Implementation of Microcontroller Based Vehicle Speed Control System Using Ultrasonic Range Finder

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Abstract

In vehicle driving, speed control is vital because of whether fast or slow driving may be collision, accidences, delay and jam the traffic.

These types of cases can be reduced or eliminated from the driving by using electronic control technology. In this paper ultrasonic range finder detects the distance between the vehicle and the obstacle during driving and speed control is depending on this detected distance. Pulse Width Modulation (PWM) controls the voltage of the motor. The duty cycle value (PWM) is calculated by fuzzy logic control system based on detected distance and current (PWM) duty value. The process of detection distance and PWM output are controlled by Microcontroller (PIC18F452). The detected distance is less then 50 CM the vehicle will stop. The vehicle can go only forward direction. The control strategy is implemented by using MikroC language.

Keyword: Fuzzy logic, PWM, PIC18F452, Ultrasonic Range Finder.

1. Introduction

Nowadays electronic control technology was developed in all over the world. Microcontroller based control technology is very useful in automatic area. In this paper PIC Microcontroller technology is used [1]. We had designed the circuitry system into the small car model to control the distance between the vehicle and the obstacle. This system consists of distance measurement and controlling the speed of the vehicle. In speed control system fuzzy logic control theory is used in controlling the PWM duty cycle of the motor rotation.

In this system DC motor is used for vehicle moving. Speed controller is the effects of nonlinearity in a DC motor. The detected distance is measured by LV-MaxSonar-EZ1 [2]. Fuzzy logic control program is built in Microcontroller PIC 18F452 and controls the motor speed. The block diagram of this system is shown in figure 1.

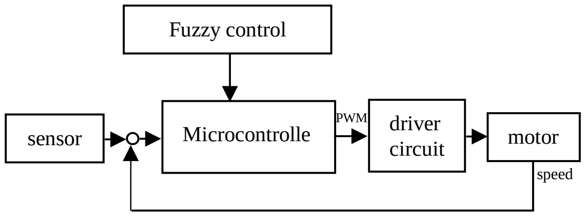

Figure 1: Block diagram of the system

2. Background Methodology

2.1 Fuzzy Logic

Fuzzy logic can be described as the practical side to Fuzzy Set Theory. Fuzzy logic is best used for systems that contain qualitative information instead of quantitative information. It is used for systems that may not have definite values to distinguish the cases that are handled.

In fuzzy logic, membership values are created that describe the degree of truth for a given situation. This degree of truth is a value from 0 to 1. Fuzzy controller has been used in many linear and non linear control systems, especially in uncertain and unknown system.

In this paper speed is controlled by fuzzy logic theory with measured distance of LV-MaxSonar-EZ1 and the current speed of motor.

Fuzzy system consists of fuzzification, rule inference and defuzzification. For fuzzification triangular membership function is used and product inference engine is used for fuzzy rule inference. For defuzzification weighted average method is used and the algebraic expression of weighted average method is described as the following equation. [3]

$$Z^* = \frac{\sum \mu c(\bar{z}).\bar{z}}{\sum \mu c(\bar{z})} \qquad (1)$$

Membership function of distances, current PWM duty value (inputs) and new PWM duty value (output) are shown in figure 2, 3 and 4. To design the database of the system, five linguistic terms are used.

They are VL (very large), L (large), M (medium), S (small) and VS (very small). The rules of the system are shown in Table 1.

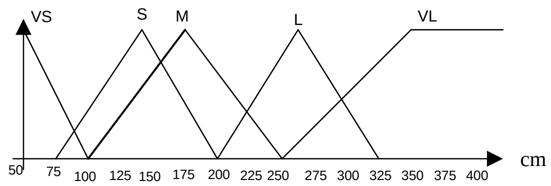

Figure 2: Membership function of distance (input 1)

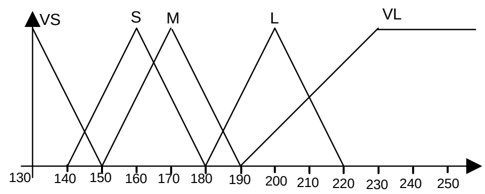

Figure 3: Membership function of current PWM duty cycle value (input 2)

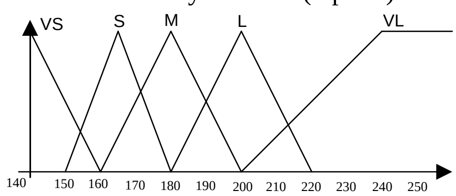

Figure 4: Membership function of new PWM duty cycle valve (output)

Table 1: Rule base for new speed output (PWM duty cycle value)

current speed / distan	VL	L	M	S	VS
VS	VS	VS	VS	S	S
S	VS	VS	S	S	S
M	S	S	M	M	M
L	S	M	L	L	VL
VL	M	M	L	VL	VL

