TRAJECTORY TRACKING OF A DATA-BASED MODEL OF A TWO-LINK ROBOTIC MANIPULATOR USING MODEL PREDICTIVE CONTROLLER

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Introduction

In robotic manipulation, high-precision trajectory tracking is essential. Physics-based models are constrained by their stiffness and complexity, and they require high performance hardware.

Reduced-order models developed from data, using subspace system identification is proposed to achieve low cost and high-precision tracking robots.

Objectives

1. To develop a data-based model of a two-link robotic manipulator using sub-space system identification
2. To design a linear model predictive controller to achieve accurate trajectory tracking performance

Methodology

The Lagrange equation for a two-link robot is given as:

$$M(q)\ddot{q} + C(q,\dot{q}) + G(q) = \tau$$

Where, $M(q)$ is the inertial matrix, $C(q,\dot{q})$ is the Coriolis and Centrifugal terms, $G(q)$ is the gravity term, τ is the torque or force vector.

Model Predictive Control (MPC) can be mathematically represented below :$min\{\sum_{k=0}^{N-1}(\| y_{t+k} - r(t) \|^2 + \rho \| u_{t+k} - u_r(t) \|^2)\}$

$$s.t.: \ x_{t+k+1} = f(x_{t+k}, u_{t+k})$$

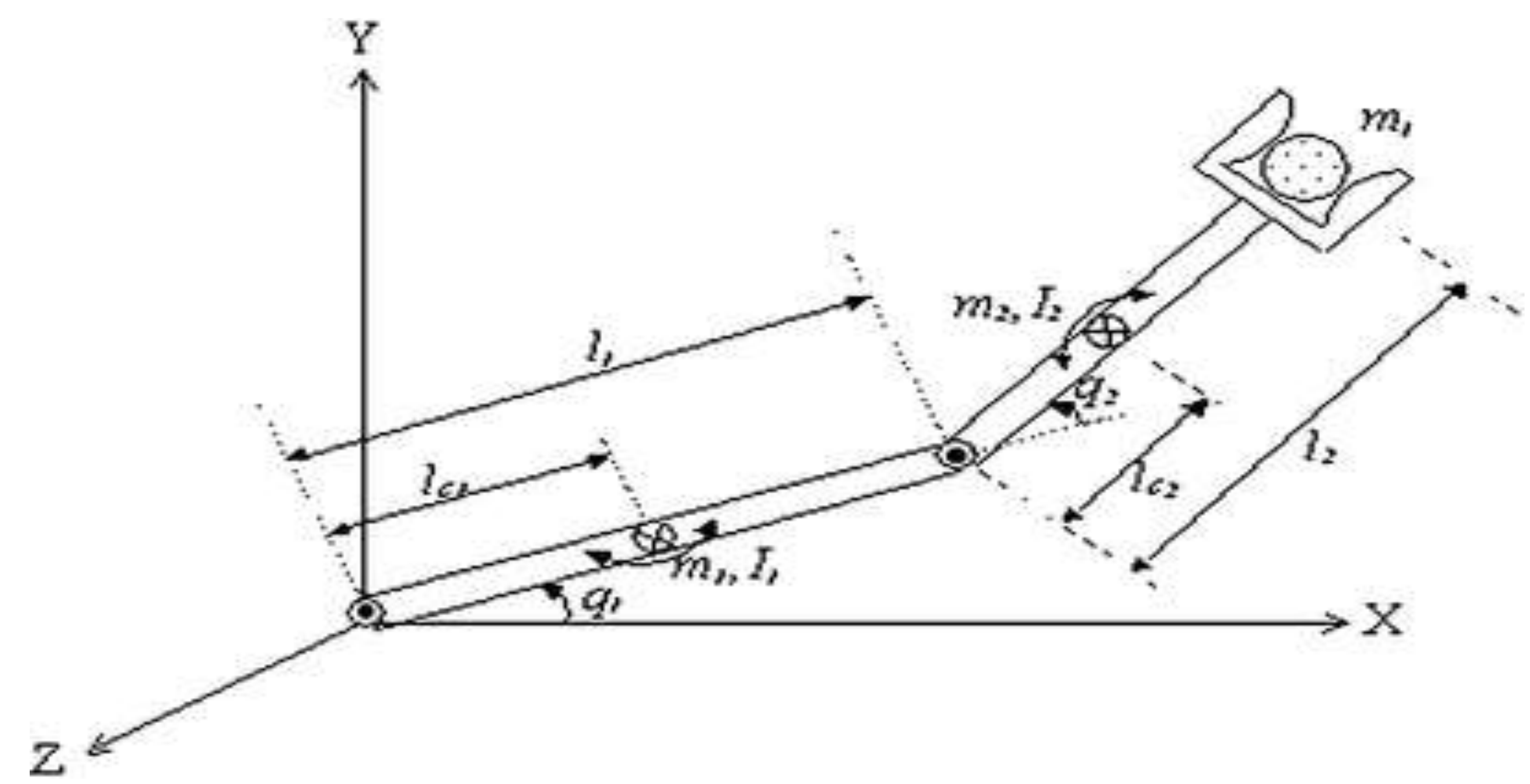
$$y_{t+k} = g(x_{t+k}, u_{t+k})$$

$$u_{min} \le u_{t+k} \le u_{max}$$

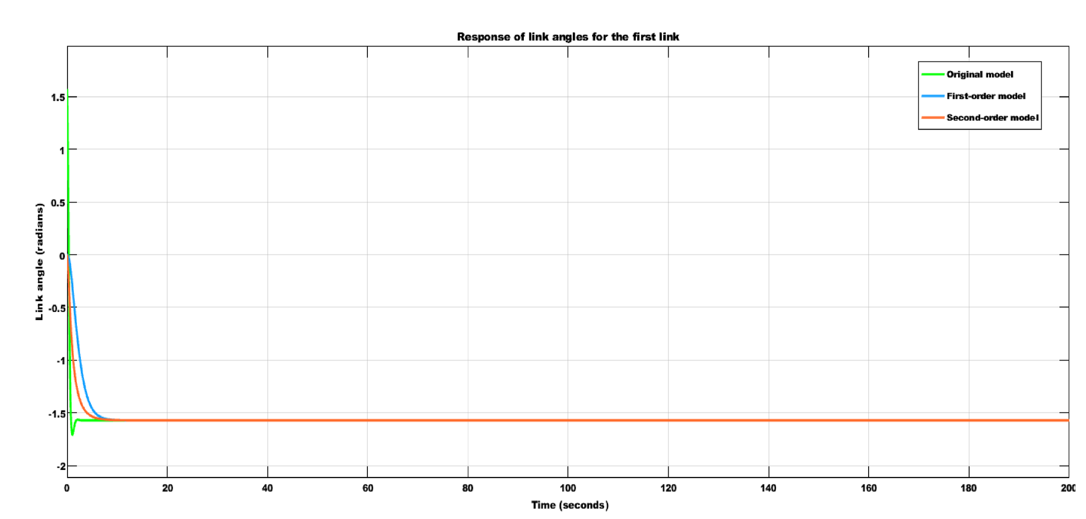
$$y_{min} \le y_{t+k} \le y_{max}$$

