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CARRYBOT USING ARTIFICIAL INTELLIGENCE

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ABSTRACT

The Line follower robot is a mobile machine that can detect and follow the line drawn on the floor. Generally, the path is predefined and can be either visible like a black line on a white surface with a high contrasted color or it can be invisible like a magnetic filed.

Definitely, this kind of Robot should sense the line with its Infrared Ray (IR) sensors that installed under the robot. After that, the data is transmitted to the processor by specific transition buses. Hence, the processor is going to decide the proper commends and then it sends them to the driver and thus the path will be followed by the line follower robot.

In this Paper, we have illustrated the process of design, implementation and testing TABAR, a small line follower robot designed for the line follower robots competition.

KEY WORDS
Line Follower Robot, Microcontroller, Sensor, Actuator, Competition Rules

1. Introduction

Generally, the line follower robot is one of the self-operating mobile machines that follows a line drawn on the floor. The path can be a visible black line on a white surface (reverse). The basic operations of the line follower are as follows:

1. Capturing the line position with optical sensors mounted at the front end of the robot. Most are using several numbers of photo-reflectors, and some leading contestants using an image sensor for image processing. Therefore, the line sensing process requires high resolution and high robustness.

2. Steering the robot to track the line with any steering mechanism. This is just a servo operation; actually, any phase compensation will be required to stabilize tracking motion by applying digital PID filter or any other servo algorithm.

3. Controlling the speed according to the lane condition. The speed is limited during passing a curve due to the friction of the tire and the floor. Better mechanisms, therefore, can improve the power of manoeuvre. The speed of the robot, hence, can be increased. Consequently, the robot's performance can be increased, too.

This kind of robot can be used for military purposes, delivery services, transportation systems, blind assistive applications. On the there hand, there are many annual line follower robots competitions organized by universities or industries around the world. They usually ask robotic teams for building a small robot with specific dimensions and weight according to the competition rules. Actually, the line follower robots are a perennial favourite of the small robot builder but definitely the tricky part is to make the line follower fast and smooth in its response.

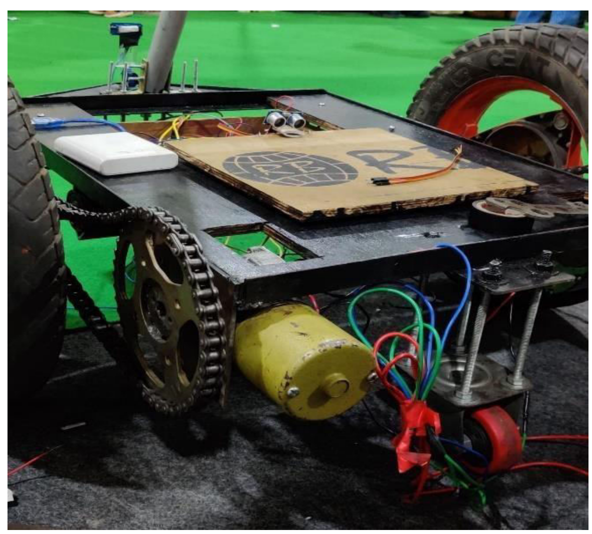

Fig. 1: The Designed Line follower robot

In order to attend at Tabriz line follower robots competition, Tabari Institute of Babol had functional support for design, implementation and testing, a small line follower robot as can be seen in Fig. 1.

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In this paper, hence, we intend to share our experiences. Therefore, the line follower robot structure and architecture issues and challenges will be discussed in section 2 and the programming subjects will be explained in section 3. The algorithms and solution of passing the lines will be illustrated in section 4. Consequently, the main points and conclusions will be explained in

section 5.

2. Line follower robot Structure

This robot can be divided into several parts:

- Sensors
- ADC (Analog to Digital Converter) and sensor circuit
- Processor
- Driver
- Actuators (Motors and wheels)
- Chassis and body structure
- Power Supply (5V / 12V DC)

The electrical circuit of some line follower robots can compare the analog signal received form sensors and then transmit the result to the processor in digit '0' or '1' and some of them send the analog signal to the processor directly. Anyway, the analog signal must be converted to the digital form and then the processor can process it according to that digit. [2]

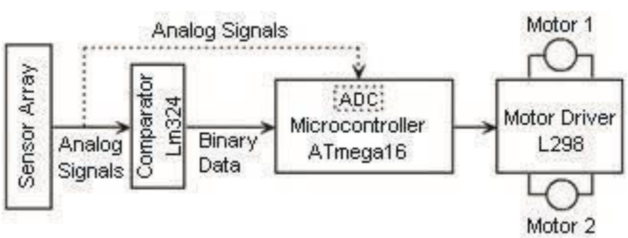

Fig. 2: Line follower block diagram

The microcontroller and other devices get power supply from AC to Dc adapter through 7805, 5 volts regulator. The adapter output voltage will be 12V DC none regulated. The 7805/7812 voltage regulators are used to convert 12 V to 5V/12V DC.

