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DESIGN AND IMPLEMENTATION OF SHORTEST PATH LINE FOLLOWING MAZE SOLVING ROBOT

#1A CHOKALINGAM, #2N RAMU
#Department of Mechanical Engineering,
AMK Technological Polytechnic College, Sembarambakkam, Chennai 600123
India,

ABSTRACT:
Maze solving problem is a very old problem, but still now it is considered as an important field of robotics. This field is based on decision making algorithms. The main aim of this project is to make an Ardunio based efficient autonomous maze solver robot. To implement in real time hardware development, software development and maze construction had been done. Capability of finding the shortest path is also verified. A maze solving robot is quite similar to a line follower which has just to follow a predetermined row is not known beforehand. However, this robot is designed to be autonomous, they basically perform different tasks. For that, it is equipped with an IR sensor array and a motor driver circuit. Both the sensor circuit as well as motor driver circuit controlling the robot has the following building blocks. The most common algorithm for maze solving robot is white line following algorithm.

Keywords: Arduino controller, IR Sensors, DC Motor etc.,

1. Introduction:

Modern robotics technologies are focused on developing self navigating autonomous robots to automate our day to day processes. This means that most of the research focuses on improving sensors and algorithms to build flexible and accurate robots. The maze solving robots also known as micro mouse is designed to find a path without any assistance or help. As a type of autonomous robot, it has to decode the path on its own to solve the maze successfully. So its logic is quite different from the line following robot which follows a predetermined route. These types of autonomous mobile robots can be used in a wide variety of applications such as material handling, ware housing management, pipe inspection and bomb disposal.
In this tutorial, I will show you how to build a simple Ardunio maze solving robot using three ultrasonic sensors.

2. Components selection and hardware structure:

The maze solving robot is a combination of electronic, electrical and mechanical parts. Figure 1 proposed whole by flow chart.
The input devices are the devices which are used to gather the information about the system which consist of switches, sensors in order to feed the controller (Ardunio) by an information about the path.
The controller, which is the main element that operate the whole system by using the information from the sensors and take the decision before sending the signal to the output devices.

The output device are the actuators that converts the electrical signal into mechanical movement, the principle types of actuators are relay, solenoid and motors.

