Dynamic Parameter Identification of a Robot in a Simulated Environment

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Abstract

A robot is in general expensive. Hence its simulation is useful for education, design, testing, research purposes, etc. Nowadays, off-line programming of a robot also relies on kinematic and dynamic models of the robot in the simulated environment. Identifying the robot parameters in the simulated environment is also essential. The dynamic parameter identified in simulated environment results in estimating the joint torques, control and to predict the performance of the designed robot in advance.

RoboAnalyzer [1-2] is a freely available 3D model-based software capable of performing kinematics and dynamics of a wide range of robots. This platform allows the user to change the kinematic and dynamic parameters of the robot, i.e., the Denavit Hartenberg (DH) and the mass and inertia parameters respectively and also to save the model with simulation results for further analysis.

In general, a standard robot identification procedure consists of modeling, experiment design, data acquisition, signal processing, parameter estimation, and model validation [3]. Dynamic parameters of the cylindrical robot in the simulated environment were identified in [4]. In simulation experimental design, data acquisition and signal processing becomes an easier task in comparison to the experimental identification process. Hence, one can test the performance of the dynamic formulation and identification technique without paying attention to those factors.

The aim of this work is to identify the dynamic parameters of the robot in a simulated environment, namely, RoboAnalyzer (RA). The simulated data of torques and joint angles obtained through inverse dynamics of the three link spatial manipulator in RA were used as input to the identification of the dynamic parameters. The approach that was used to identify the dynamic parameters of 3R spatial manipulator is as follows:

1) Model the dynamics of the manipulator using the concept of Decoupled Natural Orthogonal (DeNOC) matrices [5] or Newton Euler method and find the equation of motion.

$$\mathbf{I}(\mathbf{q})\ddot{\mathbf{q}} + \mathbf{h}(\mathbf{q},\dot{\mathbf{q}}) + \boldsymbol{\gamma}(\mathbf{q}) = \boldsymbol{\tau} \tag{1}$$

2) Transform the equation of motion which is nonlinear in joint parameters into equivalent linear (in constant dynamic parameters) of the robot model [6].

$$\mathbf{Y}(\mathbf{q},\dot{\mathbf{q}},\ddot{\mathbf{q}})\boldsymbol{\chi} = \boldsymbol{\tau} \tag{2}$$

where $\mathbf{Y}(\mathbf{q},\dot{\mathbf{q}},\ddot{\mathbf{q}})$ is the regression matrix or observation matrix. The identifiable dynamic parameters are sufficient to describe the dynamic behaviour of the manipulator with the reduced regression/observation matrix.

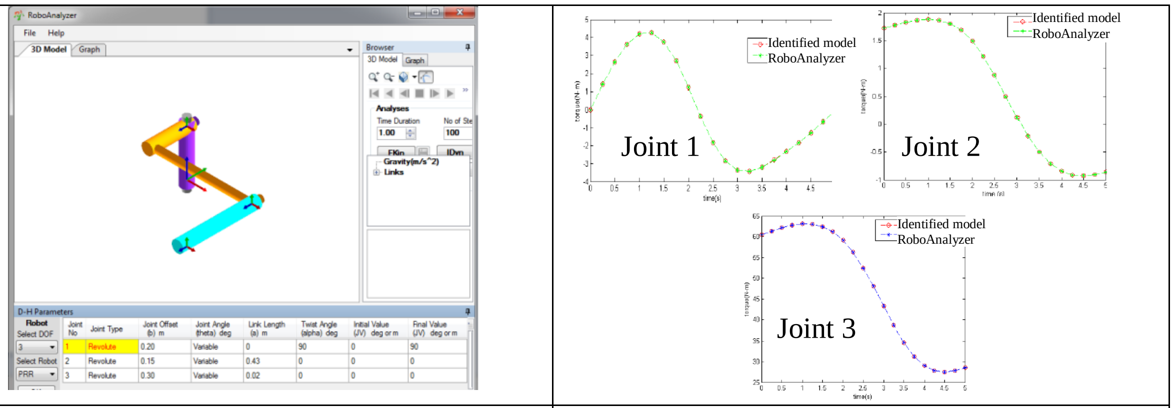
The kinematic and dynamic parameters initially assigned to the 3R spatial manipulator are listed in Table 1 was used as input to the identification method.

Table 1: Kinematic and dynamic parameters of a 3R spatial manipulator given as input in RoboAnalyzer

Link	DH parameters				Dynamic Parameters									
	b_i	a_i	θ_i	α_i	I_{xx}	I_{yy}	I_{zz}	I_{xy}	I_{yz}	I_{zx}	m	$(C.G)^*_x$	$(C.G)_y$	$(C.G)_z$
Unit	meter (m)		degree		Kg-m^2						Kg	meter (m)		
1	0.20	0		90	1.612	1.612	0.5091	0	0	0	10.521	0	0	-0.054
2	0.15	0.43		0	0.4898	8.0783	8.2672	0	0	0	15.761	-0.292	0	0
3	0.30	0.02		0	3.3768	3.3768	0.3009	0	0	0	8.767	0	0	-0.019

* (C.G.): center of gravity

A preliminary result was obtained for the 3R spatial robot shown in Figure 1. The estimated dynamic parameters were verified against those given as input to the RA. This showed the correctness of the identification technique used. This showed the correctness of the identification technique used and also the correctness of the algorithm used in the software.



Time Duration: 1.00

No of Steps: 100

D-H Parameters

Robot

Select DOF: 3

Select Robot: PRR

Joint No	Joint Type	Joint Offset (b) m	Joint Angle (theta) deg	Link Length (a) m	Twist Angle (alpha) deg	Initial Value (JV) deg or m	Final Value (JV) deg or m
1	Revolute	0.20	Variable	0	90	0	90
2	Revolute	0.15	Variable	0.43	0	0	0
3	Revolute	0.30	Variable	0.02	0	0	0

a) Screenshot of the Roboanalyzer of 3R spatial manipulator

b) Torques values obtained with identified model and the RA for a given trajectory

Figure 1: A 3R spatial manipulator and the comparison of the torque values

The dynamic formulation in linear form can be verified by comparing the joint torques obtained against those obtained from the RA for any arbitrary joint trajectory. This work be extended for six degrees of freedom industrial robot KUKA KR5 available in RA, which will be reported in the full-paper. As a result the identified linear dynamic model of a robot in simulated environment can be convinently used during offline programming of the robot.

References

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