2.2 Pulse Width Modulation (PWM)

The Pulse Width Modulation (PWM) in microcontroller is used to control duty cycle of DC motor. Power supplies to the motor in square wave of constant voltage by varying pulse-width or duty cycle [4]. PWM can change the duty cycle of the pulse based on fuzzy control condition. PWM signal wave form is shown in figure 5.

$$\% \text{ Duty Cycle} = \text{Pulse Width } (t) / \text{Pulse Period } (T) * 100\% \qquad (2)$$

From the figure 5 the pulse width could change the average voltage receipt by the DC motor. The wider the pulse width, the higher the average voltage receipt by the DC motor. The shorter the pulse width, the lower the average voltage receipt by the DC motor. Therefore by varying the pulse width we could vary the DC motor speed. The ratio between the pulse width and the total length of the pulse is called duty cycle, so 100% duty cycle means the DC motor is in its full speed and 10% duty cycle the DC motor is in its 10% of speed [5].

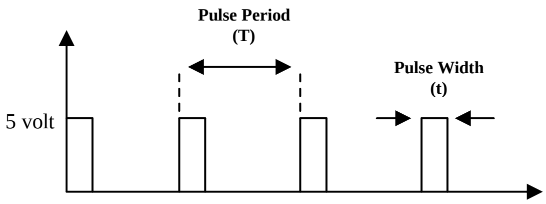

Figure 5: PWM signal

3. Design Consideration

3.1 Firmware Description

The flow chart of the system is shown in figure 7. First the required mode is initialized according to appropriated process and green LED is on. In this process PORT A pin number 1 (AN1) is used for LV-MaxSonar-EZ1 input and system reads the ADC value and calculates the distance. PORT B is used for LCD data out, PORT C is used for motor drive by using Pulse Width Modulation module and PORT D is used for LEDs [6]. Next step if sensor detects the obstacle, the ADC value is obtained from AN1 and then system calculates the distance in centimeter value. The initial speed 60% duty cycle is assigned because initial torque is required to load the motor. The circuit diagram of over all system is shown in figure 6.

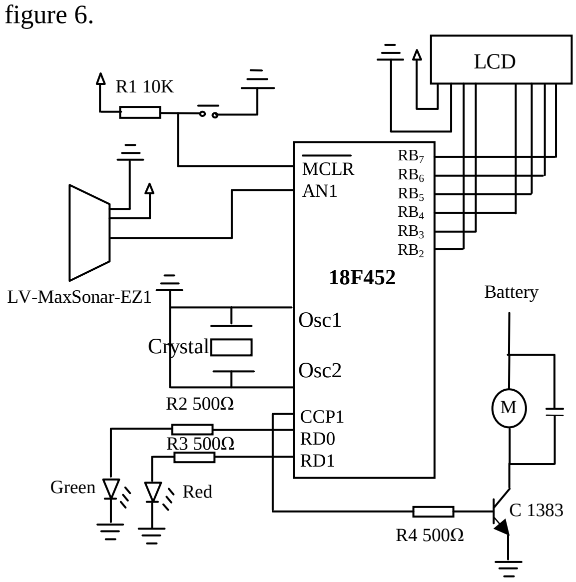

Figure 6: Circuit diagram of the overall system

If the detected distance is greater than 50 cm, this distance and current speed (PWM value) are sent to fuzzy control system and the system generates the new speed (PWM value) otherwise the vehicle will stop and red LED is on. Fuzzy control process is shown in figure 8. LCD displays the detected distance and new speed (PWM value).