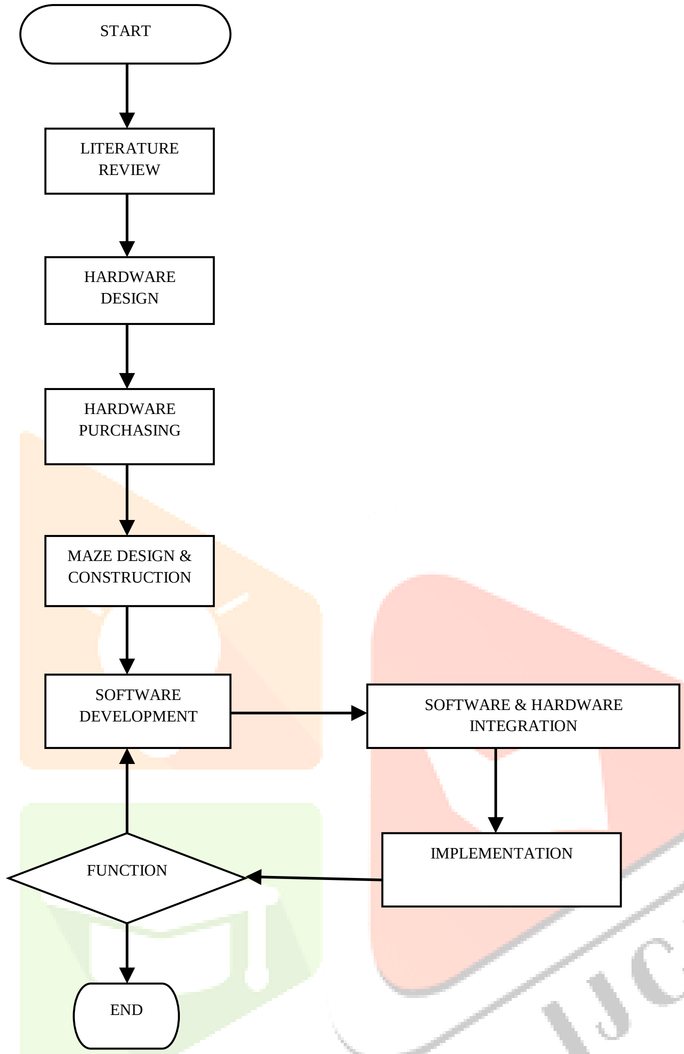


Fig 1 shows the flow chart for the whole system

The basic requirement of components is

- Robot car chassis
- Arduino Uno
- L298N Motor Driver
- 1500mAh Lithium – Polymer (LiPo) battery
- IR Sensors
- Geared DC Motor
- Robot Car wheels
- Jumper wires

2.1 Robot Car Chassis

This Robot Car Chassis used to hold all the parts needed for the maze robot and the rear wheel with motors fitted in this unit. The diagram is shown in figure 2

Fig 2 Robot Car Chassis

2.2 Ardunio Uno

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started."Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform. The photo view of the ardunio uno controller board is shown in figure 3

Fig 3 Ardunio Uno Controller Board

2.3 L298N Motor Driver

In order to control a DC motor with the Arduino Uno, a motor controller module is required. Such module is needed, for various reasons: For example, the Arduino can't power DC motors with a voltage higher than 5V. However, many DC motors need more than 5V, especially when they are supposed to move on full speed. Moreover, most DC motors need more power than the Arduino could provide. The L298N module used to control two motors with different directions and speeds. The photo copy of the L298N Motor Driver is shown in figure 4

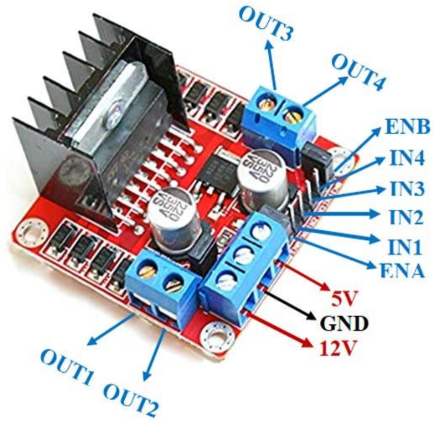


Fig 4 L298N Motor Driver

PinLayout:

In order to power the DC motors, two voltage supplies with different voltages are needed. The DC motor has an operating voltage of 12V. As the L298N module drops the voltage by more than 2V, the 5V voltage supply (USB) of the Arduino can't be used. Therefore, a second voltage supply of 9 to 12V is used.

A Brief Note on L298N Motor Driver

L298N Motor Driver IC is a 15-lead high voltage, high current Motor Driver IC with two full bridge drivers. The logic levels of L298N IC are compatible with standard TTL and IC can be used to drive different inductive loads like DC Motors, Stepper Motors, Relay, etc. The L298N Motor Driver module consists of an L298 Motor Driver IC, 78M05 Voltage Regulator, resistors, capacitor, Power LED, 5V jumper in an integrated circuit.

78M05 Voltage regulators will be enabled only when the jumper is placed. When the power supply is less than or equal to 12V, then the internal circuitry will be powered by the voltage regulator and the 5V pin can be used as an output pin to power the microcontroller. The jumper should not be placed when the power supply is greater than 12V and separate 5V should be given through 5V terminal to power the internal circuitry.

ENA & ENB pins are speed control pins for Motor A and Motor B while IN1& IN2 and IN3 & IN4 are direction control pins for Motor A and Motor B.

