. These two systems are using the same mechanism driven by a centrifugal

fan connected to the DC motor as in Figure 3. The combination of the high speed DC motor and the centrifugal fan connected to the table tennis ball container will make a miniature vacuum thus make any lightweight object will be sucked into the container including the table tennis ball.



Fig. 3 Centrifugal fan connected to the DC motor

By using the airflow from the centrifugal fan, it is more than enough to stop the fire from distance.

4. Electronic Design and Development

The electronic part is one of the important parts in building the Fire Fighting robot. It includes the several types of sensors, push button, power supply, DC motor driver, DC motor and the most important in the autonomous robot is the microcontroller. These entire components are connected together to become a system. The electronic system of the Fire Fighting robot can be simplified as in Figure 4.

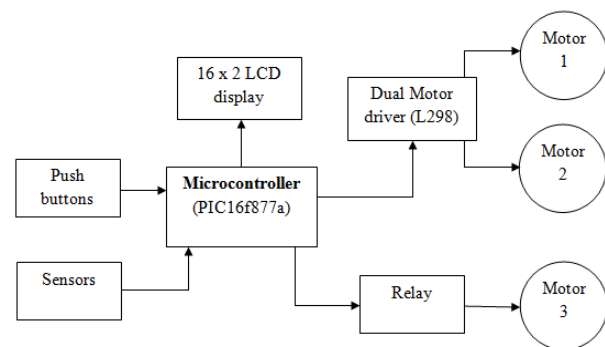


Fig. 4 The electronic system of the Fire Fighting robot.

4.1 Sensors

The Fire Fighting robot needs to navigate the maze without any direct human control, thus the robot is equipped with three types of sensors as feedback such as photoelectric sensor, RGB color sensor and Digital fiber sensor. Generally, all the sensors used in this project have digital TTL output and requires 12V of DC supply.

There are six photoelectric sensors are attached around the robot used for robot's wall following method. All of the photoelectric sensors are manufactured by SUNX.

For junction counting purpose, a fiber optic sensor as in is attached either at the right side or at the left side of the robot according to the played game field as in If the robot plays at the red game field, the fiber optic sensor is attached at the left side of the robot and if the robot plays at the blue game field, the same fiber optic sensor will be attached to the right side of the robot.

For the color-differentiating sensor, there are two RGB color sensors are attached to the robot. One is for detecting the present of the candle's base and the other one is for distinguishing the floor color.

4.2 Microcontroller circuit

PIC16F877A is used for the robot controller. It decodes the sensors output signal and gives correct output signal for LCD display, motor driver and relay circuit [4].

A 16 x 2 LCD display as in is connected to the PIC externally to become a useful interface for the user. The LCD is used to display the current action taken by the microcontroller and to show the information from the sensors.

To make the robot move, the motor driver used in the project is L298 IC. The robot is using differential drive method in other word the robot is using two motors. By using the L298, it can control two motor simultaneously. The driver allows the motor to be driven in either forward or reverse direction and sometimes brake by applying appropriate signal from the PIC [5].

For this project, a relay circuit is also used to control a DC motor for suction sub-system to for on and off switching control only.

4.3 Circuit simulation

Before fabricating the circuit, the microcontroller circuit must undergo simulation. The simulation process is using the ISIS Professional simulation software [6]. Using this approach, it can reduce the hardware development cost and it also able to reduce the time for troubleshooting and testing the hardware circuit.

4.4 Printed Circuit Board (PCB) Fabrication

The fabrication is design using ARES 7 Professional software [6]. For this project, the PCB fabrications are divided by three circuit, which is the microcontroller circuit, driver circuit and control board circuit.

5. Programming

Programming is the core element in building an autonomous robot which able it to make its own decisions using sensors as feedback. The program code is written using C language and compiled using CCS PCW C-Compiler software [7]. Once the program code compiled, the program is downloaded into the PIC16F877A using PICkit2 software, linked by Cytron's USB UIC00A downloader [8].

6. Robot Behaviour

The aim of the project is to make the robot to move around in the maze using the wall follower method, junction counting method and able to rescue the victim and stop the fire. The planning of the behaviour is starts by configuring the major movement probability of the robot such as following the right wall and following the left wall subroutine.

After that, the route of the robot must also be planed Mto make sure the robot will pick the table tennis ball and stop the fire as much as possible using shorter route. In order to archive this, the robot needs to perform several programmed subroutines such as wall following, strategy 1, strategy 2, and strategy 3 subroutine. Then, these subroutines are combined in a main program where the strategy button is configured.

6.1 Main program

The main program is written to link all the subprogram using strategy buttons selection to become a complete Fire Fighting robot program code.

6.2 Wall follower

The robot is using wall follower method to move in the maze, the method generally consist several behaviour such as move straight, turn left, turn right and more according from the sensor input regardless whether the robot is following the right wall or the left wall. The sensors are given a name that refers to its output pin connection to the microcontroller pin.

Table 1 and Table 2 show the robot action depending on the sensors input for right wall follower and left wall follower method respectively.

Table 1: The robot action using the right's wall follower method

Sensor Input							Robot Action
A ₀	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	
0	0	0	0	x	x	x	Turn left
0	0	0	1	x	x	x	Turn left
0	0	1	1	x	x	x	Follow right wall
0	1	1	1	x	x	x	Right U-turn
1	1	0	0	x	x	x	Escape Manoeuvre
1	1	1	1	x	x	x	straight

Table 2: The robot action using the left's wall follower method

Sensor Input							Robot Action
A ₀	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	
x	x	x	0	0	0	0	Turn left
x	x	x	1	0	0	0	Turn left
x	x	x	1	1	0	0	Follow right wall
x	x	x	1	1	1	0	Right U-turn
x	x	x	0	0	1	1	Escape Manoeuvre
x	x	x	1	1	1	1	straight

6.3 Strategies

There are four strategies programmed to the Fire Fighting robot determined either using strategy switch or the starting point counters. Figure 5 shows the robot path inside the house or game field.

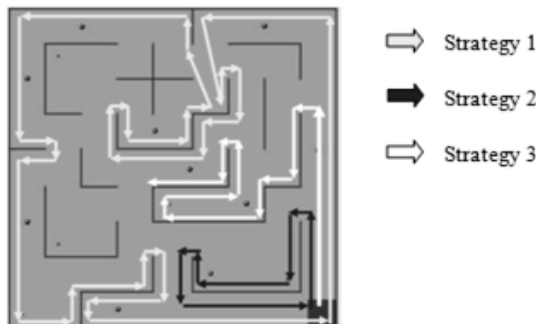


Fig. 5 The robot path inside the game field

7. Conclusion

Overall, an autonomous fire fighting robot has been successfully built. All the fundamental wall follower action such as moving forward, reverse, turn left and turn right function flawlessly. The robot has been able to pick up the table tennis ball and stop the fire. Besides that, the robot also has been able to count the maze junction and make its own decision based on the counted junction. Other than that, the robot has been able to distinguish the game field color different either red and green or red and blue. With this ability, the robot can change the current strategy to a new strategy. Other than, the robot also capable to avoid its structure from touching the fire source that can cause point deduction. As a conclusion, the project entitled "The Fire Fighting Robot" has archived its aim and objective successfully.

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