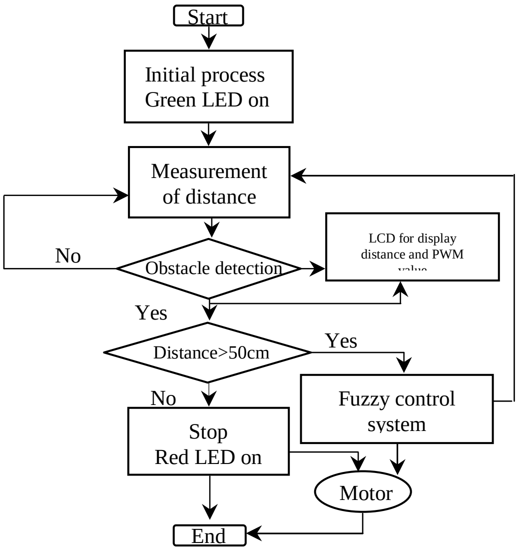

Figure 7: System flow chart

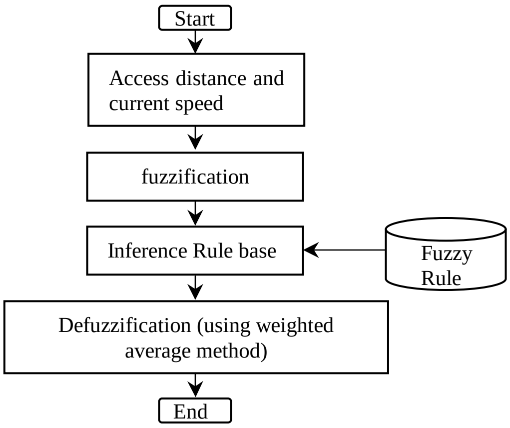

Figure 8: Flow chart of fuzzy control system

3.2 Hardware Description

3.2.1 Ultrasonic Range Finder

LV-MaxSonar-EZ1 [2] is the high performance Ultra Sonic Wave (SONAR) range finder. This is selected to fulfill our requirement and cost-effective method has a simple implementation. The algorithm for obstacle avoidance using this method is simple as it has minimal data handling, resulting in ease of computations and faster processing.

The calculation of distance equation is describe as –
dist_inc = (((5.0*Adc_Read(1))/1024)/9.8e-3)   (3)
dist_cm = dist_inc*2.54

Because LV-MaxSonar-EZ1 pin 3 (AN) has output analog voltage with a scaling factor of (Vcc/512) per inches, the power supply of 5V yields ~9.8mV/in [2]. Functional block diagram of the ultrasonic sensor is shown in figure 9.

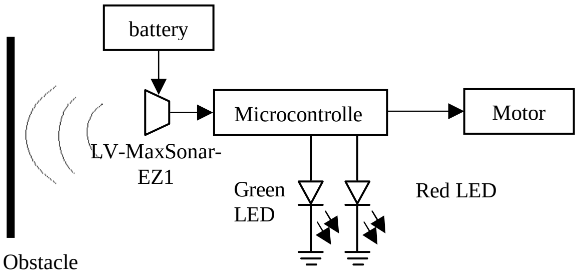

Figure 9: Functional block diagram of the Ultrasonic sensor

3.2.2 DC Motor and Motor Driver

DC motor is used to drive vehicle wheel by rolling along the ground. The purpose of a motor speed controller is to take a signal representing the demanded speed, and to drive a motor at that speed. The controller may or may not actually measure the speed of the motor. Closed-loop control system is normally used for precise speed control. Motors come in a variety of forms, and the speed controller's motor drive output has been different dependent on these forms. Motor driver circuit is shown in figure 10.

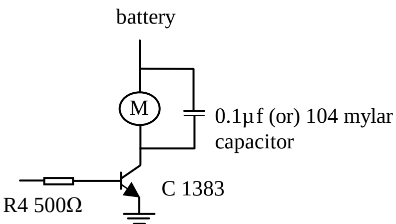

Figure 10: Motor driver circuit

3.2.3 Fuzzy Control Unit

In this paper, fuzzy logic is used to control the DC motor. The measurement distance and current PWM duty value are input of fuzzy control system and output is the generated new PWM duty value. The structure of the proposed fuzzy controller is also shown in figure 11.

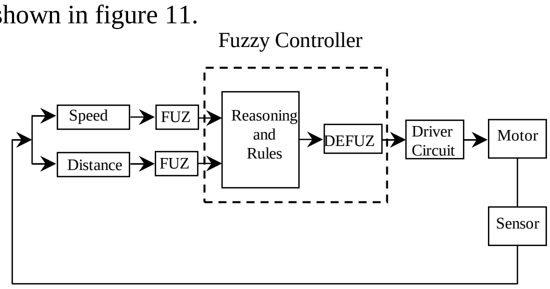

Figure 11: Structure of the proposed Fuzzy controller

3.2.4 Liquid Crystal Display (LCD)

LCD is used as a user interface. LCD will display the detected distance and current speed (PWM duty value) by using PIC18F452. LCD circuit diagram is shown in figure 12.

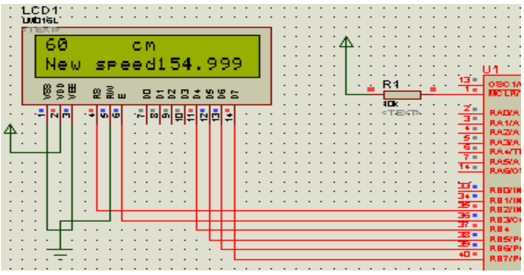

Figure 12: LCD circuit

3.3 Operation of the System

PIC 18F452 operates up to 40MHz clock input [6]. In this paper, 8MHz crystal oscillator is used for operation clock. In this circuit, the appropriate program and voltages are used to operate the whole circuit. For Microcontroller and LV-MaxSonar-EZ1 power supply use 9V battery. Two 1.5V batteries are used to drive motor. To control LCD, 8-bit interface mode is used.

