Introduction to Robotics ME 639: Industrial Project Presentation 2

Project Title: Join Impedance Control for an existing Exoskeleton

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Problem Statement:

“Model a 1-DOF Knee Joint -Shank Link rotational system for assist control utilizing impedance control methods.”

Industry name: **Timetooth**

Objectives:

- A 100% torque assist from motor corresponds to zero patient effort for its own limb movement
- A 0% torque assist from motor corresponds to full patient effort for its own limb movement. Assuming zero patient effort, deduce the motor torque identifying the subcomponents of exo link and human limb.

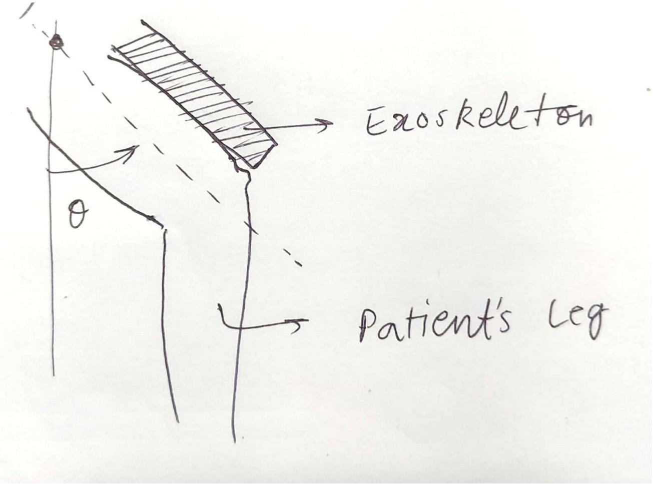
Rationale / Approach / Ideas: Rukna… kar le

Equations:

$$I_e\ddot{\theta} + C_e\dot{\theta} + G_e = \tau_m - Fl$$

$$I_L\ddot{\theta} + C_L\dot{\theta} + G_p = \tau_m + Fl$$

$$(I_e + I_l)\ddot{\theta} + (C_e + C_l)\dot{\theta} + (G_p + G_l) = \tau_m + \tau_p$$



Control Law of Exoskeleton (100% Patient Effort):

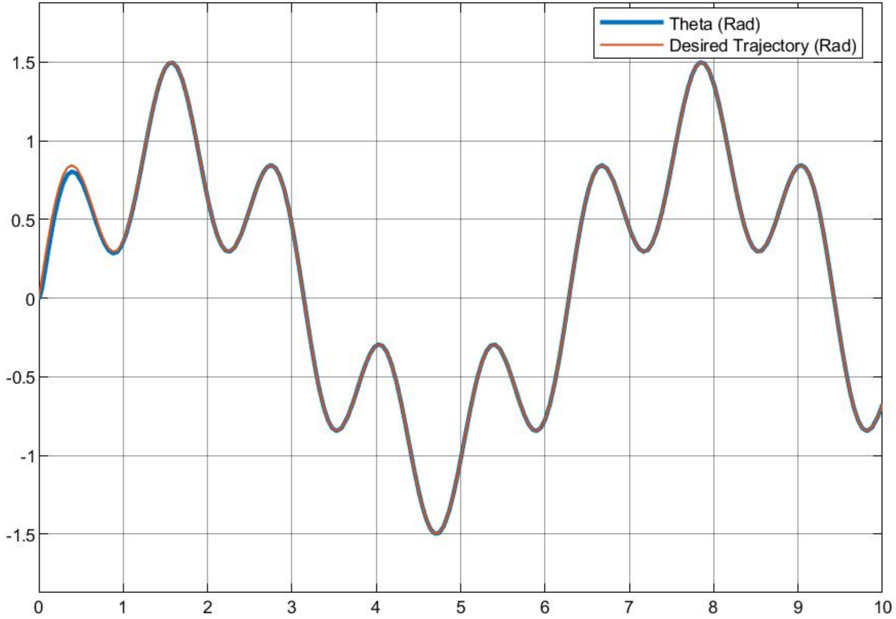
$$u_m = K(\theta_d - \theta) + D(\dot{\theta}_d - \dot{\theta}) + I_e\ddot{\theta}_d + C_e\dot{\theta} + G_e$$

