DC Motor Speed Control with Pulse Width Modulation Using Genetic Algorithm

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Abstract

Genetic Algorithm (GA) and fitness function equation is write in basic language and embedded in Microcontroller. The fitness value from function is assign as the duty cycle of the DC motor. In this system 6 bit chromosome is set up due to the memory size of the Microcontroller . Highest fitness value is determined the DC motor and others members from new population is discard. Serial interface is used for the communication between PC and Microcontroller. Magnetic sensor is used to capture the rpm of the DC motor.

1.Introduction

The technique of controlling the DC motor is PWM(Pulse Width Modulation) control, which is low cost, reliable and common. The speed of the DC motor is depend on the Duty cycle of the Pulse Width Modulation, input to it. The value of the Duty cycle can be theoretically and practically control by the Genetic Algorithm and function (or) equation of the fitness value. The aim of the thesis is to get the highest fitness value and the new population which maintain the best fitness value. Duty cycle determined the speed of the DC motor at constant voltage. The Pulse Width Modulation generates from CCP1 channel of the PIC16F877 control the DC motor.

Random population is input into the system from keyboard by user and serial interface is used to communication between Microcontroller and personal computer for random input and text message.

PIC 16F877 has two PWM channels. CCP1 is channel 1(PORTC 2) and CCP2 is channel 2 (PORTC 1). Microcontroller can change the duty cycle between 0 to 255. 0% is low all time(OFF all time). 255% is high all time (ON all time). If duty cycle is 127, 50% on all time. The higher frequency is 32767KHz. Two PWM channels have the same frequency. The speed of a DC motor can be varied by changing the average voltage applied to the input. A Pulse Width modulated signal is created by switching the output on and off at some Duty cycle. The output is switched on for a short time duration (lower duty cycle) during each cycle. The result is a low average voltage seen by the motor resulting in a slower speed. The output is switched on for a longer duration (higher duty cycle) during each cycle resulting in a high average voltage and higher motor speed[7] .

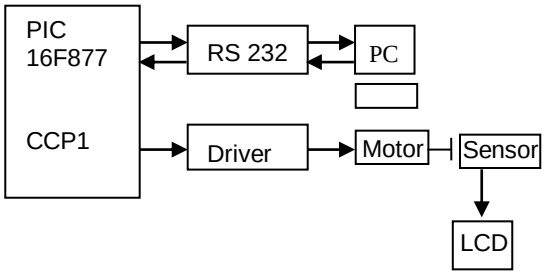


Figure 1. Block Diagram of the System

2. Background Theory

Genetic Algorithm (GA) were designed as objective search and optimization algorithm. A Genetic Algorithm (GA) is a search technique used in computing to find exact or approximate solution to optimization and search problems. GA use technique inspired by evolutionary biology such as inheritance, mutation, selection and crossover. Genetic Algorithm are implemented as a computer simulation in which a population of abstract representations (chromosomes) of candidate solution (individuals) to an optimization problem evolves toward better solutions. Solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible. The evolution usually starts from a population of randomly generated individual and happens in generations. In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population and

modified to form a new population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached.

A typical genetic algorithm requires two things to be defined.

1. A genetic algorithm representation of the solution domain.

2. A fitness function to evaluate the solution domain.

The fitness function is the function, which is to optimize. For standard optimization algorithms, this is known as the objective function.

$$F(x) = 12340.563 - \sum (y - y_i)^2$$

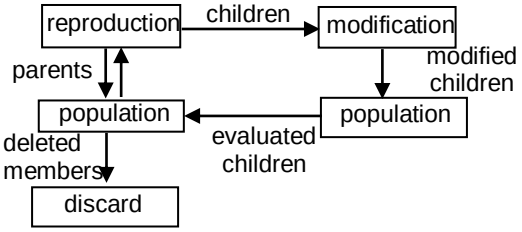


Figure 2. GA Cycle of Reproduction

Chromosome is a string of real numbers or a binary bit string. At the beginning of a run of genetic algorithm a large population of random chromosomes is created. In this system 6 bit of chromosomes is created, due to the Microcontroller's memory capacity. Then test each chromosome to get how good this drive the DC motor and assign a fitness value by genetic algorithm. The fitness value is a measure of how good that chromosome is driving the DC motor. Select member from the current population. The chance of being selected is proportional to the chromosomes fitness. Select two members from the current population. Then crossover the bits from each chosen chromosome at a randomly chosen point. Step through the chosen chromosomes bits and flip dependent on the mutation rate. Mutation function is optional for this system. Repeat these steps until a new population of 50 members has been created.

The function for the fitness value is,

$$F(x) = \text{highest fitness value} - \sum (y - y_i)^2$$

The output from the function of fitness is assign as the duty cycle of the DC motor and others members are discard in Microcontroller.