4. Experimental Result

4.1 Distance Measuring Experiment

In experiment the ultrasonic range finder measurement distance is different in the actual distance. These differences are shown in table 2.

Table 2: The differences between actual and measurement distance

Actual distance (cm)	Detected distance (cm)	Ratio of differences
20	17	0.85
40	35	0.87
60	55	0.91
80	75	0.93
100	93	0.93
120	116	0.96
140	136	0.97
160	154	0.96
180	174	0.97
200	192	0.66

All sonar ranging systems happen the problem of sonar reflection. Most objects reflect the incident light energy. The light source scattering occurs because the roughness of an object's surface is large compared to the wavelength of light. For very smooth surfaces (such as a mirror) the reflectivity become highly directional for light rays. Ultrasonic waves discover almost all large flat surfaces reflective in nature. The amount of energy returned is strongly dependent on the incident angle of sound energy. Figure 13 is the char of differences between actual and detected distance.

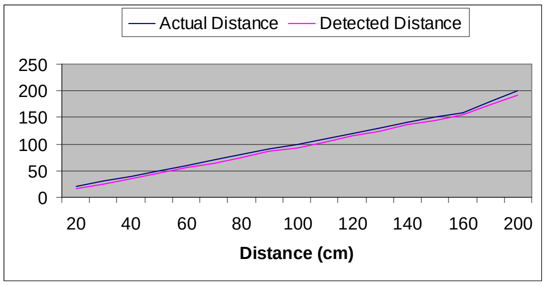

Figure 13: Differences between actual and detected distance

4.2 Vehicle Speed Control System Experiment

With fuzzy control and without fuzzy (decision-making) control [7] testing is difference in speed. Changing of Fuzzy control speed depends on its rules.

Although without fuzzy (decision making) control speed vary as constant on its decision, vehicle speed can be correctly controlled with fuzzy. With Fuzzy and without Fuzzy of vehicle speed control system differences are shown in figure 14. Constructed Vehicle Speed Control System is shown in figure 15.

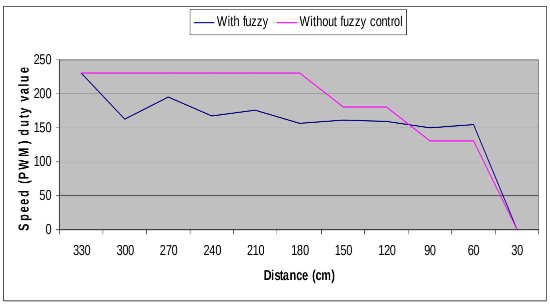

Figure 14: Vehicle speed with and without Fuzzy control system

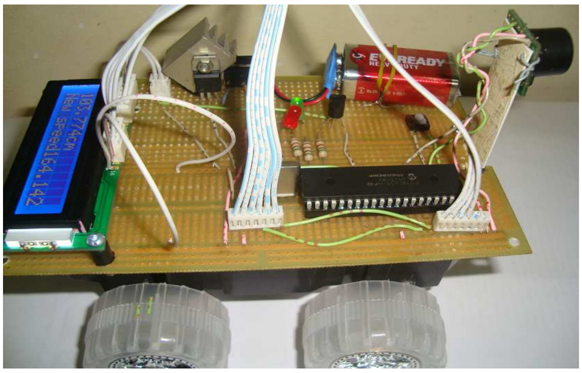

Figure 15: A photo of constructed Vehicle Speed Control System

5. Advantages

This system has advantages. These are stated as follows:

- Collision avoidance for vehicle driving.
- Efficient vehicle speed control by using fuzzy logic concept embedded in PIC.
- Applying the electronic control device into the automotive system.
- Preventing real-end crashes.

6. Conclusion

At the end of the paper, the circuit module and mechanical structure for the vehicle speed control system has been successfully constructed and demonstrated.

Based on detected distance and Fuzzy logic control, this systems adjust the vehicle speed to establish a safe stopping distance.

According to fuzzy logic control algorithm the vehicle speed control system could operate well within an expected performance. However, the models development still has some limitations.

Limited Ultrasonic sensor range is not stable for certain range. The LV-MaxSonar-EZ1 [3] sensor detection range is 6.45 meter but in real it can work well about 4 meter. The vehicle can not turn left, right and can not move backward. Vehicle stopping system can not actually stop desired distance because of vehicle inertia. So vehicle moves further distance even the motor has already stopped.

More efficient braking method can be implemented to reduce the time for the vehicle stop. To achieve less sensitive disturbances more accurate sensor must be used. For left and right turning more motors will be required. H-Bridge motor driver circuit may be used for forward and backward driving.

From the system testing and demonstration, vehicle speed control system has achieved the objective where the system is intended to prevent rear-end crashes; monitor the zone in front of the obstacle during driving.

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