Control Law of Exoskeleton (0% Patient Effort):

$$u_m = K(\theta_d - \theta) + D(\dot{\theta}_d - \dot{\theta}) + (I_e + I_l)\ddot{\theta}_d + (C_e + C_l)\dot{\theta} + (G_e + G_l)$$

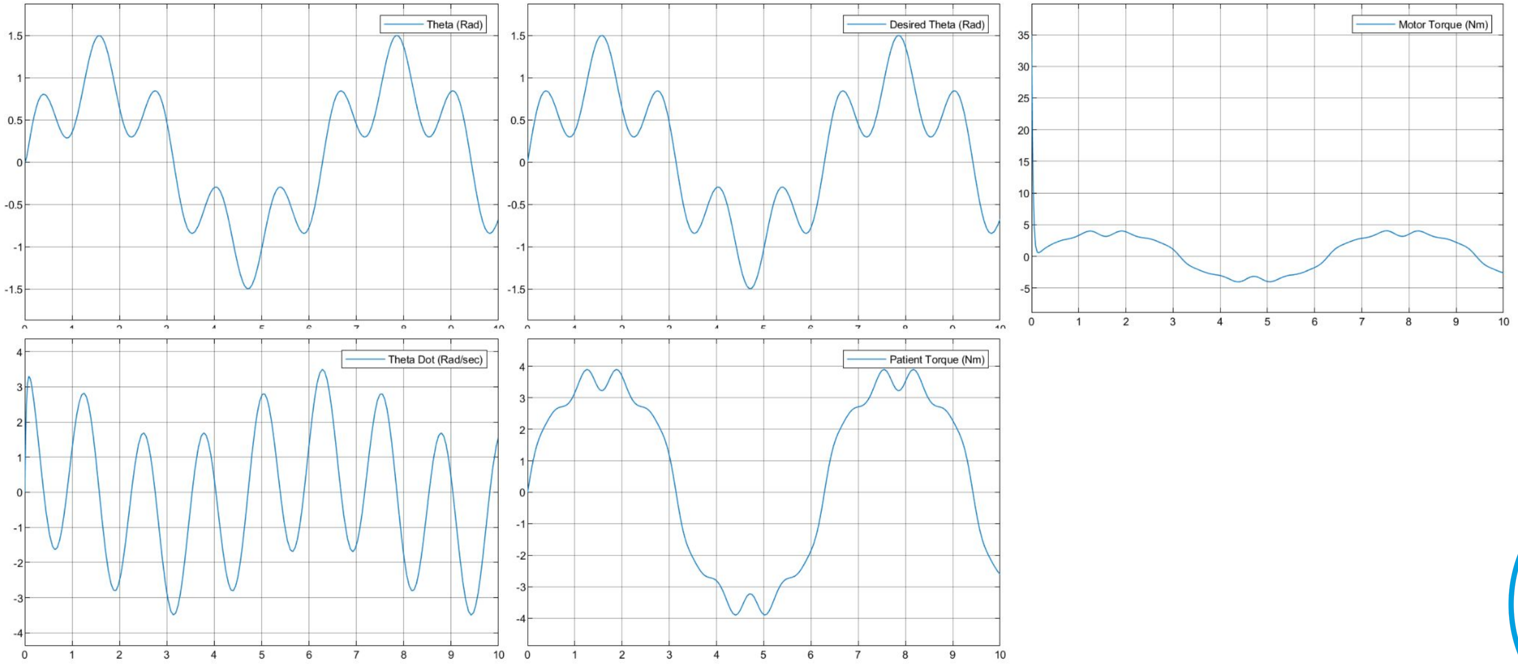
Key Results 1: 100% Patient Effort

$$u_m = K(\theta_d - \theta) + D(\dot{\theta}_d - \dot{\theta}) + I_e\ddot{\theta}_d + C_e\dot{\theta} + G_e$$



