SCALED CONTROL OF DC MOTORS

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A report submitted in partial fulfillment of the requirements for the degree of Mechatronics Engineering

Faculty of Electrical Engineering

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"I hereby declare that I have read through this report entitle "Scaled Controled of DC Motors" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering"

Signature :……………………………………………….

Name : Dr. Ahmad Zaki bin Haji Shukor

Date :

I declare that this report entitle "Scaled Controled of DC Motors" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :…………………………………………….

Name : Ng Cho Liang

Date : 18th June 2015

To my beloved mother and father

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ABSTRACT

Scaling of DC motors using a control system can be used in many applications such as robotics, pneumatic or even in the industry. The importance of this scaling control of DC motors can save a lot of time and energy for the user. In many applications, scaling control of DC motors causes a lack of performance in the delay time when the motor rotated to the desired set point and the deviation error when each of the motors being rotated to the specified angle. The delay time and deviation error are crucial for the whole development of the process in order to increase the smoothness and efficiency of the system. The main objective is to scale the smaller motor or the larger motor respectively, which act as an actuator under a standard force on one of the motors, the larger motor or smaller motor respectively will scaled the torque to become smaller or larger. Other than that, to calculate the delay for the DC motors and the deviation of the error in the motors. For the methodology, the first part is to take the encoders reading for both motors in order to calculate the time delay for both of the motors. Second part comprises of measuring the beginning angle and last angle of the motor in order to know the exact error after the scaling being done. Hence, the parameter of each of the results tabulated need to be calculated accordingly in order to know the scaling factor which will relate to the torque parameters which the current and force that being applied on the DC motors. The error in time delay is about 5.0s. The deviation of the angle that produces is around 5˚. Lastly, the scaling factor around the range of 10.

ABSTRAK

Motor DC menggunakan skalar sistem kawalan boleh digunakan dalam pelbagai aplikasi seperti robotik, pneumatik atau dalam industri. Kepentingan kawalan skalar ini dengan menggunakan DC motor boleh menjimatkan banyak masa dan tenaga untuk pengguna. Dalam banyak penggunaan, kawalan mendaki DC motor menyebabkan kekurangan prestasi dalam masa tunda apabila motor berputar ke titik set yang diingini dan kesilapan sisihan apabila setiap satu daripada motor yang berputar dengan sudut tertentu. Masa tunda dan kesilapan sisihan adalah penting untuk pembangunan keseluruhan proses bagi meningkatkan kelancaran dan kecekapan sistem. Objektif utama adalah untuk skala motor yang lebih kecil atau motor yang lebih besar, masing-masing yang bertindak sebagai penggerak di bawah satu kuasa standard di salah satu motor, motor yang lebih besar atau lebih kecil motor masing-masing akan diskalakan tork untuk menjadi lebih kecil atau lebih besar. Selain daripada itu, untuk mengira tunda bagi motor DC dan sisihan ralat dalam motor. Untuk kaedah ini, bahagian pertama adalah untuk mengambil pengekod membaca untuk kedua-dua motor untuk mengira kelewatan masa untuk kedua-dua motor. Bahagian kedua terdiri daripada mengukur sudut bermula dan sudut terakhir motor untuk mengetahui ralat sebenar selepas skalar yang telah dilakukan. Oleh itu, parameter setiap keputusan perlu dijadualkan akan dikira sewajarnya untuk mengetahui faktor penskalaan yang berkaitan dengan parameter tork yang semasa dan kuasa yang sedang digunakan pada motor DC. Kesilapan kelewatan masa adalah dalam 5.0 saat. Sisihan bagi sudut yang menghasilkan sekitar 5˚. Akhir sekali, faktor bersisik di sekitar lingkungan 10.