Internal circuit diagram of L298N Motor Driver module is given below in figure 5

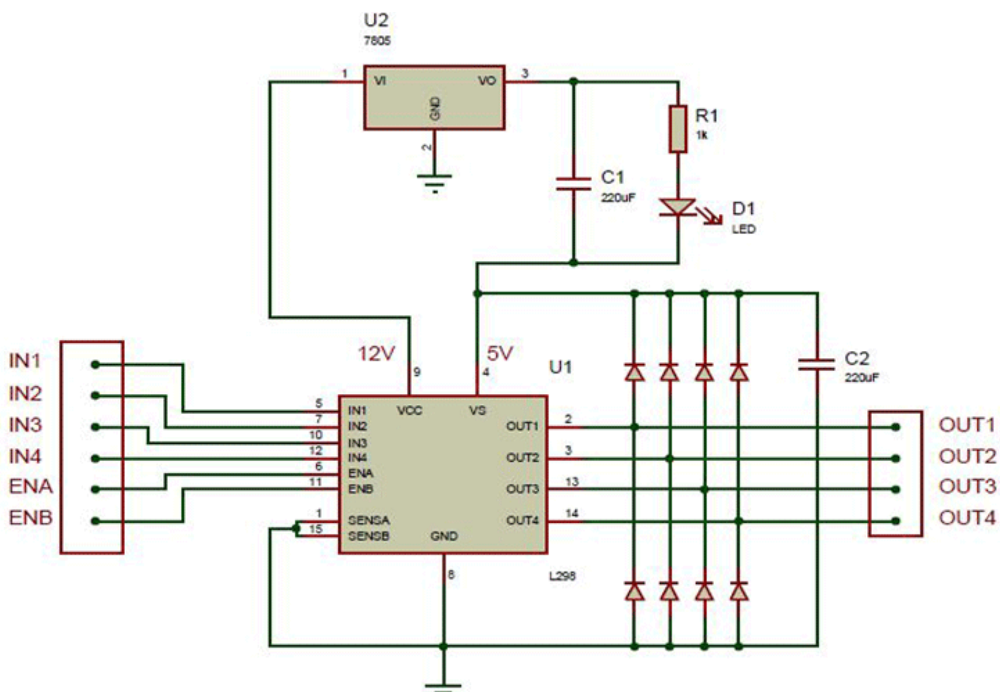


Fig 5 L298N Motor Driver module

Since the L298N Motor Driver IC is a dual full bridge driver IC, you can control two motors at the same time with individual inputs. The logic supply voltage is 5V but the motor supply voltage can be as high as 45V. The peak output current per channel is 2A.

2.4 1500mAh Lithium – Polymer (LiPo) battery

A lithium-polymer battery (LiPo) is a rechargeable battery uses solid polymer for the electrolyte and lithium for one of the electrodes. Commercially available LiPo are hybrids: gel polymer or liquid electrolyte in a pouch format, more accurately termed a lithium ion polymer battery. The diagram is shown in figure 5

Fig 5 Lithium – Polymer batter (LiPo)

2.5 IR Sensors

The IR sensor module consists mainly of the IR Transmitter and Receiver, Opamp, Variable Resistor (Trimmer pot), output LED in brief.

2.5.1 IR LED Transmitter

IR LED emits light, in the range of Infrared frequency. IR light is invisible to us as its wavelength (700nm – 1mm) is much higher than the visible light range. IR LEDs have light emitting angle of approx. 20-60 degree and range of approx. few centimetres to several feets, it depends upon the type of IR transmitter and the manufacturer. Some transmitters have the range in kilometres. IR LED white or transparent in colour, so it can give out amount of maximum light.

2.5.2 Photodiode Receiver

Photodiode acts as the IR receiver as its conducts when light falls on it. Photodiode is a semiconductor which has a P-N junction, operated in Reverse Bias, means it start conducting the current in reverse direction when Light falls on it, and the amount of current flow is proportional to the amount of Light. This property makes it useful for IR detection. Photodiode looks like a LED, with a black colour coating on its outer side; Black colour absorbs the highest amount of light. The photo copy of photo diode receiver is shown in figure 6