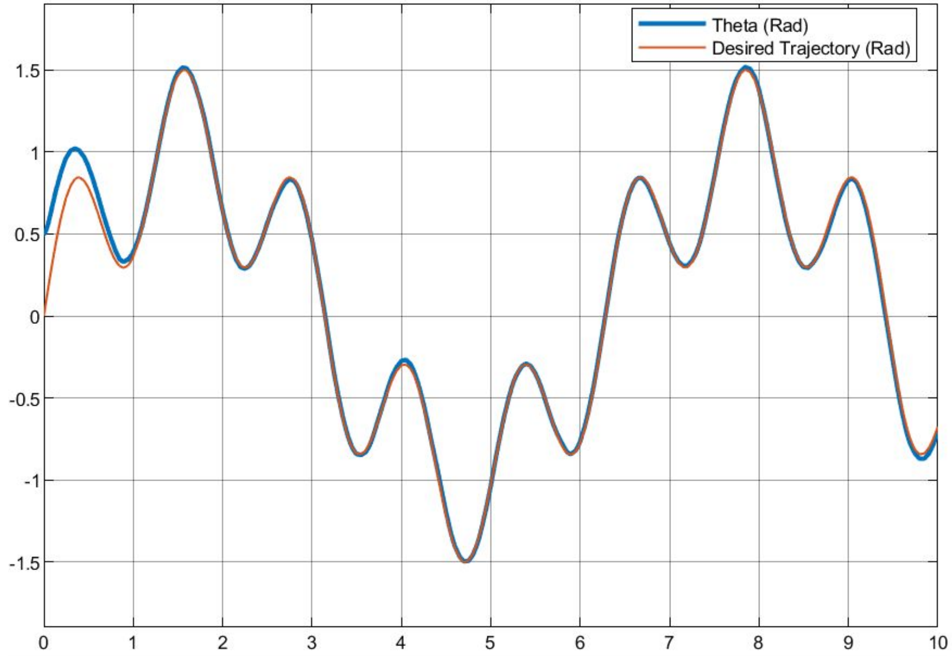
Key Results 1: 100% Patient Effort

$$u_m = K(\theta_d - \theta) + D(\dot{\theta}_d - \dot{\theta}) + I_e\ddot{\theta}_d + C_e\dot{\theta} + G_e$$