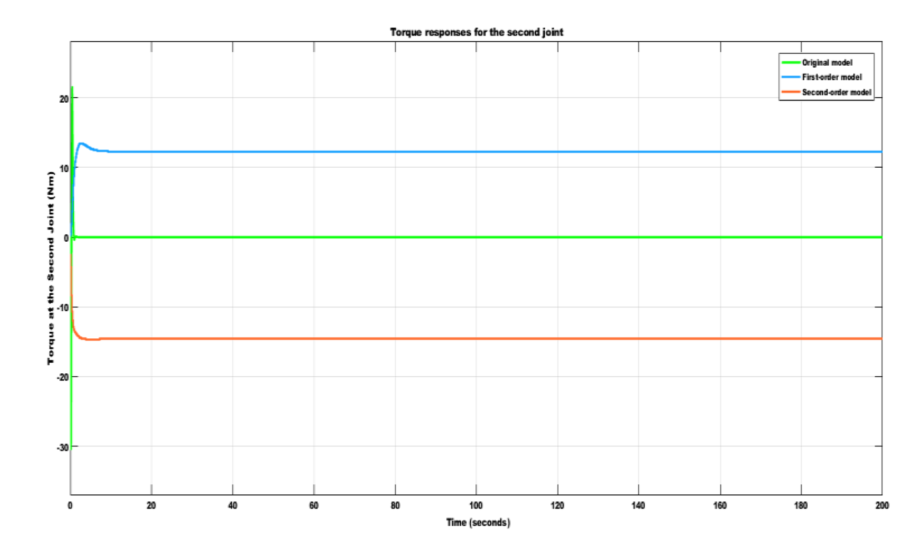
$$x_t = x(t), k = 0, \ldots, N-1$$

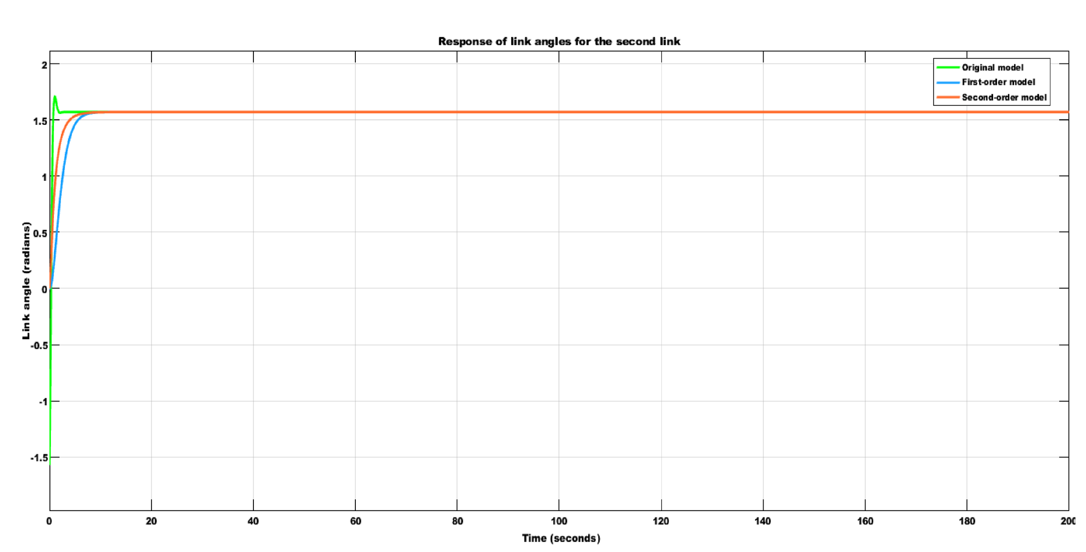
Two-Link Robot

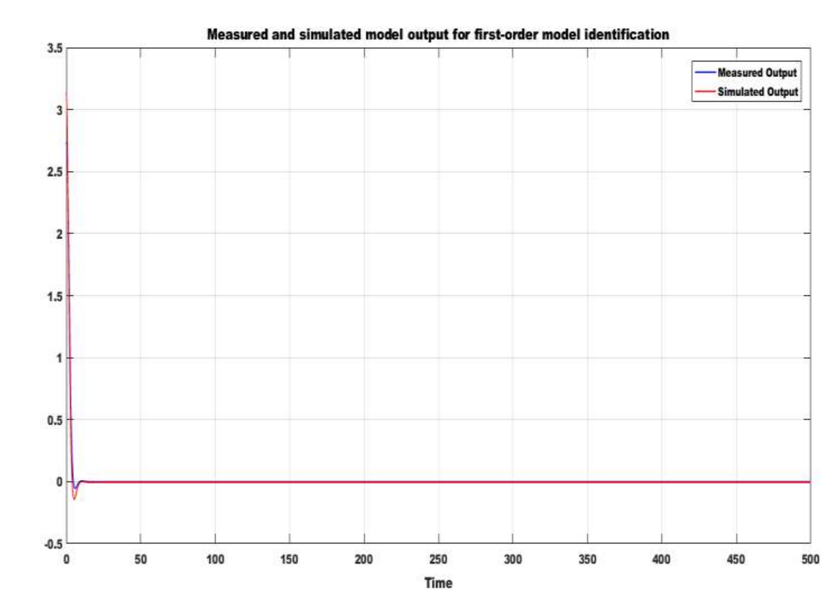


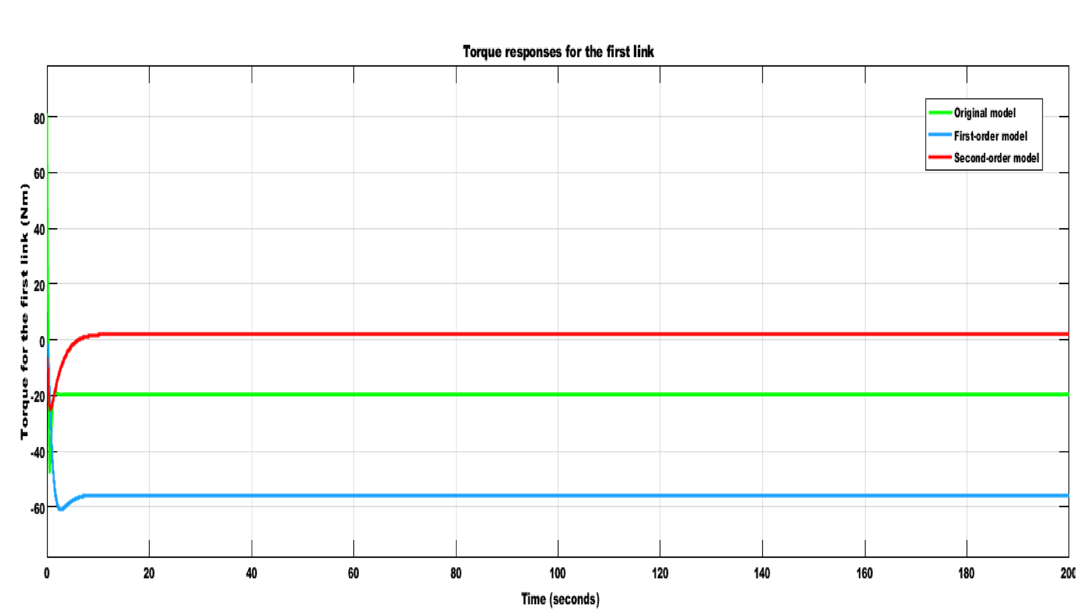
Results

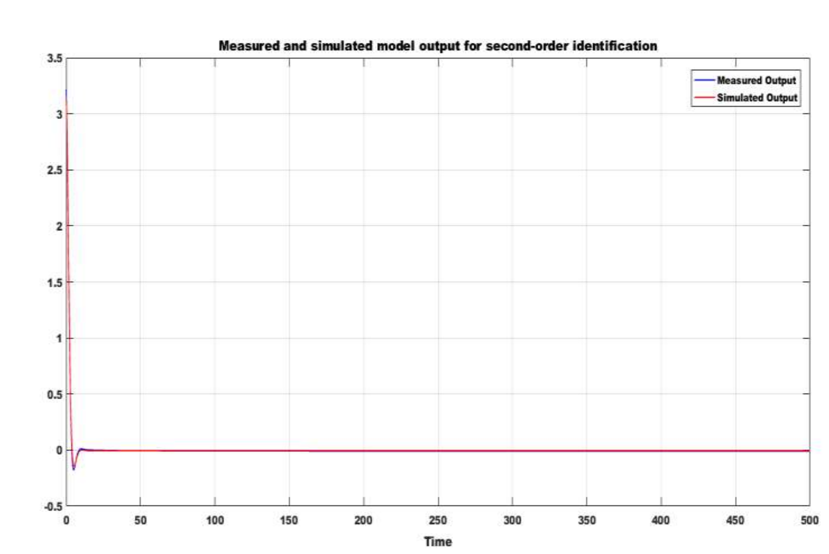












Conclusions

A data-driven model of a two-link robot arm using sub-space system identification is presented. Synthetic data was generated from a high-fidelity simulation model developed in MATLAB and Simulink, and the acquired data was used for model estimation and validation of first- and second-order linear state-space models. Model predictive control strategy was employed for trajectory tracking due to its good tracking characteristics. It was deduced that, the first-order model is capable of achieving trajectory tracking of the desired set-point, but higher toque will be required at the second joint to maintain the stability of the second link of the robotic manipulator. The data-driven models are suitable for trajectory tracking applications such as welding, machining, laser cutting, surgery et cetera, when the robot arm model is not available or is too complex to model mathematically since they also exhibit high trajectory tracking performance characteristics when compared with the original model.

References

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