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Neural Network electric motor parameters estimation

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Contents

1 Introduction

The aim of the present work is the development on MATLAB suite a Neural Network able to estimate the following relevant parameters of a generic brushed DC Motors:

Symbol	Name	Unit Measure
R	Input resistance	Ω
L	Rotor inductance	H
K_t	Torque constant	$\frac{\mathrm{N}\cdot\mathrm{m}}{\mathrm{A}}$
K_e	Back emf constant	$\frac{\mathrm{V}}{\mathrm{rpm}}$
f	Viscous friction coefficient	N·m·s
J_m	Rotor inertia	kg·m^2

Table 1: Target parameters

Receiving at the input specific measured quantities, which are:

Symbol	Name	Unit Measure
$\omega(t)$	Output Rotational Speed	$\frac{\mathrm{rad}}{\mathrm{s}}$
$i(t)$	Input Current	A

Table 2: Input parameters

The first chapter describes the considered electric motor mathematical model, including the simplifications adopted. In the second chapter the methodology and criteria employed for the design of the Neural Network are described. Eventually, the report concludes with the results attained.

2 DC Motors

2.1 Model

The considered equations which describe the brushed DC motor are the following ones:

$$V(t) - e(t) = R \cdot i(t) + L \cdot \frac{di(t)}{dt} \tag{1}$$

$$T_m(t) - T_l(t) = f \cdot V(t) + J_m \cdot \frac{d\omega(t)}{dt} \tag{2}$$

$$T_m(t) = K_t \cdot i(t) \tag{3}$$

$$e(t) = K_e \cdot V(t) \tag{4}$$

Where the variables involved, besides the ones previously introduced, are listed in Table 3.

Symbol	Name	Unit Measure
V	Input Voltage	V
e	Back emf	V
T_m	Electromotive Torque	N·m
T_l	Load Torque	N·m

Table 3: Other parameters

Different assumptions have been made before proceeding with the development of the Neural Network:

- $K_t = K_e = K$, since the two constants are usually very similar in values (considering K_e measured in $\frac{\mathrm{V}}{\mathrm{rad/s}}$).
- $T_l(t) = 0$, which means estimations are evaluated without having any load applied.
- Within the motors' datasheets collected to constitute the training inputs of the NN, the viscous friction coefficient f has not been listed. Therefore, considering the equilibrium condition of Equation 2, it has been assumed $f = \frac{\mathrm{T}}{\omega}$, where T and ω are respectively the nominal Torque and Speed the motors.

2.2 Dataset

The motors collected for the generation of the NN input dataset are 40. Their relevant characteristics have been listed within a spreadsheet and categorized. Table 4 shows the ranges in which the parameters fit.

Parameter	R	L	K	f	J_m
Range	[1e-1, 1e2]	[1e-5, 1e-2]	[1e-3, 1]	[1e-7, 1e-4]	[1e-8, 1e-4]

Table 4: Ranges

3 Neural Network

MATLAB Deep Learning Toolbox offers functionalities to easily build feed-forward networks with sigmoid neurons and back-propagation training algorithm. It is possible to launch the Neural Network training both by command-line instructions and through the application wizard.

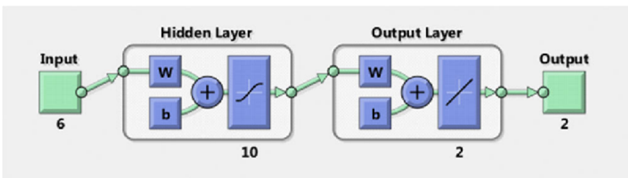

Figure 1: NN standard architecture

In the following subsections the factors influencing the training will be described. Throughout the refinement phase, they have been tuned in order to reach progressively better performance.

3.1 Input & Output

As previously mentioned, Table 2 lists the parameters used as inputs for the NN. Knowing the ranges in which the desired parameters could sweep, different randomized sets of output values have been used as network output targets. The corresponding input vectors $\omega(t)$ and $i(t)$ data have been calculated from their respective transfer functions

$$\omega = \frac{K}{s^2 J_m L} \tag{5}$$

3.2 Subsection 3.2

Text

3.3 Subsection 3.3

Text

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