IIT ROORKEE

NPTEL ONLINE
CERTIFICATION COURSE

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Model Based Control of Robot Manipulators

Outline

1. Introduction
    - Kinematics
    - Dynamics
2. Model-Based Control of Robotic Systems
    - Kinematic Model Based Scheme
    - Dynamic Model Based Scheme
3. Conclusion

Introduction

Kinematics:

Introduction

Dynamics:

Kinematic Model Based Control

- Closed Loop Inverse Kinematics (CLIK)

$$e = x_d - x = x_d - k(q)$$

$$\dot{e} = \dot{x}_d - \dot{x}$$

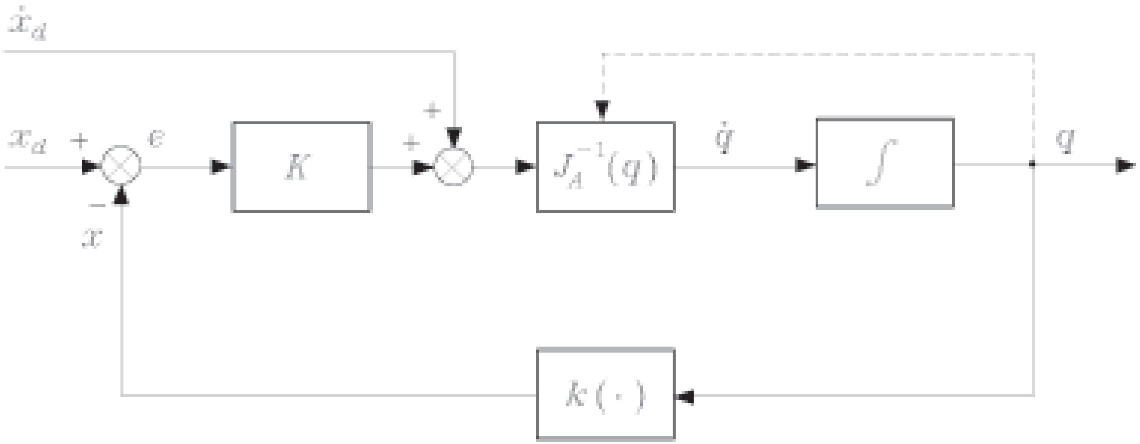
$$\dot{e} = \dot{x}_d - J_A(q)\dot{q}.$$

$$\dot{q} = J_A^{-1}(q)(\dot{x}_d + Ke)$$

$$\dot{e} + Ke = 0.$$

Kinematic Model Based Control (cont'd)

- Closed Loop Inverse Kinematics (CLIK)



Dynamic Model Based Control

The rigid-body dynamics have the form

$$\tau = M(\Theta)\ddot{\Theta} + V(\Theta,\dot{\Theta}) + G(\Theta) \quad (1)$$

Assuming that our model of friction is a friction is a function of joint positions and velocities, we add the term $F(\Theta,\dot{\Theta})$ to eq. (1), to yield the model

$$\tau = M(\Theta)\ddot{\Theta} + V(\Theta,\dot{\Theta}) + G(\Theta) + F(\Theta,\dot{\Theta}) \qquad (2)$$

Dynamic Model Based Control (cont’d)

The problem of controlling a complicated system like (2) can be handled by the partitioned controller scheme. In this case, we have

$$\tau = \alpha\tau' + \beta(3)$$

where τ is the $n \times 1$ vector of joint torques. We choose

$$\alpha = M(\Theta),$$

$$\beta = V\left(\Theta,\dot{\Theta}\right) + G\left(\Theta\right) + F(\Theta,\dot{\Theta}) \qquad (4)$$