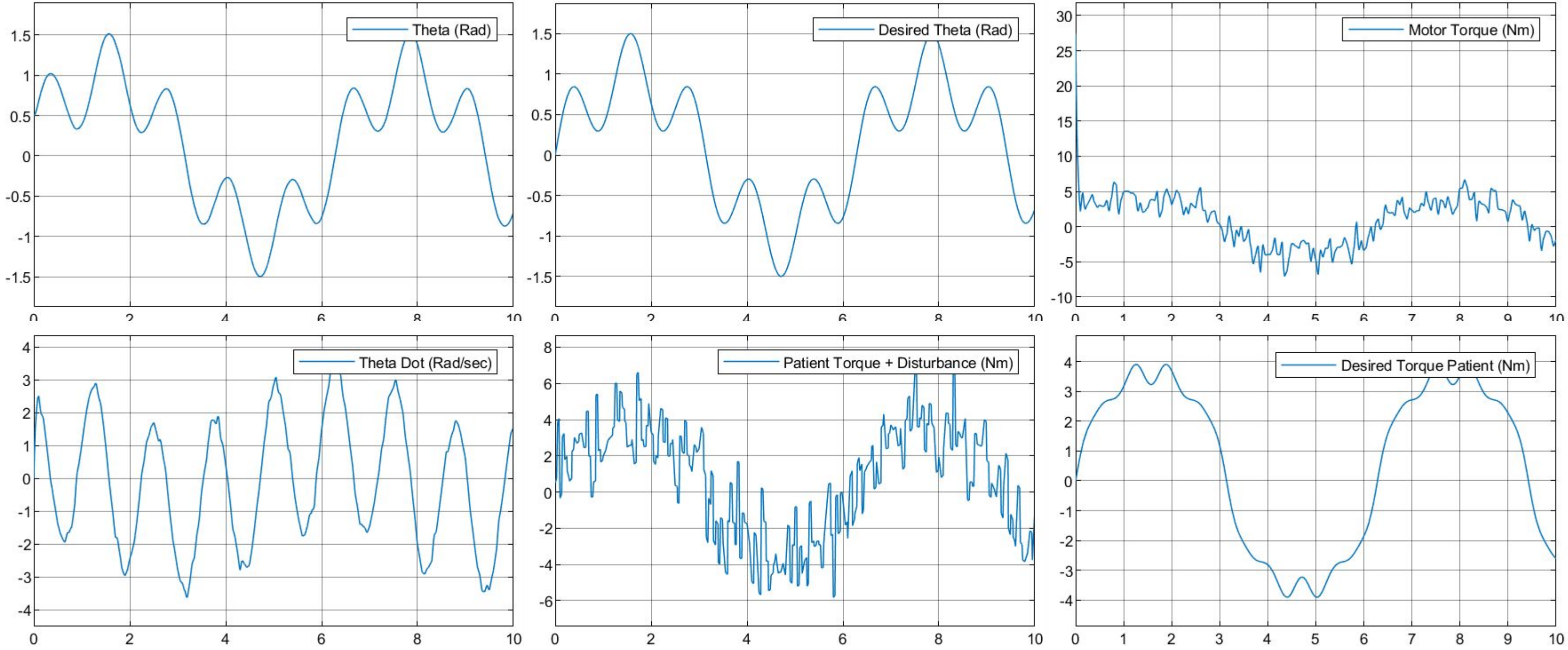
Key Results 2: 100% Patient Effort with disturbances added in Patient Torque

$$u_m = K(\theta_d - \theta) + D(\dot{\theta}_d - \dot{\theta}) + I_e\ddot{\theta}_d + C_e\dot{\theta} + G_e$$



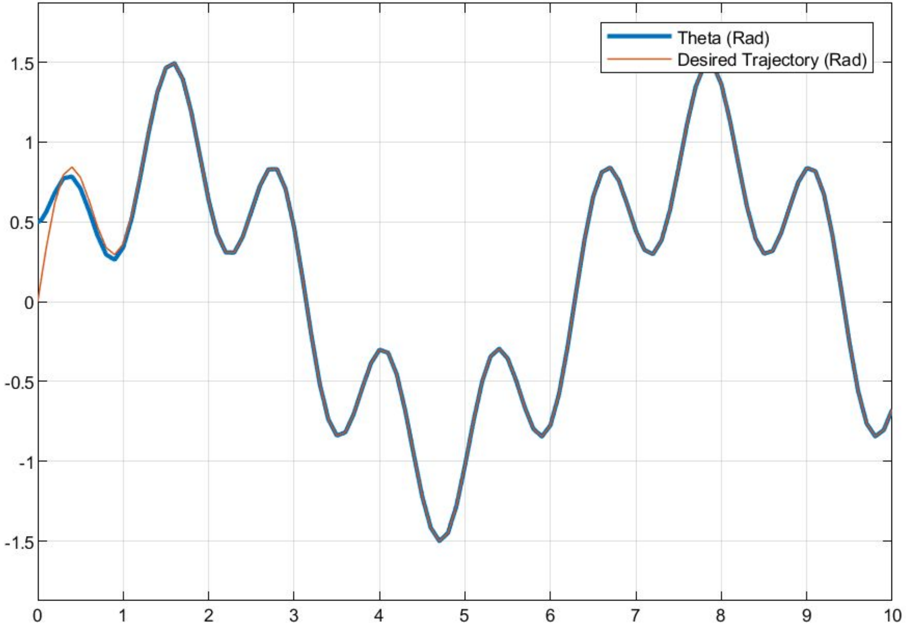
Key Results 2: 100% Patient Effort + disturbances in Patient Torque

$$u_m = K(\theta_d - \theta) + D(\dot{\theta}_d - \dot{\theta}) + I_e\ddot{\theta}_d + C_e\dot{\theta} + G_e$$