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LIST OF ABBREVIATIONS

cpm	-	Cubic feet per minute
s	-	Seconds in Time
Nm	-	Newton metre
^{o}	-	Degree
V	-	Voltage or Voltage unit
I	-	Current
A	-	Ampere unit
RPM	-	Revolution per minute
α	-	Angular acceleration
P	-	Power
τ	-	Torque
ω	-	Angular velocity
k	-	Constant
Hz	-	Hertz
J	-	Inertia
N	-	Force
k	-	Scaling factor

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CHAPTER 1

INTRODUCTION

1.1 Motivation

DC motors are widely used nowadays no matter in a small or big industry. The usage of DC motor advantage over AC motor is the starting torque. This advantage is important for the processor to save the delay time occurred when measuring the speed. DC motor steady state speed can be achieved in just less than 5 seconds while AC motor tends to use longer than 5 seconds. DC motor is a very useful application in robotics and industrial. For examples in robotics, as shown in Figure 1.1 below. The arm uses for microsurgery in the surgery for complicated surgery. Doctor just needs to move the robot assisted microsurgery (RAMS) and the other end of the micro forceps will apply the small and precise force [1].

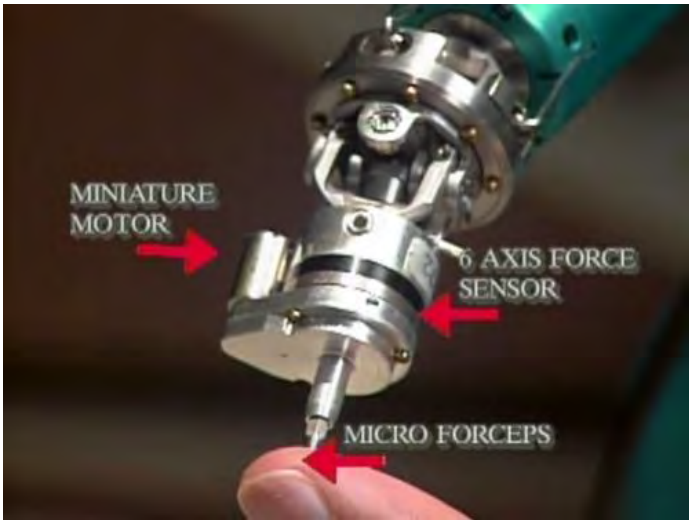

Figure 1.1: Robot Assisted Microsurgery (RAMS) arm [1]

In a pneumatic system, the DC motor used for scaling from small to big motor as shown in Figure 1.2 below. The pneumatic system with 40 head rotary fillers can produce speed up to 400 cpm. The motor can turn from the PLC Allen Bradley controller to the 40 head rotary filler using the provided motor.

Figure 1.2: Pneumatic Filler Liquid (PNEUMAFLOW) [2]

DC motor with higher torque can amplify the torque with a DC motor with a smaller torque as a reference. This shows that the performance of the whole system will improve tremendously and hence given me, an aspiring idea to do this project. Examples of application can be used in this project will be electric cars, robotics parts and pneumatic cylinder in car manufacturing industry. The diagram below Figure 1.3 and Figure 1.4 shows the simple illustration of the project:-

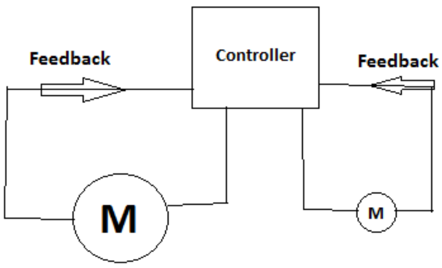

Figure 1.3 and 1.4: Illustration of scaling using a small motor to a bigger motor

1.2 Problem Statement

Due to the lack of performance when running two DC motors together synchronously, the value of the encoder in the motor varies a lot from the actual value. This cause a lot of problems to the user and the system. The system might breakdown or the whole operation will suspended. The problem arises is the deviation of values between the two motors when running together in which, causes the desired setpoint cannot be achieved. Secondly, the deviation to the error percentage of both the DC motor when being rotated and the delay time for the primary motor to the secondary motor response time which causes the motor to operate improperly. The force amplication of the small motor to the large motor need to be known in order to get the exact value after the small motor being rotated. The value of the force decrement from the large motor to the small motor also needs to be found out in order to get the correct decrement of force in the system. However, the tuning of the control parameter from the Proportional Intergral Derivative controller (PID) can reduce the deviation of angle and time delay in the motors.

