Automobile Prototype Servo Control

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Abstract

Now day's servo system has huge industrial applications. In this paper we have given a detailed study of the servo control that is needed for the prototype. In many applications like vehicle control, medical applications, robotic movement control, etc.; distance measurement of an object is used. The distance measurement by the sensors controls the servo motor output. The servo will then control the direction of an automobile prototype using Raspberry Pi.
Keywords: Servo Motor; Sensors; Distance Measurement; Direction Control; Object Following Algorithm

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I. Introduction

The accelerating change in technology has resulted in the increase of automation. Controlling robot arms, unmanned airplanes control surface or any object that you want it to move at certain angle and stay at its new position is made possible using servo motors. Servo motor applications are also commonly seen in remote controlled toy cars for controlling direction of motion and it is also very commonly used as the motor which moves the tray of a CD or DVD player. Besides these, there are other hundreds of servo motor applications we see in our daily life.[1]

Usually servo motors come with arms (metals or plastic) that are connected to the object required to move. Servo motors may be classified according to size or torque that it can withstand. They are classified as mini, standard and giant servos.

II. Working Principle Of Servo Motor

The main reason behind using a servo is that it provides angular precision, i.e. it will only rotate as much we want and then stop and wait for next signal to take further action.

Unlike dc motors, with servo motors you can position the motor shaft at a specific position (angle) using control signal. Inside the servo box is a DC motor mechanically linked to a position feedback potentiometer, gearbox, electronic feedback control loop circuitry and motor drive electronic circuit. The motor shaft will hold at this position as long as the control signal is not changed.

The shaft of the DC motor is coupled with another shaft called output shaft, with help of gear assembly. This gear assembly is used to step down the high rpm of the motor's shaft to low rpm at output shaft of the servo system. The voltage adjusting knob of a potentiometer is so arranged with the output shaft by means of another gear assembly, that during rotation of the shaft, the knob also rotates and creates an varying electrical potential according to the principle of potentiometer. This signal i.e. electrical potential is increased with angular movement of potentiometer knob along with the system shaft from 0° to the desired angle.

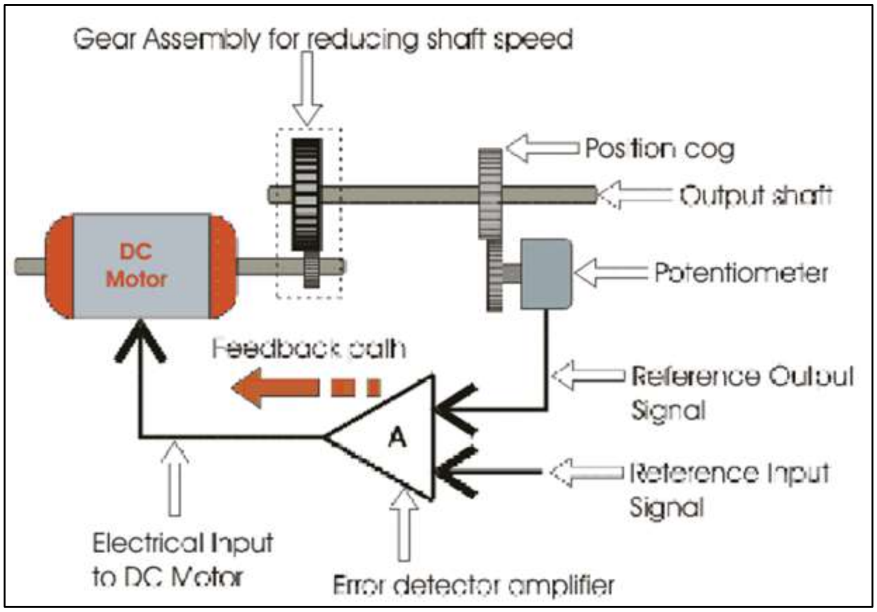

Fig. 1:

This electrical potential or voltage is taken to the error detector feedback amplifier along with the input signal voltage. As the angle of rotation of the shaft increases, the voltage from potentiometer increases. At the desired angle, this voltage reaches to a value which is equal to the given input voltage to the system. At this position of the shaft, if there is no difference between the signal voltage coming from the potentiometer and reference input voltage to the system, the output voltage of the amplifier becomes zero. Hence the motor will stop rotating after the shaft rotates to the desired angle. The motor will be at this rest position until another command is given to the system for further movement of the shaft in desired direction. [2]