Table 1. Calculation of the Genetic Algorithm

String	F(x)= 12340.563- $\sum (y-y_i)^2$	Expected count F/average	Actual Count
000101 000110	150.01	1.70	2
001010 000011	60.01	0.68	0
000111 010101	55.46	0.63	0

$C_{mini} = 1$, $C_{maxi} = 5$ (user defined constant)

$$C_i = C_{mini} + \frac{b}{2^L - 1} (C_{maxi} - C_{mini})$$

C_i , i = 1, 2

b = the number in decimal form

L = Length of the bit string

$y = C_1x + C_2$

3.Implementation

3.1 Software Implementation

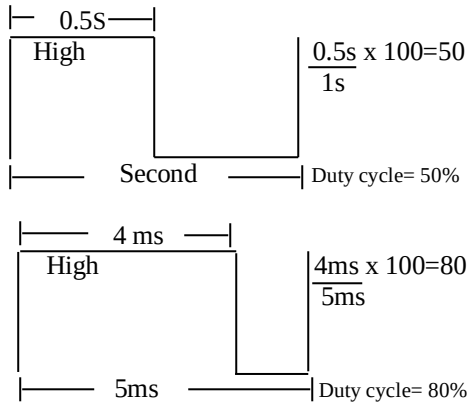
The operating program is write in the PIC Basic Pro compiler. The compilation code is assemble with the PIC Basic Pro assembler. Assembler code is burned into the PIC Microcontroller by EPICWIN programmer software.

The main program is written in Microcode Studio IDE software. It is used the PM compiler to implement the control algorithm with the fitness equation. PIC Basic PRO assembler and EPICWIN programmer is used for downloading the .Hex Files to the microcontroller. Serial communication is used for the communication.

The speed of the DC motor is control with pulse width modulation. The duty cycle is come from the fitness function of genetic algorithm in this system. When the new fitness value is evolve, Microcontroller change the duty cycle of DC motor by CCP1 (PORTC.17) pin.

$$\text{Duty cycle} = \frac{\text{Time signal in high state}}{\text{Period of cycle}} \times 100$$

For example,



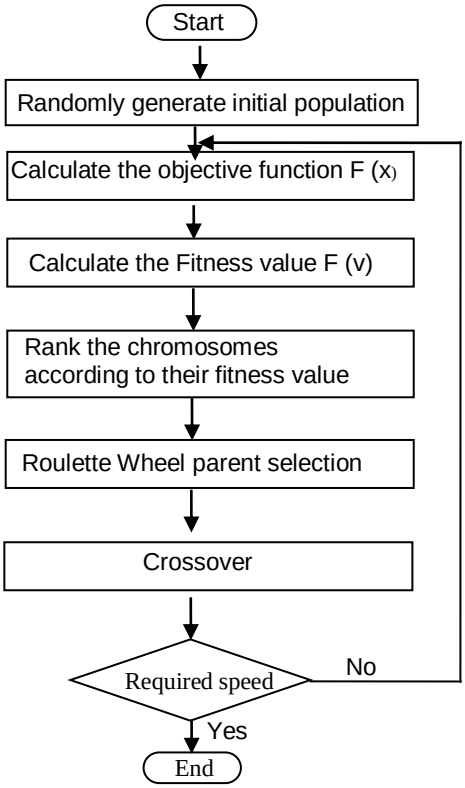


Figure 3. Flowchart of the Genetic Algorithm

3.2 Hardware Implementation

Program burned, PIC is install on the application circuit board. MAX 232 level shifter Ic is used for the serial communication. The voltage supply for the DC motor is fixed on circuit board and the pulse width modulation is derived by the PIC output user can input the duty cycle from Pc. The speed of the DC motor is compute by the speed equation.

The required switching sequences are produced by the PWM generator from microcontroller PIC 16F877 (pin 17, CCP1) through the IRF 540N MOSFET. Magnetic sensor used has low resistance value to prevent power losses.

PWM controls the average of the motor current and is suitable for precise current control. The advantage of controlling a motor with PWM instead of a real analog signal is that full torque of the motor can be used. The PWM signal is not used to directly drive the load. It is used to control a switch that delivers the need power to the load.

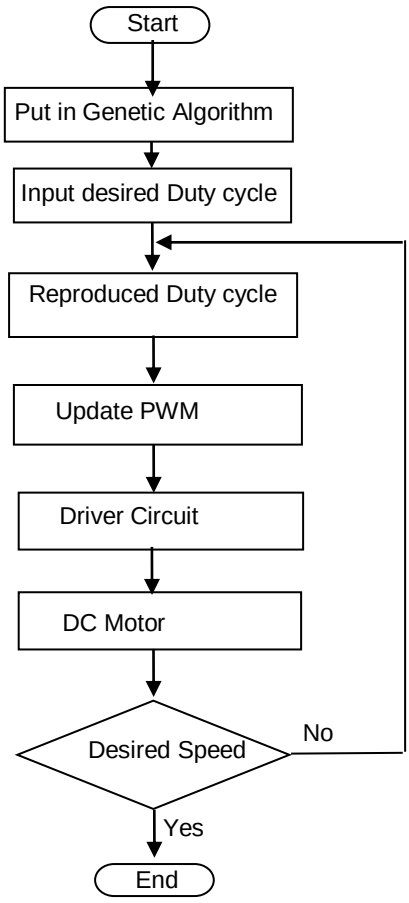


Figure 4. Flowchart of the DC Motor Control System

3.2.1 Operation Concepts

It can be run the system OFF-Line with required input to achieve desired level of control and results by using the terminal software. For instance smart term.