1.3 Objectives

The objectives for this final year project are:-

1. To implement motion and force amplification for small DC motor to large DC motor which can replicate the movement of each other at different torque and scaling.

2. To implement motion and force decrement for large DC motor to small DC motor which can replicate the movement of each other at different torque and scaling.

3. To analyse the time delay and deviation error from the encoders of both the motor.

1.4 Scope

The scope of this project covers mainly about hardware and software. The hardware, DC motor range of torque between 0.1Nm and 2.0Nm. The power supply for both DC motors consists of 12V only. The microcontroller that using will be Arduino Uno. All the components will be fixed to a board that can hold the motor from dislocated from its position. The small and large motor rotation only limits to less than 270º which the link cannot exceed the 360º rotation. Since the voltage input is fixed at 12V, the current for the motor need to be varies for the large and small motor. Large motor will need at least 2.0A current supply which the maximum current can go up to 5.0A while small motor need around 0.5A current supply. The current sensor only can sense up to 5A based on the ACS712 model. This is suitable for both the motor which carries only 0.5A and 5.0A maximum current based on the current input. The encoder for the motor having clockwise and anticlockwise rotation produces in four phases that are 90º, 180º, 270º 360º and it is continuous.

CHAPTER 2

LITERATURE REVIEW

2.1 Background Study

Main characteristics of the DC motor depending on the motor current, magnetic field, voltage, torque, load and power. Each of the motors differs by the most important features that is torque and power. In AC motor characteristics, the starting torque will be more than 5s and this will cause time consuming. The steady state for the motor must be as short as possible in order to make the starting torque increase [6].

In DC motors, the speed (RPM) can be easily controlled and change in the desired speed that wanted while in AC motor, the speed hardly manageable due to the changing of the waveform from positive to negative or negative to positive. Normally in the industry, AC motors are being applied because they need a very fast start up speed which can increase the profit of the industry [6].

2.2 Theories and basic principles of the DC motor

There are many types of DC motor in the market with different types of specifications. Most of the motor used in the industry to operate their production and use for moving a larger item with just a controller. In this particular section, some theories and basic principles for the scaled control DC motor will be discussed here. DC motor works with a direct current supply that is always positive.

2.3 Types of Sensors

Current sensor

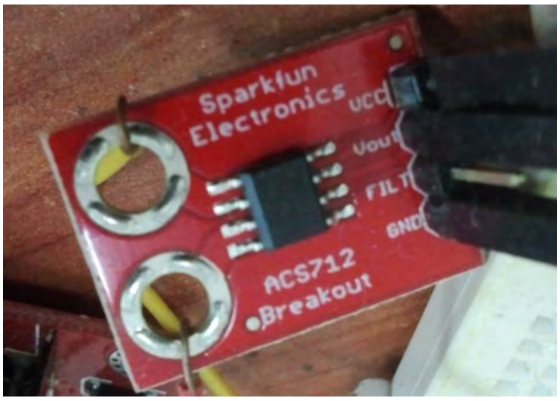

Figure 2.1: ACS-712 Breakout

The current can sense up to 5Amp with model of xx05b version. The low noise analog signal path makes it easier to get the current data. Device bandwidth is the filter pin. 1.5% output error at 25 ºC. Output voltage proportional to AC or DC currents. Extremely stable output offset voltage which makes the graph stable [7].