The Sensors

The robot uses IR sensors to sense the line, IR sensors consist of two diodes that one of them sends ray and another one must receive it. If the receiver receives the reflection ray, it means that the robot is on white anc cannot receive it, so the robot is on black.

Fig. 3: IR diodes (Sender and Receiver sensor)

IR reflectance sensors contain a matched infrared transmitter and infrared receiver pair. These devices work by measuring the amount of light that is reflected into the receiver. Because the receiver also responds to ambient light, the device works best when well shielded from ambient light, and when the distance between the sensor and the reflective surface is small (less than 5mm). IR reflectance sensors are often used to detect white and black surfaces. White surfaces generally reflect well, but while black surfaces reflect poorly. Instead of IR diode we can use a sensor package that consist a diode and a transistor.

CNY70 is a reflective optical sensor with transistor output. It consists of two sections: photodiode and phototransistor as can be seen in Fig. 4.

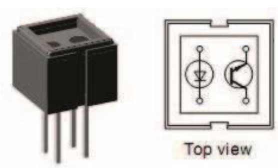

Fig. 4: CNY70 sensor

Diode sends rays and transistor must be receive it. It is very small package and we understood it is better to use The CNY70 because it took fewer parasites.

The distance between sensors and ground surface is important and it is more important that how we put sensors near each other, actually sensors location must be define well. The distance between sensors and ground surface must be 3 or 2 mm and the distance between each sensor is depending to your line width. [1]

In the designed robot, we have used eight sensors and they have suitable distance by each other as can be seen in Fig. 5 and our competition line width was 18 mm.

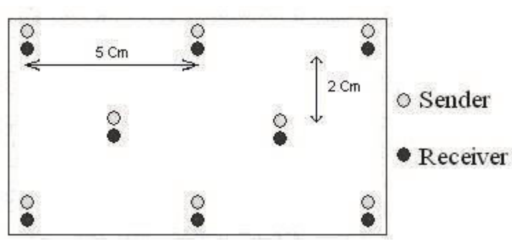

Fig. 5: Sensors location method

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An array of eight sensors, facing the ground has been used in this setup. The output of the sensors is the analog signal which depends on the amount of light reflected back. This analog signal is given to the comparator producing 0s and 1s which are fed to the processor. The processor sends instructions to the driver according to sensors amount. [1]

Each sensor has own fictitious name that we can use them on the programming. For example in Fig. 6 you can be seen our designed sensor name.

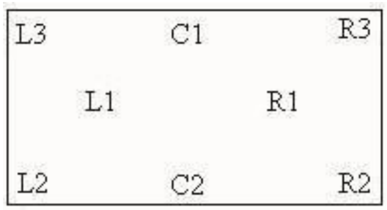

Fig. 6: Sensors name for programming

A simple program written for three sensors robot is shown below. You can pay attention to Fig. 7.

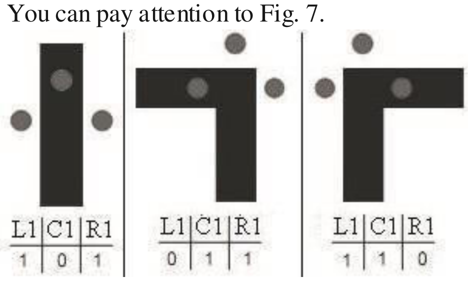

Fig. 7: path of a three sensors line follower

If C1=0 then move forward
If C1=1 then
If L1=0 then move left
If R1=0 then move right

The ADC and sensor circuit

The Sensors Received signal must be converted to the digital form, an ADC can convert it. A good ADC is IC LM324 that can support four sensors. We must use two LM324 to support eight sensors.

The resistance of the sensor decreases when IR light falls on it. A good sensor will have near zero resistance in presence of light and a very large resistance in absence of light. [2]

You can see schematic of circuit of CNY70 and IR diode in Fig. 8 and Fig. 9.