Dynamic Model Based Control (cont'd)

with the servo law

$$\tau' = \ddot{\Theta}_d + K_v \dot{E} + K_p E \qquad (5)$$

where

$$E = \Theta_d - \Theta (6)$$

Using (2) through (5), it is quite easy to show that the closed-loop system is characterized by the error equation

$$\ddot{E} + K_v \dot{E} + K_p E = 0 \qquad (7)$$

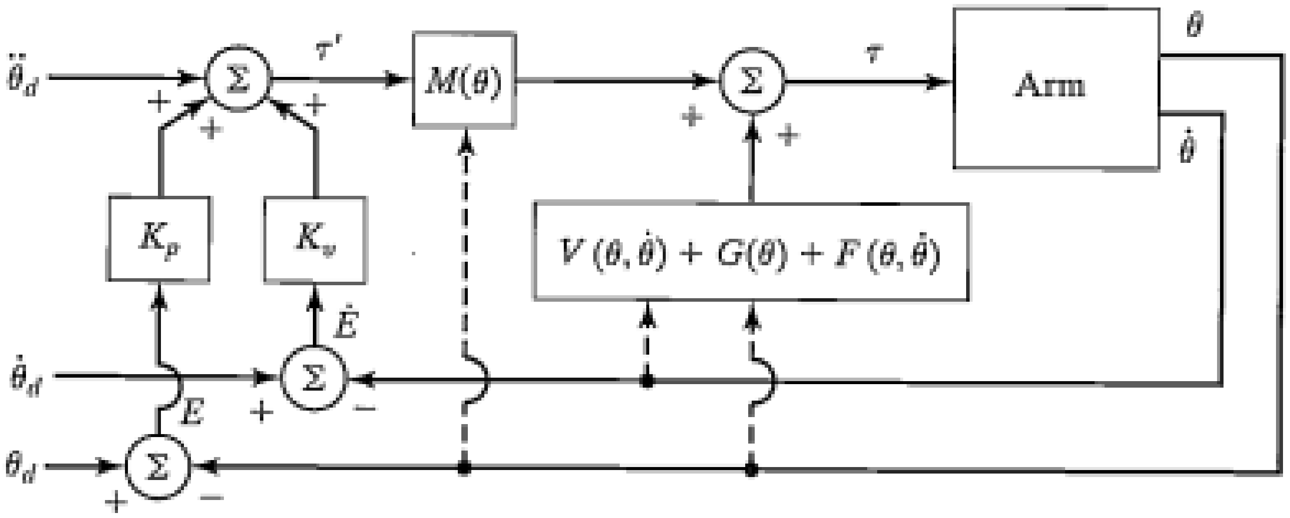
Dynamic Model Based Control (cont'd)

Note that this vector equation is decoupled: The matrices K_v and K_p are diagonal, so that (7) could just as well be written on a joint-by-joint basis as

$$\ddot{e}_i + k_{vi}\dot{e} + k_{pi}e = 0 \qquad (8)$$

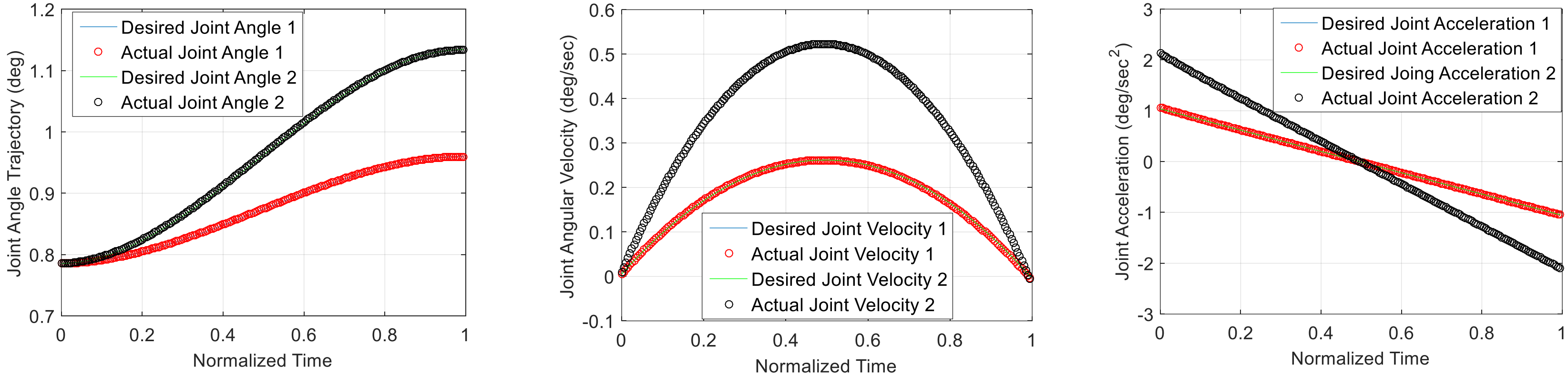
Dynamic Model Based Control (cont'd)

