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Implementation of Multi Wheeled Omni-wheel Line Following Robot Using ARM7 Processor

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Abstract- Line following robots with multiple sensors and actuators need to have highly efficient processors for precise movement. However the currently employed line following robots in the industries with conventional wheels are less efficient and require multiple loops for the movement. These defects may be improved with highly efficient robot built using LPC2148 microprocessor with omni-wheels and IR sensors. The ARM processor generates the desired pulse width modulated signals for motor control and quickly responds to the digital signals provided by the IR sensors. The use of multiple wheels system reduces the movement time or rotation time.

Keywords – line following; Omni-wheel; Multi-wheel; ARM Processor; Sensors.

I. INTRODUCTION

Line follower robots are type of mobile robots having ability to follow a line precisely with the help of onboard circuitry [1], [2]. This line or path may be a physical mark on the floor. Line tracer will trace black line on a white surface or vice versa [3], [4]. The sensors give the mobility of the robot, which works with analog signals from the microcontroller and the digital input is used to drive the motors [5]. The motor works according to the sensor output and driver.

The usage of line following robots is also increasing day by day. Automation is very much desired in large industrial areas which can be implemented with the help of line following robots for automatic transportation procedure. The next generation airports can be another section to use this line following robot technology. Practical applications of a line follower include automated cars running on roads with embedded magnets; guidance system for industrial robots moving on shop floor etc. [6] – [8].

The current use of conventional type of wheels in line following robots is simplest and its availability can offer only a single rotational axis. The movement of this robot is restricted to the axle shaft it is attached to. The usage of omnidirectional wheels and in these line following robots will have higher flexibility and higher motion performance in replacing conventional wheel based line following robots as it can provide multidirectional and sideways movements perpendicular to the wheel's rotation.

In this work, the following objectives are explored:

1. To explore the features and functionality of ARM7.
2. To design & develop a multi-wheel line following robot using IR sensor.
3. To design a mechanical system that uses three independent omni-wheels for movement.

This paper is organized in following ways. Section II concentrates on overall system architecture. Multi-wheel system, wheel placement and omni-wheels are described in section III. Section IV describes the software development while section V describes the results and analysis.

II. SYSTEM ARCHITECTURE

The LPC2148 Blue Board is an evaluation board for LPC2148 ARM7TDMI based microcontroller. The LPC2148 has an internal memory of 512KB and 32+8K RAM. Of the total number of I/O pins, 9 pins are used for LCD, 3 pins for IR sensors, 9 pins for DC motors and 3 for obstacle sensor. The system architecture is as shown in Figure 1 [9].

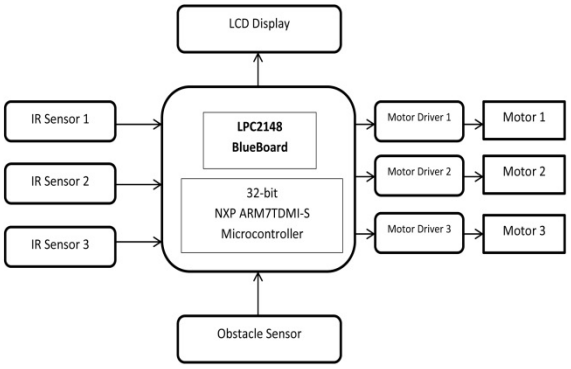

Figure 1: Block diagram of LPC2148 connected I/O pins.

Fig.1. shows the block diagram of the electronic control circuit of the robot. The sensors (phototransistors) are used to detect the black strip on a white background. The sensor output is fed to the micro-controller, which takes the decision and gives appropriate command to motor driver L293D so as to move the motor accordingly.

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The sensor senses the light reflected from the surface and feeds the output to the comparator. The comparator compares the analogue inputs from sensors with a fixed reference voltage. The reference voltage can be adjusted by changing the value of the variable resistor. The micro-controller is programmed to make the robot move forward, backward, turn right or turn left based on the input coming from the comparator. The outputs of the micro-controller are fed to the motor driver. The current supplied by the micro-controller to drive the motor is small. Therefore a motor driver IC is used and it provides sufficient current to drive the motor

III. MULTI WHEEL SYSTEM

Multi-wheel steering is a very important and effective way to improve vehicle maneuverability and handling stability and hence allowing us to achieve the desired function. The Omni-directional vehicle can generate flexibility three degrees of motion freedom on a flat surface using Omni-wheels. Omni-wheels are special wheels having free rollers on wheel circumference. Omni-directional motions are possible if three Omni-wheels are arranged in different directions.