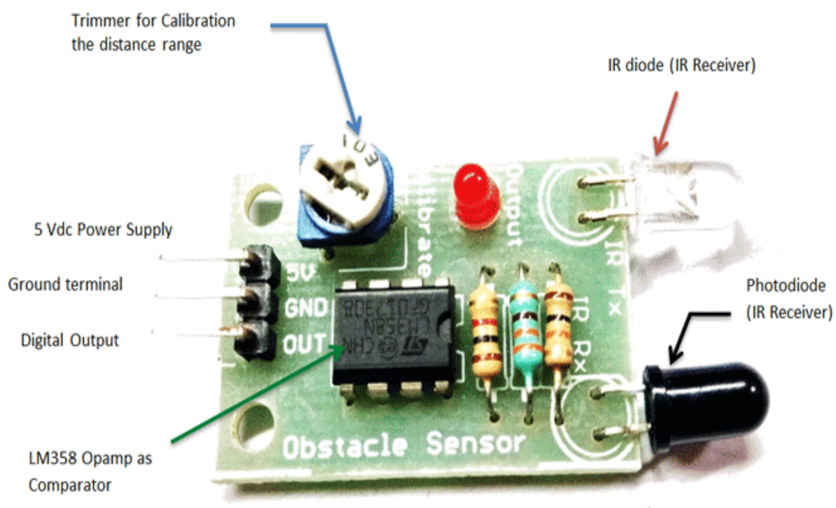


Fig 6 Photodiode Receiver

2.5.3 LM358 Opamp

LM358 is an Operational Amplifier (Op-Amp) is used as voltage comparator in the IR sensor. The comparator will compare the threshold voltage set using the preset (pin2) and the photodiode's series resistor voltage (pin3).

Photodiode's series resistor voltage drop > Threshold voltage = Opamp output is HighPhotodiode's series resistor voltage drop < Threshold voltage = Opampoutput is Low.WhenOpamp's output is **high** the LED at the Opamp output terminal **turns ON** (Indicating the detection of Object).

2.5.4 Variable Resistor

The variable resistor used here is a preset. It is used to calibrate the distance range at which object should be detected.

2.5 Geared DC Motor

The geared DC motors are an advanced variation of the brush DC motors. They have a gear assembly attached to the motor. The speed of the motor is measured in Rotation Per Minute (RPM). The speed of the motor is reduced with an increase in torque with the help of gear assembly. By using a correct combination of the gears to motor the speed of the DC motor can be reduced with an increase in torque. This provides stability in the rotation of the motor and the motor can be stopped or changed speed in a controlled manner.

The DC motors work in a specified range of the voltage and higher is the input voltage, higher is the RPM. For Example, if the motor works in the range of 6-12V, it has the least RPM at the input voltage of 6V and the maximum RPM at the input voltage of 12V. The photo view of the Geared DC motor is shown in figure 7

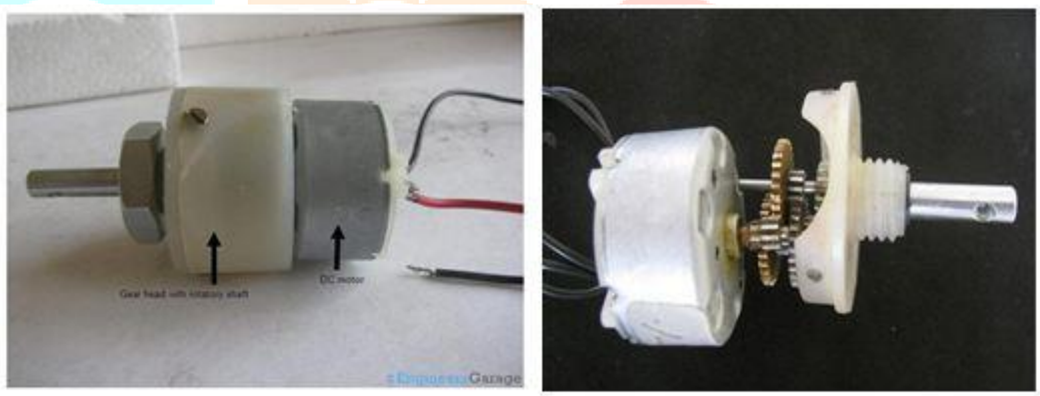


Fig 7 Geared DC Motor

2.6 Robot Car Wheels

The Robot Car Wheels consists of the following components and the diagram is shown in the figure 8