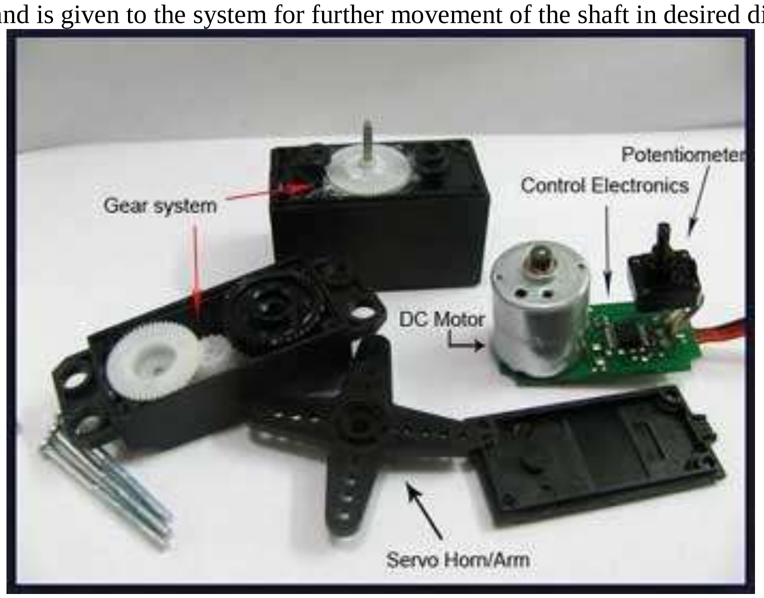

Fig. 2:

In simple words, the shaft of the servo is connected to a potentiometer. The circuitry inside the servo, to which the potentiometer is connected, knows the position of the servo. The current position will be compared with the desired position continuously with the help of an Error Detection Amplifier. If a mismatch is found, then an error signal is provided at the output of the error amplifier and the shaft will rotate to go the exact location required. Once the desired location is reached, it stops and waits.

III. Servo Ratings

A. Servo speed

defined as the amount of time (in seconds) that a servo arm attached to the servo output shaft will move from 0-60 degrees. Lower the time, the faster the servo can move an attached wheel or arm.

B. Servo Torque
defined as the total push/pull power a servo can apply on a 1" servo arm when moving.

C. Servo Power
defined as the amount of DC voltage needed to operate a servo without damage. Servos operate from 4.5 to 6.0 volts. Higher voltage makes the servos move faster.

The Servomotor we've selected for our purpose is the TowerPro MG995R Servo Motor. Its specifications include.

1) Dimension: 40.7 x 19.7 x 42.9 mm approx.
2) Servo torque: 9.4 kgf•cm (4.8 V), 11 kgf•cm (6 V)
3) Operating speed: 0.17 s/60º (4.8 V), 0.14 s/60º (6 V)
4) Operating voltage: 4.8 V a 7.2 V
5) Double Ball bearing design

Fig. 3:

IV. SERVO MOTOR DRIVER

A servo motor controller is a circuit that is used to control the position of a servo motor. It is also called as a servo motor driver. It consists of a controller, the servo motor and the power supply unit. It may be used to control a single servo or even a group of servo motors. The connections of the servo motor are given in figure 4. Servo motors operate from 4.8V to a 6V supply voltage. The typical value is 5v. Applying voltages greater than the supply voltage is not advisable. The current draw of the motor is variable and depends on the torque that it generates. It will draw less current when in idle mode and more current when it is running.

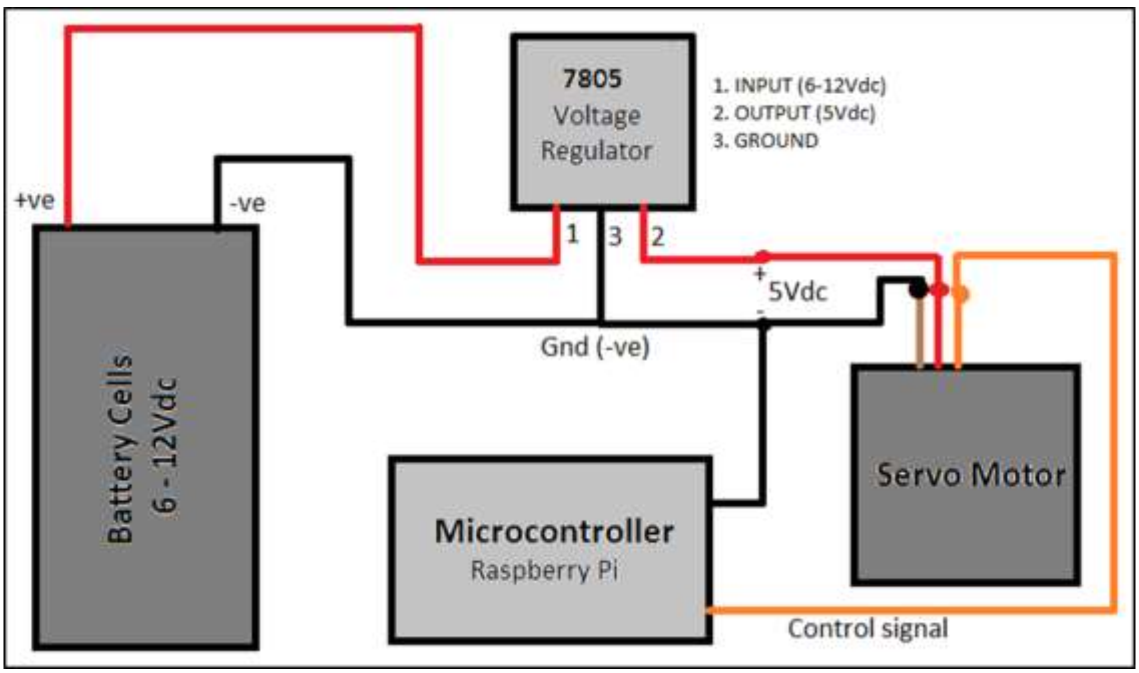

Fig. 4:

Each servo has a built-in processor that responds to electrical pulses sent to it. The servo creates an electrical pulse by sending voltage to one of its pins for a very specific amount of time. The microcontroller cannot control how much voltage is sent – it simply turns the voltage on or off. The servo can turn the output voltage on and off rapidly, thereby creating pulses of high and low voltages. The duration of these pulses is known as the pulse width. The longer the voltage is applied, the larger the pulse width.

The servo motor angular position is controlled by applying PWM pulses of specific width. The duration of pulse varies from about 1 ms for 0 degree rotation to 2 ms for 180 degree rotation. The pulses need to be given at frequencies of about 50Hz to 60Hz.[3]

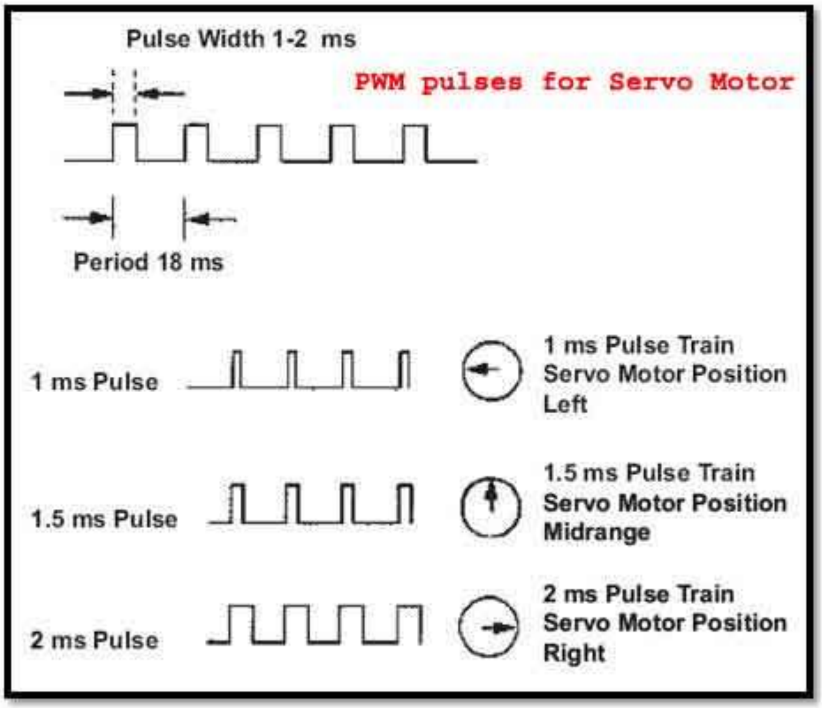

Fig. 5:

V. Servo Logic Used

A. *Object Following Algorithm:*

Considering the values of the 2 HCSR04 ultrasonic sensors, i.e. the left and the right sensor; the direction in which the servo is to move, is implemented. The 2 sensors measure the distance of the object/ car ahead of it. The values of both the sensors are compared to give an appropriate output to follow the object/car.[4]

1) Case 1: The distance measured by left sensor > distance measured by right sensor The servo motor will be given a pulse width less than 1.5ms to give an output of 65 degrees angle which will move the prototype in the left direction.
2) Case 2: The distance measured by left sensor = distance measured by right sensor The servo motor will be triggered a pulse width of 1.5ms to give an output of 90 degrees which will keep the prototype moving continuously in the neutral mode. It will follow the object/car straight ahead.
3) Case 3: The distance measured by left sensor < distance measured by right sensor The servo motor will be given a pulse width greater than 1.5ms to give an output of 105 degrees angle which will move the prototype in the right direction.

Table I gives the experimental results for the object following algorithm carried out. We observe that there is considerable error. The errors that occurred to get the exact angle by the servo were corrected while programming the code.

Table – 1

Left sensor distance (in cm)	*Right sensor distance (in cm)*	*Servo direction*	*Angle (in degrees)*
27	*7.5*	*Right*	*65*
25.3	*10.6*	*Right*	*65*
23.3	*13.2*	*Right*	*65*
20.8	*15.4*	*Right*	*65*
17	*17*	*Neutral*	*90*
15.1	*20.3*	*Left*	*105*
13.6	*23.9*	*Left*	*105*
10.5	*25.1*	*Left*	*105*
7	*27.8*	*Left*	*105*

VI. Conclusion

The working principle of the servo motor was studied carefully to choose the right servo motor, satisfying all needs for use in the automobile prototype system being developed. Distance measurement using ultrasonic sensors and object following algorithm has been successfully implemented on the prototype.

Acknowledgment

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