Force Sensitive Resistor

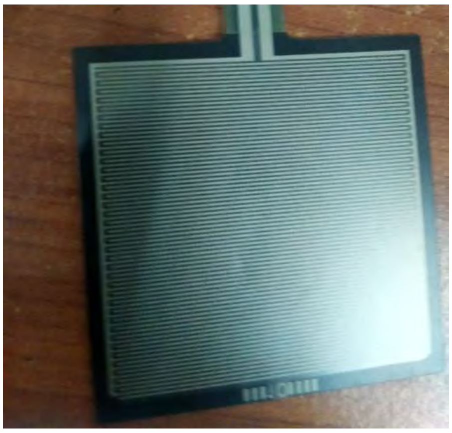

Figure 2.2: Force Sensitive Resistor

The maximum mass can be withstood by this force sensitive resistor is 100kg and minimum is about 0.1kg. Overall length is 3.5 inches and width is 1.75 inches and sensing area is 1.75 inches x 1.75 inches. [17]

2.4 Types of Actuator

Smaller torque motor

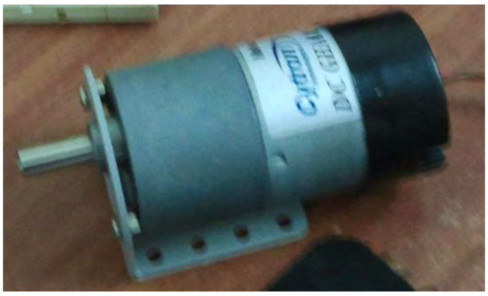

Figure 2.3: SPG30E-150K

Input voltage is DC12V. Output Power for this motor is 1.1 Watt. The rated speed is 26RPM. The rated current will be 410mA while the rated torque is 0.588Nm [8].

Large torque DC motor

Figure 2.4: IG42E-49K [9]

The voltage input is 12V DC and the rated torque is 1.76 N.m. The speed of this motor is 120 RPM. Rated current is 5.5A and power output is 41.3W. [9]

Motor driver

Figure 2.5: Motor driver MD10C

The motor driver which can support up to 25V of voltage in the DC motor. The current that can be input inside the motor driver can up to maximum 13A and 30A peak, which can only hold for 10 seconds. The motor driver provides a bi-directional way of turning. [15]

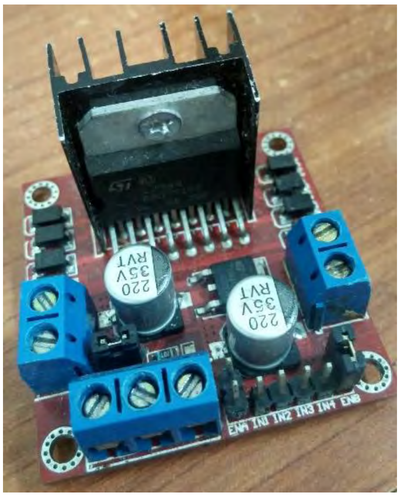

Figure 2.6: Motor driver L298N

The operating voltage can be up to 46V from the input supply. The maximum current can hold for this motor driver is about 4A maximum.

2.5 Reviews of previous related works

DC Motor and Control Technique

Application of the DC motors can be controlled by many types of controller. One of it was using an emotional intelligent controller. Based on the article by Daryabeigi in [1], he concluded that the speed of the DC motor can be controlled using an emotional intelligent controller. The controller uses a brain emotional learning based intelligent controller. This intelligent controller inspired by the limbic system of human or animal brain especially in the amygdala. This intelligent controller had a design which looks simple and high auto learning feature. By using Matlab, the results of the simulation show that steady state and fast transient speed responses to a wide range of 20 to 300 rpm. The controller had been compared with a conventional PID controller [1].