- Compatible with: DC Motor
- Dimensions: 5.0 cm X 2.0 cm
- Colour: White rim and Black rubber
- Material: Plastic and rubber
- Applicable for: Vehicle, robot or any moving robotic

Fig 8 Robot car wheels

2.6.1 CASTOR WHEEL

15mm diameter caster wheel with 3 mounting holes. Ball diameter 13mm.this wheel is mounted at front side of the robo car for the purpose flexible steering and the view is shown in the figure 9

Fig 9 Caster wheels

Ball caster wheel Small is an Omni directional wheel. This caster wheel comes with a red cap over it. This wheel can be used as a neutral wheel for small robots.

The caster wheel makes the robot to walk or move at a more flexible and comfortable way.

2. 7 JUMBER WIRES

Jumper wires are used here for making connections between the sensors and L298N motor driver module and Arduino's header pins. The photo view of the jumper wires is shown in figure 10

Fig 10 Jumper Wires

3 WORKING METHODOLOGY

3.1 BLOCK DIAGRAM

The hardware chosen to complete this project is Arduino based two-wheel mobile robot. Three Ultrasonic sonar sensors have been used to map the maze and solve the wall maze. The block diagram is shown in figure 11

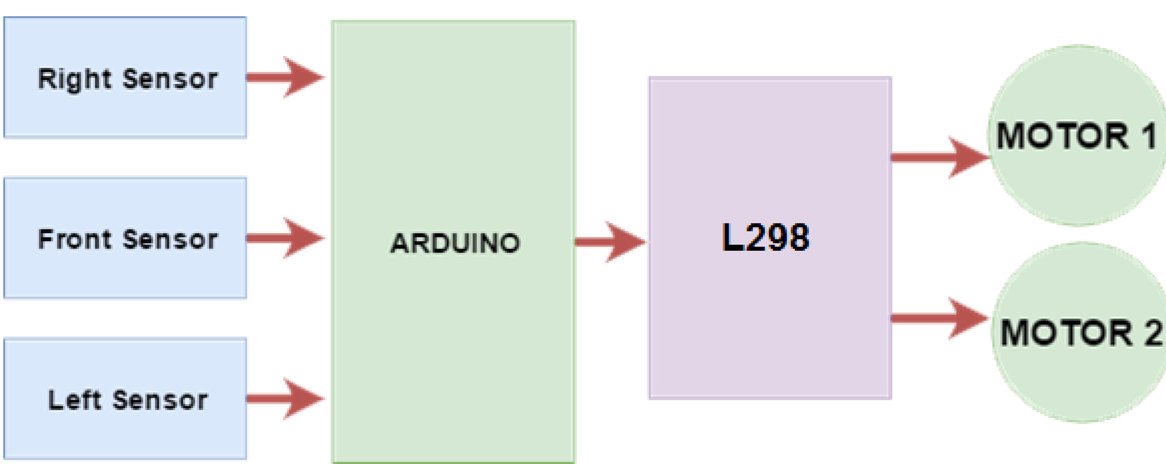


Fig 11 Block diagram of working principle Maze Solving Robot

3.2 Robot Implementation

3.2.1 Physical configuration

Figure- shows the physical configuration of the robot. The robot body (chassis) is three layered. And it is made of abrasive cut 6mm novopansheet. Arduino and motor driver circuit has been placed on the top robot chassis. The six IR sensors have also been placed at the front side of chassis. The power section has been placed at the middle part of the chassis. One 12vdc battery holders is used for power supply and the 5V voltage regulator circuit has been taken from the L298N Motor driver module. At bottom part, two gear motors with wheel and two caster wheels have been attached. The Maze Solving robot is shown in figure 12

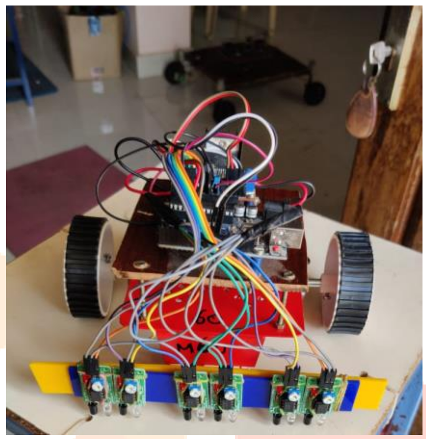


Fig 12 Maze Solving Robot

3.3 THEORY

Maze Solving steps:

1st run – Drive through the maze and find the finish point.