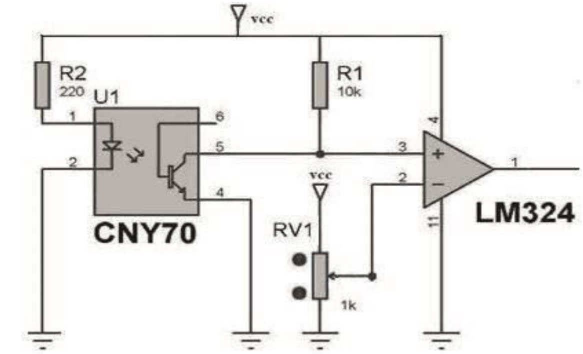

Fig. 8: Schematic of a CNY70 sensor

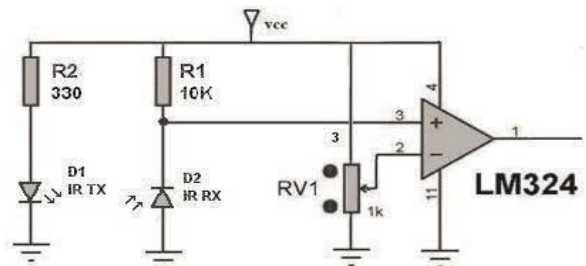

Fig. 9: Schematic of a Diode sensor

To get a good voltage swing, the value of R1 must be chosen carefully.

If RX sensor = a when no light falls on it and RX sensor = b when light falls on it. The difference between the two potentials is:

Vcc * {a/ (a+R1) - b/ (b+R1)}
Relative voltage swing = Actual Voltage Swing / Vcc
= Vcc * {a/ (a+R1) - b/ (b+R1)} / Vcc
= a/ (a+R1) - b/ (b+R1)

The resistance of the sensor decreases when IR light falls on it. A good sensor will have near zero resistance in presence of light and a very large resistance in absence of light. We have used this property of the sensor to form a potential divider. A good sensor circuit should give maximum change for no-light and bright-light conditions. This is especially important if you plan to use an ADC in place of the comparator. [4]

The Processor

We have used the Atmel's AVR microcontroller "At Mega 16" in our project. Because Atmel's AVR microcontrollers have a RISC core running single cycle instructions and a well-defined I/O structure that limits the needs for external components. Internal oscillators, timers, UART, SPI, pull-up resistors, pulse width modulation, ADC, analog comparator and watch-dog timers are some of the features you will find in AVR devices.

AVR instructions are turned to decrease the size of the program whether the code is written in C or Assembly. With on-chip in-system programmable Flash and EEPROM, the AVR is a perfect choice in order to optimize cost. [5, 3]

One of the best AVR is "At Mega 16" which has four ports for I/O and 16 MIPS speed in 16 MHz. The microcontroller power is 5V and it is better to use the 7805 regulator.

The Driver

We must use a driver IC for controlling the motors. The microcontroller sends a signal to the driver that acts as a switch. If the signal received by the driver is high, it will rotate the motor or else it won't do so. Note that the microcontroller only sends a signal to a switch which gives the voltage required by the motor to rotate.

One of good driver for our project is L298 which can be used to control two motors. The L298 motor driver has four inputs to control the motion of the motors and two enable inputs which are used for switching the motors on and off. Many Circuits use L293D for motor control, we chose L298 as it has current capacity 2A per channel 45V compared to 0.6A 36V of a L293D.

L293D's package is not suitable for attaching a good heat sink; practically you can't use it above 16V without cooling it. On the other hand, L298 works happily at 16V without a heat sink, although it is always better to use one. [4]

You can be seen driver schematic in Fig. 10.

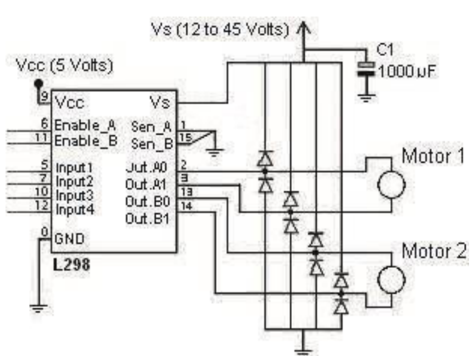

Fig. 10: Front and rear wheels

The microcontroller sends instructions to the driver after processing the data coming from sensors part. The driver gives voltage to the motors according to the inputs. Actually the diver gives positive voltage to one of the motor pins and gives negative voltage to another one which there is five states:

1. Both of the motors are turn on and rotate forward simultaneously. (Move Forward)
2. The right motor is turn on and the left motor is turn off. (Move Left)
3. The left motor is turn on and the right motor is turn off. (Move Right)
4. The right motor rotates forward and the left motor rotates backward. (Move Left Fast)
5. The left motor is rotate forward and the right motor rotates backward. (Move Right Fast)

- Usually two states are not practical in this kind of line follower robots:
  1. Both of the motors are turn off.
  2. Both of them rotate backward.