A. Wheel alignment:

For multi-axis automobile such as construction vehicles, trucks and other large-tonnage vehicles, the main purpose of multi-wheel steering is to reduce the turning radius currently, improve vehicle mobility. When small angle turns, the wheels before the vehicle center of mass only participate the turn. The common multi-axis vehicles used three axes, four-axis, or more. Obviously, the more the vehicle axis used, the more group participation in steering wheel to enhance its low-speed steering in case of mobility is needed [10]. The proposed three wheel system is as shown in figure 2.

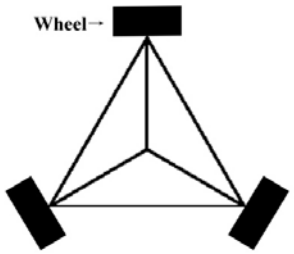

Figure 2: Three wheel system and axis alignment

B. Omni-Wheels:

Automobiles need to switch drives often when engaged in tasks such as parallel parking. The drive performance of ordinary automobiles, which includes neither rotating in place nor maneuvering in a sideways fashion, cannot be considered satisfactory for confined operational environments. For this reason, numerous efforts have been made to develop Omni-directional vehicles with two independent translational degrees of freedom and one rotational degree of freedom, for a total of three degrees of motion freedom on a flat surface [11]. A typical Omni-wheel is as shown in figure 3.

Figure 3: Omni-wheel

IV. HARDWARE REQUIRED FOR PROPOSED WORK

The robot prototype circuit consists of a line detection circuit, a comparator circuit and a motor driver circuit. The information collected by the sensors is forwarded to comparator and the compared signal is fed to the microcontroller. Microcontroller determines the action to be performed and generates a control signal to the motors via the motor driver chip, L293D.

A. Line Sensors:

Line sensor is a circuit which is able to see the black and while lines on the floor and translate the wheels locations in relation to the line. In this robot we have 3-4 infrared sensors. Infra Red option has two major advantages over the light sensor solution. Firstly, the IR spectrum is a lot cleaner than the visual spectrum, as there is a lot less potential for interference. Secondly, the phototransistors will react much quicker than photo cells.

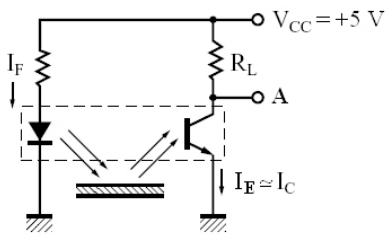

Figure 4: Sensor circuit

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B. *Comparator:*

OPAMP is a voltage comparator. The sensor output is analog. We compare sensor voltage with potentiometer circuit voltage and the OPAMP outcome is the conclusion of this comparison. The LM324 consists of four independent, high gain operational amplifiers on a single monolithic substrate.

i. Binary 1 for high voltage i.e., 5 V
ii. Binary 0 for low voltage i.e., 0 V.

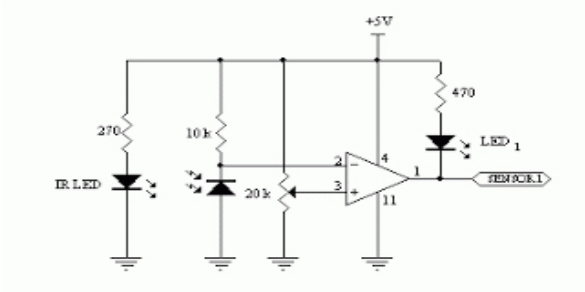

Figure 5: LM324 circuit part

C. *Motor Driver:*

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications [12].

V. METHODOLOGY

A microcontroller is nothing without software to run it. The program file has to be downloaded to the microcontroller written in Programmers Notepad and has to be simulated. The hex file that has to be produced from compiling the program which then transferred serially to the LPC2148 Board via a USB to RS232 converter cable using LPC Flash Utility version 2.2.3 that can be obtained for free from NXP website. Figure 6 shows the overall flow process.

