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Identifying a two linked robot with non-symmetrical modified friction and Backlash-flexibility models

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***Abstract*— Identifying a robotic system, especially in presence of some nonlinear phenomena, such as friction and backlash, is a troublesome problem. In this paper, initially single link parameter identification is discussed. Parameters such as actuators parameter, link inertia, friction and backlash are identified in this section. A combination of actuator's model and a model of two flexible masses in attendance of friction and backlash is utilized for this purpose. Identifying two link robot parameters will be under debate afterwards and identification results for the second link are presented in three distinct forms. Furthermore, a method is introduced for selecting best estimated parameters set, in order to be exerted on systems controller. The effects of identified friction torques and backlash modeling on controller improvement are presented. Grey box structure model, available in Matlab's system identification tool box is utilized in this research.**

I. Introduction

System identification for robots can be studied in three major levels. First level is assigned to identifying kinematic parameters. In the second level dynamics model parameters are identified such as inertia's parameters. During third level, in addition to previous identifications, friction model parameters and backlash are identified [1].

Friction is a nonlinear phenomenon which can be found in every object movements that are in contact with each other. Friction plays a substantial rule in every stages of motion in every machine. In high precision positioning systems, it is beneficial to be aware of the friction magnitudes, and it can be helpful in preventing undesirable effects such as limit cycles and constant errors [2].

Backlash exists in most mechanical systems with actuator just like friction. Controlling the load after a backlash is very troublesome, especially where high precision motion is essential [3].

DC motors are some electromechanical parts with a wide range of use in industries due to their ease of position and velocity control abilities [4]. DC motor Identification in presence of nonlinear friction behavior is highly under consideration [5].

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Several surveys have been accomplished in the field of robotic arms identification. Bompos et al. worked on a problem of modeling, identifying and controlling a robot in [6]. Discovering dynamic parameters along with nonlinear friction modeling, they were able to increase the accuracy of target tracking of an arbitrary trajectory and proved the certitude of identification. Kara and Eker [7], used the Hemerestian model for motor DC identification. To identify mechanical arms, Wernholt and Gunnarsson [8, 9], used flexible two and three masses models. They didn't consider any backlash in their models. Kostic et al. [10], demonstrated the importance of choosing an appropriate friction model and applying the estimated parameters to a control system. Radkhah et al [11], moreover, estimated 32 inertia parameters for a serial robot.

Within this survey a grey box model is used for identifying mechanical arms. To determine the nonlinear gray box, model structure is considered as a continuous time space state as follow;

$$\begin{aligned} \dot{x}(t) &= f(t, x(k), \theta, u(t)) \\ y(t) &= h(t, x(k), \theta, u(t)) + e(t), \end{aligned} \qquad (1)$$

where f and h are nonlinear functions, $x(t)$ is a variable vector and $u(t)$ and $y(t)$ are input and output signals of the system, respectively. $e(t)$ is the white disturbance signal of measurement and t represent the time. θ is also a parameter vector. Based on measured input and output test, purpose is to determine parameters in a way that minimize the criterion,

$$V_N(\theta) = \frac{1}{N}\sum_{t=1}^{N} \varepsilon^2(t,\theta), \ where \ \ \varepsilon(t,\theta) = y(t) - \hat{y}(t,\theta). \qquad (2)$$

Gray box structure model, available in Matlab system identification tool box is utilized within this research [12].

II. Combined Model of Robotic Arms and DC Motor

Combining two masses flexible model with DC motor model, a combined model of planar single link is generated [7,8], where motor's voltage is the input and motor's angular position is the output (Figure 1).

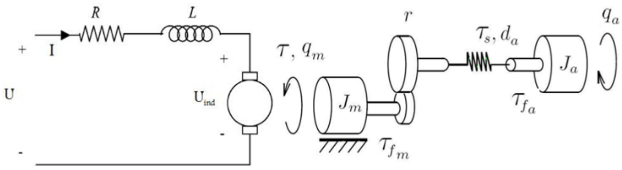

Fig. 1. Combined model of two flexible masses and DC motor

A. Model of a DC motor

For the electrical circuit of a DC motor U is voltage, I is