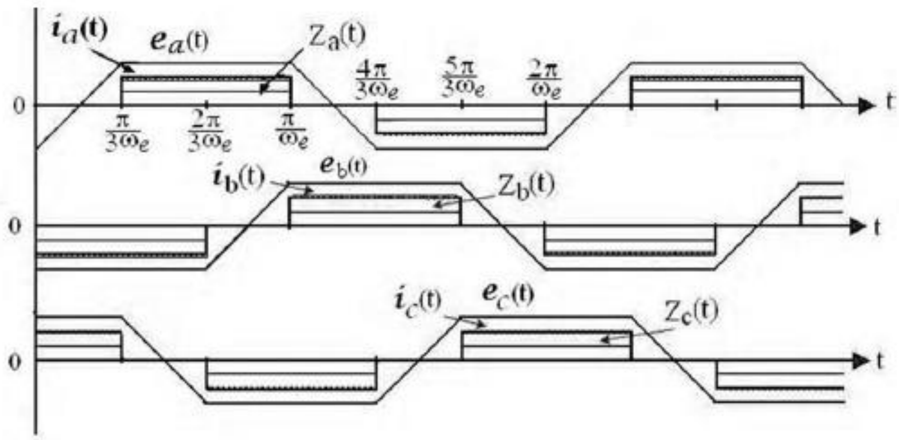

Figure 2.7: Waveforms of the EMFs, phase currents and commutating signal for brushless DC motor [1]

$$\frac{\omega_r(s)}{i_{eq}(s)} = \frac{\sqrt{2}\, k_c \emptyset}{Js + B} \qquad (2.1)$$

Based on above Figure 2.7, the equation 2.1 formed and proven that three phase brushless DC motor equivalent to DC brush motor with equal back EMF and equal armature current which proportional to the torque of the system. Therefore, all this parameter can be reduced to a simple scalar control. [1]

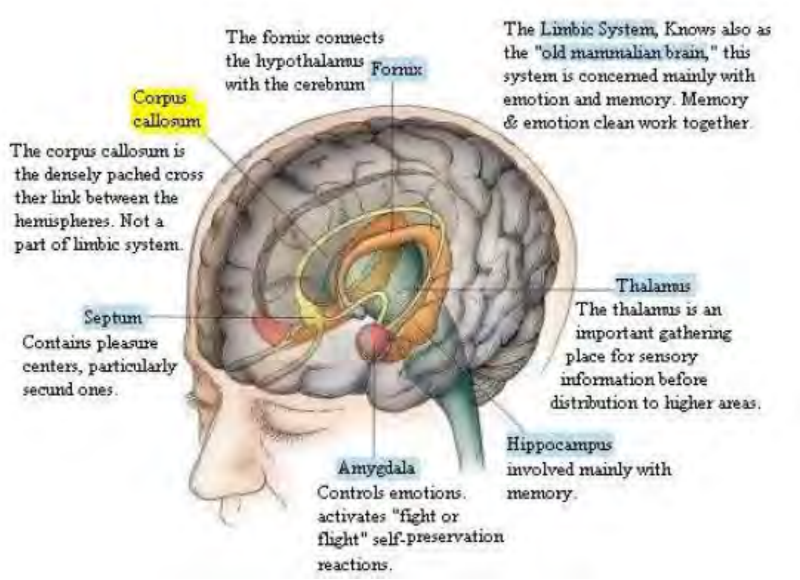

Figure 2.8: The sectional structure of the brain, which amygdala shown [1]

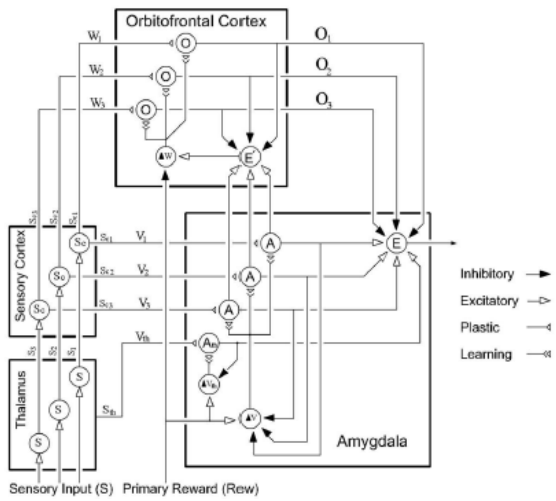

Figure 2.9: Graphical presentation of the computational model of brain emotional learning [1]