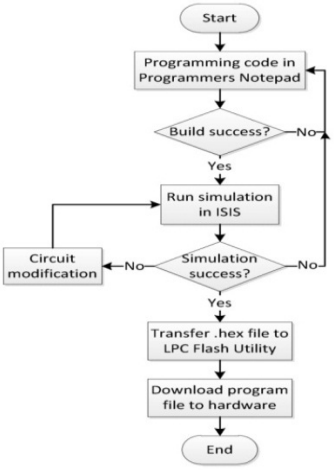

Figure 6: Process flow

The IR sensor will first initialize all variables included and will detect line afterwards as shown in Figure 7. The sensor will either initiate or stop the motor movement in Motor Control subroutine and continuously repeating the same steps corresponding on the line it detects. To move forward or backward, motor 1 and motor 2 speeds are to be controlled in clockwise or counterclockwise while motor 3 is set to zero, this is as shown in figure 7.

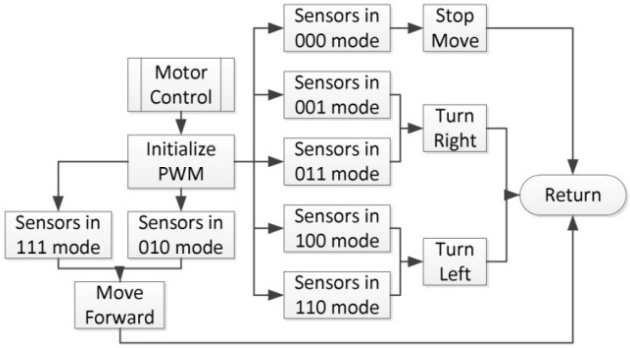

Figure 7: Motor control

The Pulse Width Modulation (PWM) of the Motor Control subroutine in Figure 7 is first initialized before the readings from the IR Sensor subroutine act as the trigger input to drive the corresponding wheels. The program will continuously wait for another reading from the IR sensors.

The application of the high-level software in Figure 8 below starts by configuring the clock frequency of the microcontroller to 12MHz, Phase-Locked Loop (PLL) Multiplier to 5, Peripheral Bus Speed Divider (PBSD) to 4, and not to forget disabling the watchdog timer. The corresponding I/O ports were then initialized before the IR Sensor subroutine takes place.

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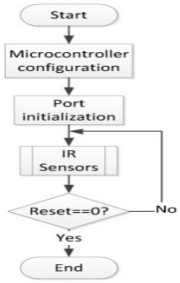

Figure 8: Software application flow

VI. TEST & ANALYSIS

We have used H-bridge circuit to drive the motors.

Pulse width modulation is a square pulse, which we control efficient voltages that goes into the motor terminals. For controlling the speed of motors, microcontroller generates this pulse. And in the robot programming to vary this speed, we specify pulse amount range (periodic) and 12V time amount.

For pulse width motor control,

$$f = {}^{1}/_{t}, \quad (1)$$

where, f=frequency
t = time period.

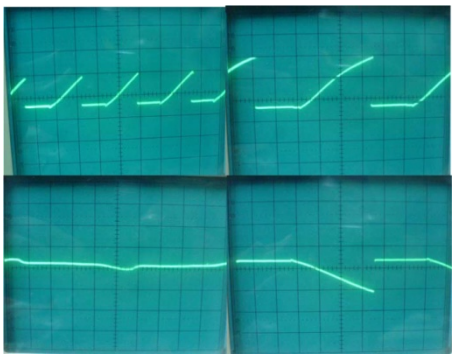

Figure: PWM duty cycle motor control output.

VII. CONCLUSION

The interface functionality between the IR sensors, ARM7 LPC2148 microcontroller and the motor control has been successfully accomplished. Based on test results, the objectives were successfully accomplished. This project can be further expanded and enhanced by using gyro-sensors for advanced navigation systems. Further, the IR sensor can be replaced by CMUcam1/2 sensor for color line tracking, motor sensing. The line following robots can be employed in library inventory management, advanced navigating autonomous robot for disabled persons in hospitals, airport, etc.

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