The Actuators (Motors and wheels)

The movement system is an important part of a robot. And its objective is how to move robot from one point to another one. This system has some details shown us how we should use motors and wheels. We use motors to convert electrical energy to the mechanical energy. There are a lot of kinds of motors and we must choice the best one that we need. Our choice is depended on the robot function, power and precision. Undoubtedly, one of the agents of success of our robot is to choose good motors.[4]

Motor gearbox is one of the best motors for line follower robots. Because it has some gears and axle and its speed doesn't change in towards the top of a hill or in downhill. In this project, two gearboxes 6V 800RPM have been used and we understood that we must use high speeder motor for our project, for example a 12V 1200RPM or 12V 2000RPM motor. Of course, the wheel's radius has effects on the speed.

Usually there are two movement systems for robots:
1. Wheel
2. Tank system

wheel is free and installed front of the robot. Like Fig. 11 shown below.

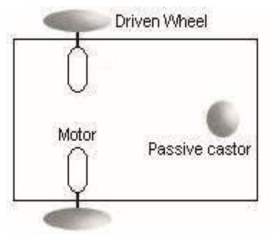

Fig. 11: Front and rear wheels

I designed my Robot, which use two motors control rear wheels and the single front wheel is free.

The Chassis and Body

There are some good materials for designing robots such as wood, plastic, aluminum and brass alloys. We must

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pay attention to the resistance, weight and mechanical ability for choosing one of them. There are some agents that we can use them to choose a good body, ability to perforate, incision, flexibility and etc. [4]

In the designed robot, aluminum has been used for chassis because of its lightweight and being strong enough for our project.

To decrease weight you can install all components on the circuit fiber. For example, you can install motors under the fiber and install battery on the fiber but sometimes it is impossible. In a robot, appearance is not important. The performance is more important than other things.

Warning: Don't use any glue for installing component to each other.

3. Programming

Every microcontroller has own special compiler which we can write program with the language C or Basic for them. After compiling, we must send the compiled program to the microcontroller with programmer. A programmer is a device that can be connected with a computer and we must put the microcontroller on the programmer and then the programmer sends the program into the microcontroller's ROM. There are a lot of programmers and we must use a programmer which can support our microcontroller. [2, 5]

A program has been written for our robot with the language C and the summary of the program has been shown below. In this project, we use At Mega 16 that has four ports. Port A and port B have been used for inputs and outputs, respectively. The data the perform from sensors after Analog to Digital Converting will sends to the microcontroller in port A and after processing with microcontroller the instruction will send to the driver from port B. Below we offer our program to you. For writing the program easily, we define new name for port A's pins and port B's pins. We use the renamed pin in our project. We showed the name of sensors (Port A) in Fig. 5 and use LM0 and LM1 for the left motor pins and RM0 and RM1 for the right motor.

```
#include <mega16.h>
#define LM1 PORTB.1
#define LM0 PORTB.2 #define
RM1 PORTB.3
#define RM0 PORTB.4
#define R3 PINA.7
#define R2 PINA.6
#define R1 PINA.5
#define C1 PINA.4
#define C2 PINA.3
#define L1 PINA.2
#define L2 PINA.1
    #define L3
    PINA.0 void
    main (void) {
    bit FLL=0; bit
    FRL=0; while
    (1) {
          If (C1)
        {   LM1 =1;
            LM0 =0;
            RM1 =1;
            RM0 =0;              }
        else if (R1 ||
    R2)     { LM1
    =1;
            LM0 =0;
            RM1 =0;
            RM0 =1;              }
        else if (L1 ||
    L2)     { LM1
    =0;
            LM0 =1;
            RM1 =1;
            RM0 =0;    }
        if (C1 && C2 && R1 && R3 && !R2 && !R1 && !L2 &&
    !L3)
         {
             if (!FLL)
    { FLL =1;
    LM1 =0;
               LM0 =1;
               RM1 =1;
               RM0 =0;           }
           else
    { FLL =0;
               LM1 =1;
               LM0 =0;
               RM1 =1;
               RM0 =0;           }
         }
      else if (C1 && C2 && L1 && L3 && !R2 && !L1 && !L2 &&
    !R3)
                 { if (!FRL)
```

```
        { FRL=1;
           LM1 =1;
           LM0 =0;
           RM1 =0;
            RM0 =1;           }
        else
{ FRL=0;
           LM1 =1;
           LM0 =0;
           RM1 =1;
            RM0 =0;           }
} }; }
```