The main program is written in Microcode Studio IDE software. It is used the PM compiler to implement the control algorithm with the fitness equation. PIC Basic PRO assembler and EPICWIN programmer is used for downloading the .Hex Files to the microcontroller. Serial communication is used for the communication.

In this system, the voltage supply (+5v) is fixed for permanent magnet low voltage DC motor and the speed is controlled by changing duty cycle. The Pulse Width Modulation, input by the user determined the speed of the motor. The desired speed of duty cycle is first input to the Genetic Algorithm and manipulated variable outcome from algorithm is assign as the value of desired duty cycle. By the aid of the driver circuit, the Pulse Width Modulation through the IRF 540N MOSFET is control the speed of the motor. Current speed and distance is shown by LCD when the system is diverse, there is no fitness value in calculation, it may need to reset the system. Input value of x is assigned as the chromosome and y is assigned as the length of chromosome. Value of x determined the duty cycle of the system and the voltage is fixed in the control circuit.

4. Experimental result

Table2. The Experimental Result of the System

Time	Duty Cycle	Speed	Distance
30 s	1	27.33	0.273
		26.33	0.550
		27.55	0.822
30 s	5	32.53	0.235
		36.44	1.193
		39.04	0.367
30s	7	40.34	0.756
		40.02	0.388
		42.25	0.411

The speed of DC motor is read with speedometer by magnetic sensor and shown with LCD. Table 2 show the duration of test time, duty cycle. Speed and distance from the speedometer.

In this system, when the computed fitness value is reached at maximum 21340.563, the speed is 76.55 ms^{-1}. According to the algorithm the motor must be stop in this condition.

5. Conclusion

Genetic Algorithm make searching more efficient, as well. Instead of attempting to find a certain value within a range of values by testing each value element, a Genetic Algorithm can evolve a match in only few iterations. Genetic Algorithm differ from traditional optimization algorithms in four important respects, they work using on encoding of the control variables, rather than variables themselves. They search from one population of solution to another rather than from individual to individual. They use only objective
function information, not derivatives and use probabilistic, not deterministic, transition rules.

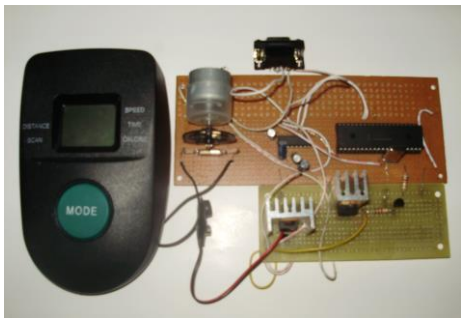


Figure 5. DC Motor Control Circuit

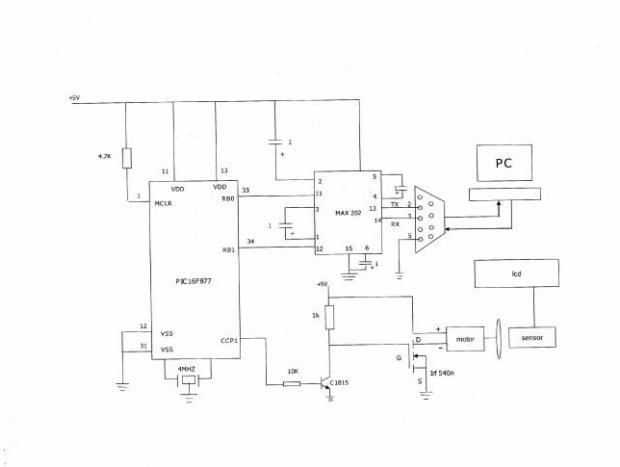


Figure 6. Circuit Diagram of the System

6. REFERENCES

[1] "A Genetic Algorithm Tutorial By Darrell Whitley"
http:// samizdat.mines.edu/ga_tutorial

[2] “A field Guide to Genetic Programming”
http://www. gp field-guide.org.uk
[3] “A Paractical Tutorial on Genetic
Algorithm” http://fog.neopages.org
[4] “Control System”
http://www.en.wikipedia.org/wiki/Control
theory
[5] “DC Motor Analysis & Troubleshooting”
http://www.pdma.com/oldart.html
[6] “DC Motor Model”
http://www.circuitcenter.com/ circuits/ dc
motor/ dc motor model.CIR
[7] “DC Motor Speed Modelling”
http://www.engin.umich.edu/group/ctm/
example/motor/motor.html
[8] “DC Motor Theory”
http://www.zone.ni.com/devzone/
devzonewe.nsf/opendoc
[9] “DC Motor Theory”
http://www.zone.ni.com/devzone/
conceptd.nsf/ webmain