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A Comparison based Line Following Robots Design for Path Planning and Maze Solving

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Abstract - This paper presents the development of autonomous Line Following Robot which is based on atmega328p (development board) and AT89S51 IC as the main microcontrollers to give fast, smooth, accurate and safe movement in any complexly designed path. The experimental approach of comparison is used in designing two line following robots for efficient maze solving and path planning. They will be practically implemented as hardware platforms for further robotics and simultaneously simulated in Proteus 8 professional Design Suite. The following two robots are designed at two different levels of circuit abstraction and further a comparative assessment has been performed.

Key Words: Arduino, Comparison, AT89S51, Robotics, Abstraction, microcontrollers.

1. INTRODUCTION

This line follower is an autonomous robot. It is used for detection and following of a line on the surface. We here detected a black line on a white surface (vice-versa). For path detection we have used an infrared sensor. A project based learning approach to design a line following robot for several industrial and competitive purposes such that a complete digital system can exist for various robotics applications.

1.1 Approach

The idea of building a line following robot with the above mentioned objective has be achieved by the following –

- Cost Reduction
- Low Power Consumption
- Finding The Shortest Path
- Circuit Improvisation
- Real time simulation using MATLAB

1.2 Components

The proposed two robots are build using the following components –

- Microcontrollers ICs- AT89S51, AT89C51 AND ATmega328P (Development board), microchip based PIC 16F877A.
- Two motor drivers, L293D
- Operational amplifiers, LM324 (comparators)
- Phototransistor (sensor) and processing circuit
- Other circuit requisites (capacitors, resistors, switch, crystal Xtal, diode, battery, breadboard, PCB)
- Chassis, motors and wheels
- Actuators

2. Methodology

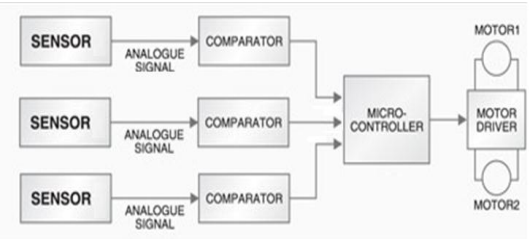

Fig -1: Methodology Blueprint

- Optical Sensing – When light falls on the phototransistors, it goes into saturation and starts conducting. When no light falls on the phototransistor, it is cut-off. A white LED has been used to illuminate the white path on a black background. Phototransistors used for detecting the white path on the black background. Phototransistors are connected to the inverting inputs of operational amplifiers. The signal voltage at the inverting input of the operational amplifier is compared with the fixed reference voltage, which is formed by a potential divider circuit of 4.6-kilo-ohm resistor and 8-kilo-ohm preset. This reference voltage can be adjusted by changing the value of the 8-kilo-ohm preset.

- Sensor Positioning- As IR sensors are the one which decide the motion of the line following robots, they have to be placed in the most precise manner possible. We are using 3 IR sensors in the robots. The working range of IR sensors in our case is 2mm-10mm. The distance

between the surface and the sensors should be as low as possible for accurate reflection. If the black line is thick comparatively then the distance between the sensors should be more as compared to a thinner line. The emitter and the reflector should be placed in a "V" pattern so that they do not obstruct each other's working.

- Robot Steering Mechanism – The steering and the pattern of movement of the line following robots will depend on the algorithm coded in the respective microcontrollers. In order to move forward the sensor in the middle will be turned off as it falls on the black line and the left and right sensors will pass the current and both motors will be turned ON. To move left the left sensor will be turned OFF and the middle and right sensors will operate and the right motor will control the left moving action. Similar action will be performed for taking a right turn.

- Speed Control – The speed of the line following robot will be depend on the following two factors –

a.) Battery - We have used two 9V batteries for each respective motor for optimum speed. We brainstormed, hit and tried batteries of different power and simulated the robot in real time to finalize the power for the circuit. The two batteries are used for powering the two H bridges motor drivers L293D respectively.

b.) Level of Abstraction – As we have used two different robots with different levels of abstraction and came to the conclusion that a robot with a higher level of abstraction (development board) will require more power.

3. Electronic Design

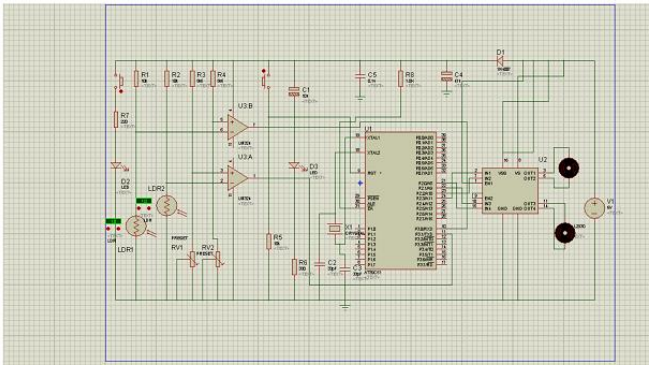

Fig -2: Schematic Design of the Line Following Robot.