4. Some Line follower's path

The figures and rolls that you see in below are according to the First National student's Robotic Competition of the University of Tabriz in year 2009. [6]

The scales and angles of the lines can be changed in the other playgrounds. Actually each competition has its rules and maybe it is different with the other competitions.

We explain some path rules with their in below:

- Usually the ground color is white and the line color is black and line width is variable between 15 mm to 20 mm. The line color and ground color can be exchange together (Fig. 13) but there is no problem because you can write two procedure functions in program for support both of them.

- There is some unwonted change in line width. Pay attention to Fig. 12.

You can write program with this method: if all of the sensors are in black then go forward.

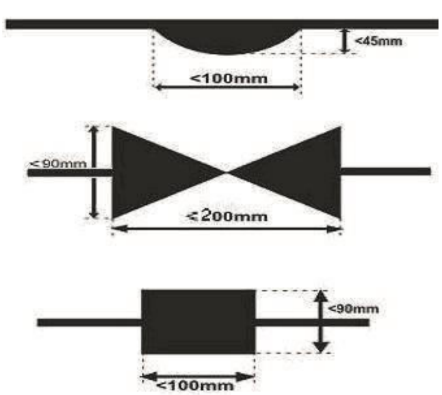

Fig. 12: Unwonted change in the line width

- Suddenly the line color can be invert. Pay attention to Fig. 13.

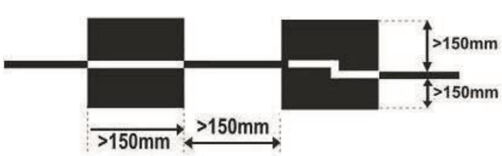

Fig. 13: Inverting in the line color

- Be sure that the line has cycloid or break. Pay attention to Fig. 14.

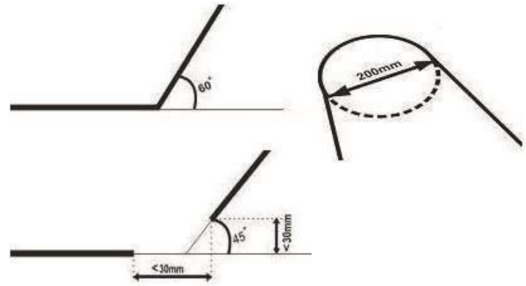

Fig. 14: cycloid and break in way

- Maybe the line has some cycles or bad curves. Pay attention to Fig. 15.

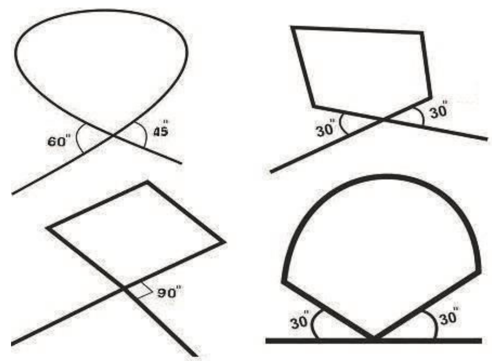

Fig. 15: cycle

5. Conclusion

In its current form robot is enough capable. It can follow any curve and cycle. We must build a robot that has light weigh and high speed because points are awarded based upon the distance covered and the speed of the overall robot. Therefore, we used two high speed motors and high sensitivity sensors circuit.

The body weight and wheels radius have effects on speed, too. The weight of the designed robot is around 300 gram and it can be lighter. To get better maneuver, we must build a robot that uses two motors and two wheels on the rear and a free wheel on the front. The power supply is 12 with regulator.

The designed robot has eight infrared sensors on the bottom for detect line. Microcontroller ATMega16 and driver L298 were used to control direction and speed of motors. The robot is controlled by the microcontroller. In performs change the motor direction by giving signal to driver IC according to receives signals fromsensors.

Acknowledgements

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