System Identification of a DC Motor Using ARX Model

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*Abstract*— Behavior of the system can be characterized with System Identification by measuring on a system data response. This paper presents a study of modelling brushed dc motor using ARX structure written by python code.

Keywords—DC Motor, System Identification, Autoregressive-eXogenous, python

# Introduction

DC Motor play significant role for operation of machines and mechanical system. DC Motor have many problem like weak control and instability because of inaccuracy in calculating motor parameter. Extracting parameter accuracy is crucial. Parameter can be determined from identifying mathematical model [1]. There are two major class for identifying mathematical model, theoretical model and experimental model. Theoretical models describe complete description of system by physical and mathematical laws. Experimental models are based on input/output data [2]. In this articles using experimental modelling for identifying dc motor using ARX models in python. Python can easily integrate to microcontroller and sensors devices via serial, MQTT or even MODBUS devices.

# Literature Review

## Mathematical DC Motor Model

DC Motor Model can be described as mathematical Modelling. DC Motor are separately excited. Power Supply is directly connected to the winding of motor. Fig. 1 is shown the DC Motor equivalent circuit. See figure 1

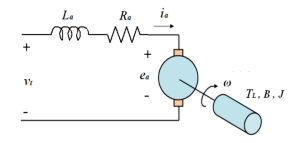


Figure 1: Brushed DC Motor equivalent circuit

Equation represented as electromechanical energy convention and torque balance rules. Electromechanical energy consist of two component, electrical and mechanical. The following is the electromechanical equation derivation below.

1. Electrical equation : Kirchoff Voltage Law

Ohm law:

Laplace transform of electrical equation :

Laplace transform for motor current:

1. Mechanical equation :
2. Electromechanical equation :

Laplace transform for electromechanical:

[3]

## ARX Model

ARX (Auto Regressive eXogenous) for a SISO (Single Input Single Output), ARX model are relationship between its input u(t) and output y(t) structure model is as the following expression:

A(q) represent the polynomial order of output, B(q) represent the polynomial order of input, and e(t) is residual error assumed to be gaussian noise, a and b are model coefficient [4].

A(q) and B(q) are:

[5]

Parameter for ARX equation:

[8]

# Research Method

## Experimental Setup

The computer is interfaced to the quanser DC Motor trainer include brushed dc motor and sensor via USB. QNET Software designed to generate control signal and read speed sensor from the motor. See figure 2

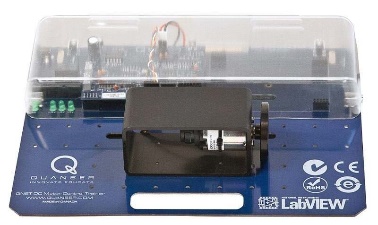


Figure 2: Quanser DC Motor Trainer

In this experiment a square and sine wave used during data collection for dc motor modelling. The data collected being export to excel and then input and output data proceed for system identification.



Figure 3: NumPy logo

After experiment data collected (input signal and output signal), data processed with ARX equation using python with NumPy library. NumPy support numerical operation with vector programming style where numerical operator operates on full array and frequently used by academic and the industrial community [6].

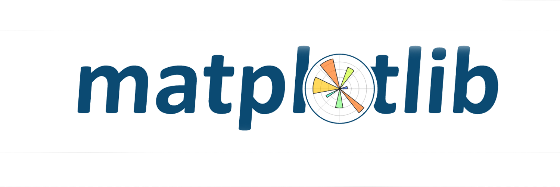


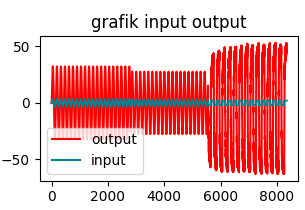
Figure 4: matplotlib logo

After input and output data proceed by NumPy using ARX equation. Data displayed in a cartesian graph using matplotlib library. Matplotlib is useful to develop a graphical application and suitable for two-dimensional application and three-dimensional application. Matplotlib provide variety chart like line, bar, scatterplots, and pie chart [7].

## Estimation of the DC Motor Parameters

## Input and Output of the system

1. Input and Output Signal



1. Validation Signal

# Result and Discussion

# Conclution

In this study, we successfully identified the system parameters of a DC motor using the ARX (Autoregressive with eXogenous inputs) model. The research demonstrated the effectiveness of the ARX model in capturing the dynamics of the DC motor system, providing a reliable representation of the system's behavior based on input-output data.

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