- Sensing action – Phototransistor (IR sensor) and processing circuit. The sensor is used to sense the light reflected from the surface and feeds the output to the given comparator. When the sensor is above the white background, the light that is falling on it from the source will be reflected to the sensor and when the sensor is above the black background the light from the source will not be reflected back.

- Comparing action- Operational amplifiers LM324 (comparators). The comparator is used to compare the analogue inputs from sensors with a fixed reference voltage. If the voltage is greater than the reference voltage the comparator outputs a low voltage and if it is smaller the comparator generates a significantly high voltage that acts as input for the decision-making device (microcontroller).

- Controlling action- Microcontroller ICs AT89S51/AT89C51 or Development board (atmega328p) are used in the respective line following robots. The microcontroller is programmed such that it makes the robot move forward, turn right or left based on the input coming from the comparator. The outputs of the microcontroller are further fed to the motor drivers for the movement of the robot.

- Driving action - Motor drivers L293D is used to fulfill this task. The current supplied by the microcontroller which is used to drive the motor is small. Therefore a motor-driver IC consisting of two H-bridges are used providing sufficient current to drive the motor.

4. Simulation

A standard simulation of the proposed line following robots was carried out on Proteus 8 Design Suite. External libraries were installed to perform the task.

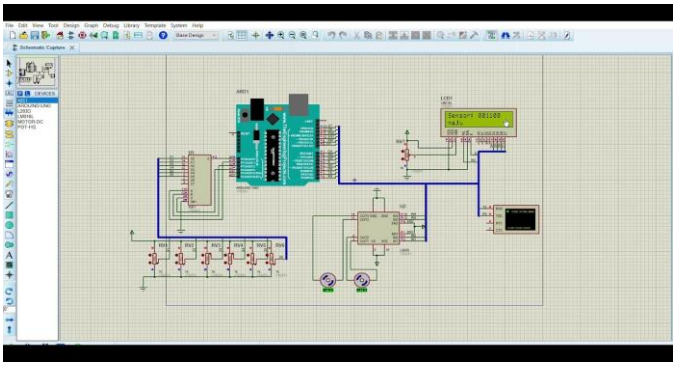

Fig -3: Simulation 1(Development Board)

drive the LFR properly.

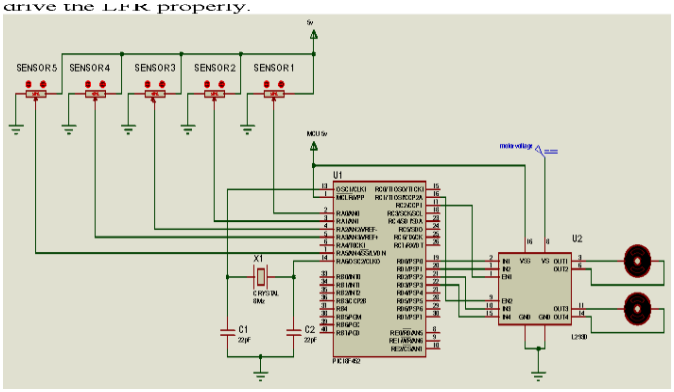

Fig -4: Simulation 2(Microcontroller IC and discrete components)

5. Comparison

Table -1: Comparison Table

FEATURES	Development Board (ATmega328P)	icrocontroller IC (AT89C51/ AT89S51)
Power Consumption	High	Low
Circuit Simplicity/ design	Simple	Complex
Circuit Board	Arduino (PCB)	Bread Board
Efficiency	Low	High
Cost	High	Low
Speed	High	Higher

6. Algorithm Design

The robot uses three IR sensors to sense the line. The sensing takes place in such a way that output of the sensors is an analog signal which depends on the amount of light reflected back.

The analog signal is given to the comparator to produce 0s and 1s which are then fed to the microcontroller.

Further the microcontroller decides the position of the robot in either left or right direction.

- To move forward, both the motors are turned on and rotated forward simultaneously
- To move left, the right motor is turned on and the left motor is turned off
- To turn right, the left motor is turned on and the right motor is turned off
- In order to solve the maze, the robot needs to traverse the maze twice
- In the first run, it goes down some number of dead-ends, but records these as "bad" paths so that they can be avoided on the second run when it actually solves the maze

7. Application and Industrial Uses

- A construction robot for rescue operations during natural disasters.
- For transportation of goods in warehouses
- For autonomous mopping of floors in houses, offices etc.
- For security purposes.
- Uses infrared sensors for path detection.

8. Future Scope

- Line following robots with pick and place capabilities in difficult terrains
- Time reduction and speed improvisation.
- Miniaturization of line following robots.
- Radio frequency communication system
- Proportional integrative and derivational (PID) control.
- Remote controlling and cloud processing using IoT.

9. Conclusions

- We have successfully implemented the two proposed line following robots, one based on the Development board (atmega328p) and the other one using microcontroller ICs (AT89S51/AT89C51) with discrete components. The comparison based approach helped us in realizing the basic circuit issues of design and implementation and further allowed improvisations in the following circuit parameters such -
- Low power consumption
- Efficient IR sensing
- Simple circuit design

The working Line following robots can be used in various industrial applications and robotic competitions and are ready for any complex maze solving problem even with challenging terrains.

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