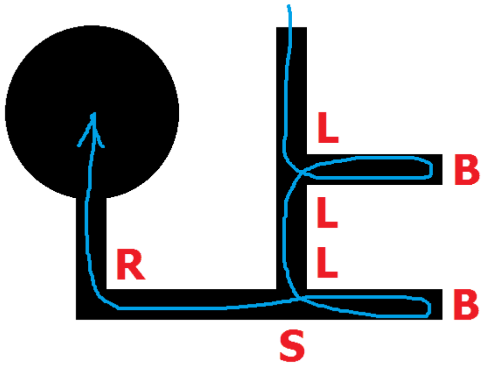
2nd run – Drive through the maze to the finish point with shortest path (not enter the dead path)**Maze Solving technique:**

For non-looped maze solving, we can use "left hand on the wall" technique. Imagine walking through a real labyrinth (a human-sized maze built with stone walls) while keeping your left hand on the wall at all times. You'll turn left whenever possible and only turn right at an intersection if there is no other exit. Sometimes, when you reach a dead end, you'll turn 180 degrees to the right and start walking back the way you came. Eventually, as long as there are no loops, your hand will travel along each length of wall in the entire labyrinth exactly once, and you'll find your way back to the entrance.

This "left hand on the wall" algorithm can be expressed into these statement:
IF you can turn left then turn left,
ELSE IF you can continue driving straight then drive straight,
ELSE IF you can turn right then turn right.
IF you are at a dead path then turn back.

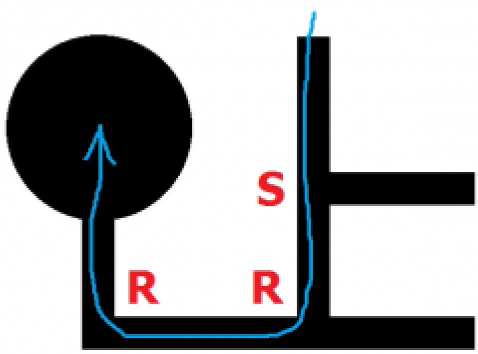
Define the path name:

To make the path easier in programming, we can define it as follow,
Left – **L**
Right – **R**
Straight – **S**
Turn back – **B**
Example: **LBLLBSR** (This path represent the picture below)



Simplifying the solution:
We can see in the picture above, at the 1st junction the robot should go straight for correct path, so we can simplify the path by substituting **LBL to S**, and this is the whole list for substitution:
LBL = S
LBR = B
LBS = R
RBL = B
SBL = R
SBS = B

We can try to simplify this path, LBLLBSR.
LBLLBSR = **S**LBSR
S**LBS**R = S**R**R
So the final path optimization is **SRR** (refer picture below). In other words, as long as 'B' exists, the optimization is needed.



To make better understanding, we try another example. Simplify this path LLRBLRLLRLLSBLL.
LL**RBL**RLLRLLSBLL = LL**B**RLLRLLSBLL
L**LBR**LLRLLSBLL = L**B**LLRLLSBLL
LBLLRLLSBLL = **S**LRLLSBLL
SLRLL**SBL**L = SLRLLRL
So the final path optimization is **SLRLLRL**.

4.0 CONCLUSIONS

When working with this robot system, the interaction with sensor has some limitations. Because due to intensity of environmental lighting effect leads to error in sensor signal. Moreover the battery should be recharged frequently.
The path following left hand rule algorithm receives inputs from the six IR sensors and then calculates the best move. Finally, the movement algorithm outputs commands to the motor drivers for finding the target of the maze move in shortest path with minimal amount of time.

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