Block Diagram:



Dynamic Model Based Control (cont'd)

Results for 2R planar manipulator:



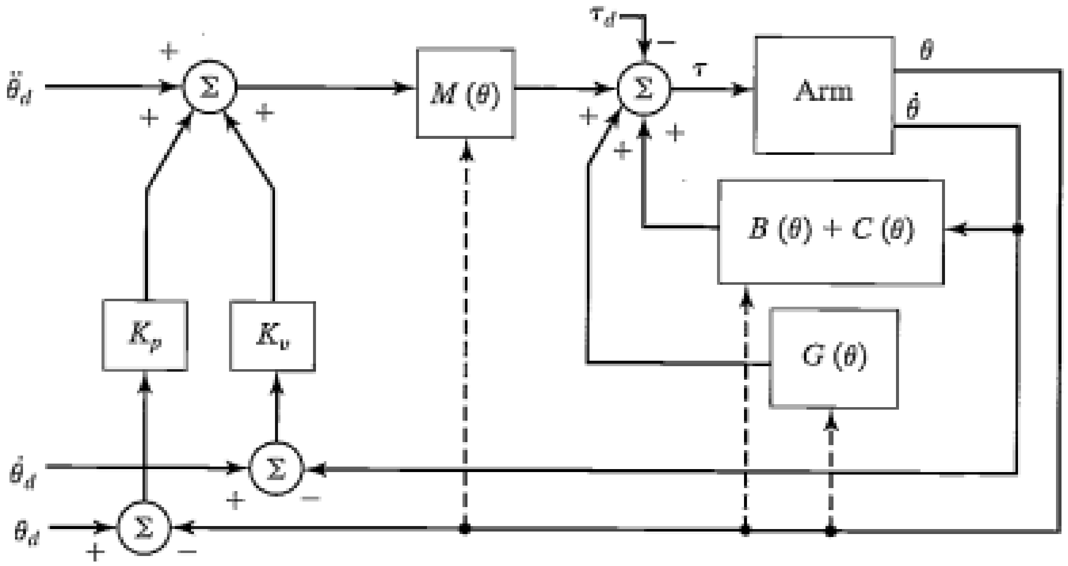
Dynamic Model Based Control (cont'd)

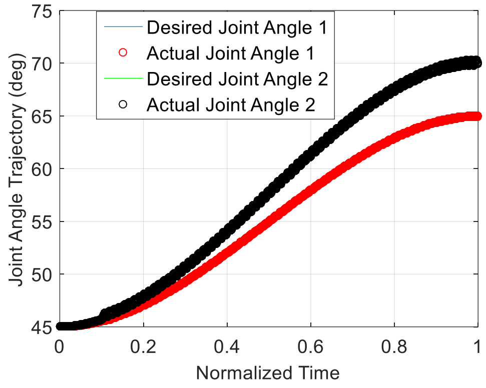
2R planar manipulator Dynamics:

Dynamic Model Based Control (cont'd)

2R planar manipulator Dynamics:

With External Disturbance





Cartesian Model-Based Control Scheme

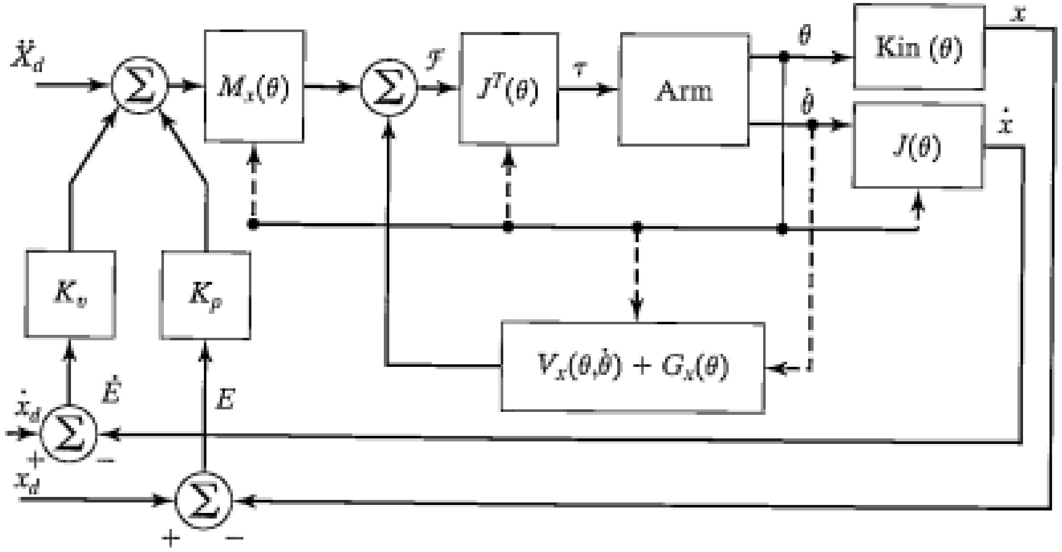
The rigid-body dynamics can be written as

$$\mathcal{F} = M_x(\Theta)\,\ddot{\chi} + V_x\left(\Theta,\dot{\Theta}\right) + G_x(\Theta)$$

$$\tau = J^T(\Theta)\mathcal{F}$$

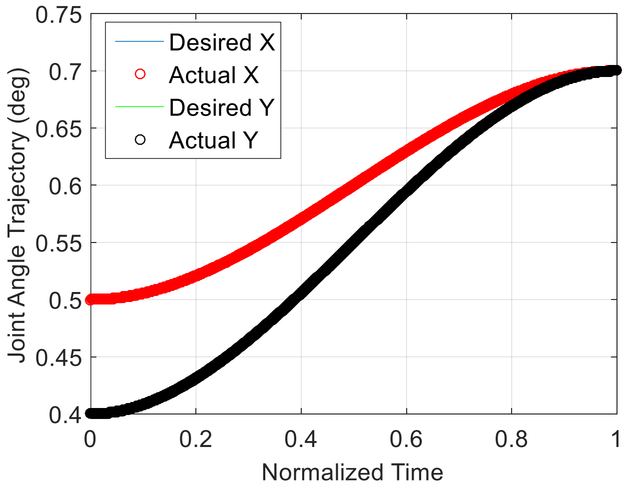
Cartesian Model-Based Control Scheme (cont'd)

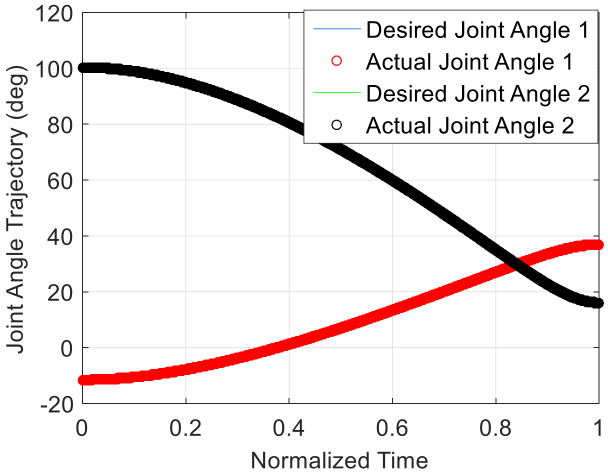
Block Diagram:



Cartesian Model-Based Control Scheme (cont'd)

Results:





Conclusions

- Kinematic Model Based Control
- Dynamic Model Based Control

Thank You!