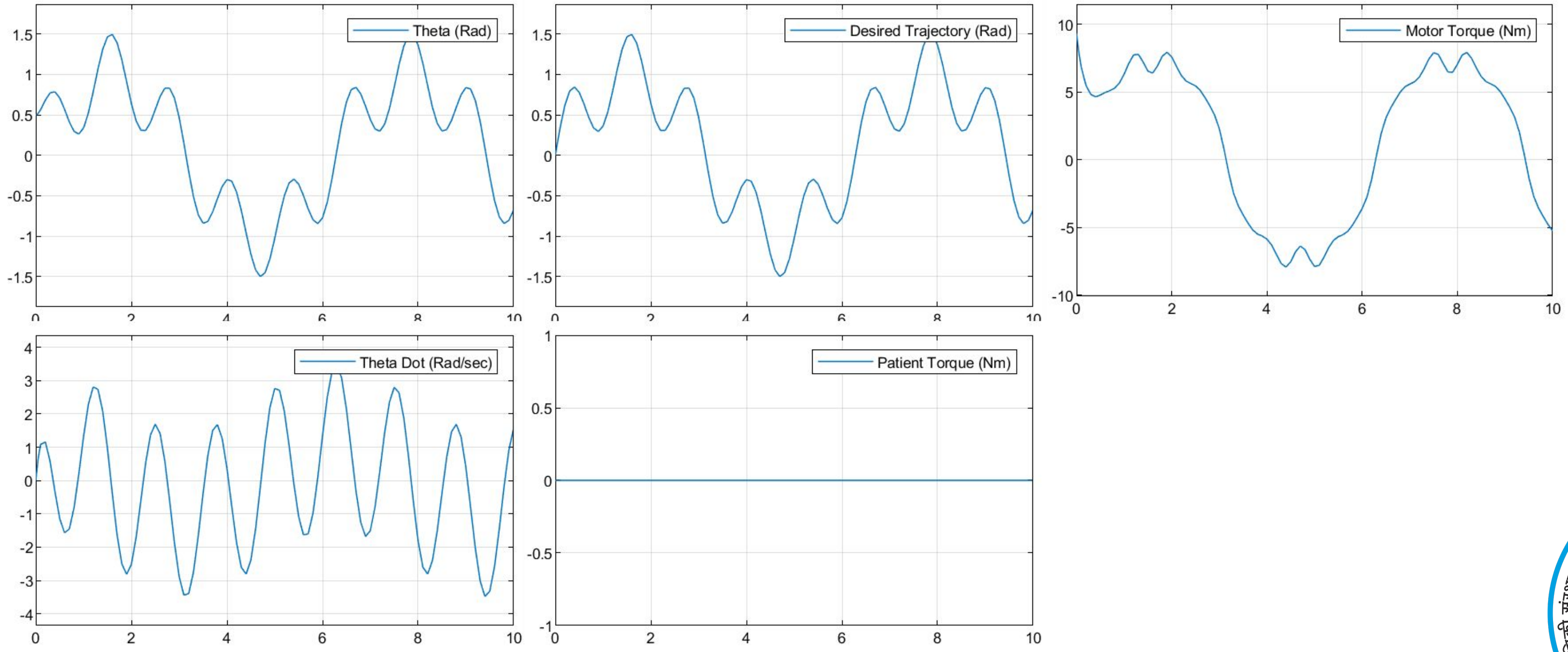
Key Results 2: 0% Patient Effort

$$u_m = K(\theta_d - \theta) + D(\dot{\theta}_d - \dot{\theta}) + (I_e + I_l)\ddot{\theta}_d + (C_e + C_l)\dot{\theta} + (G_e + G_l)$$

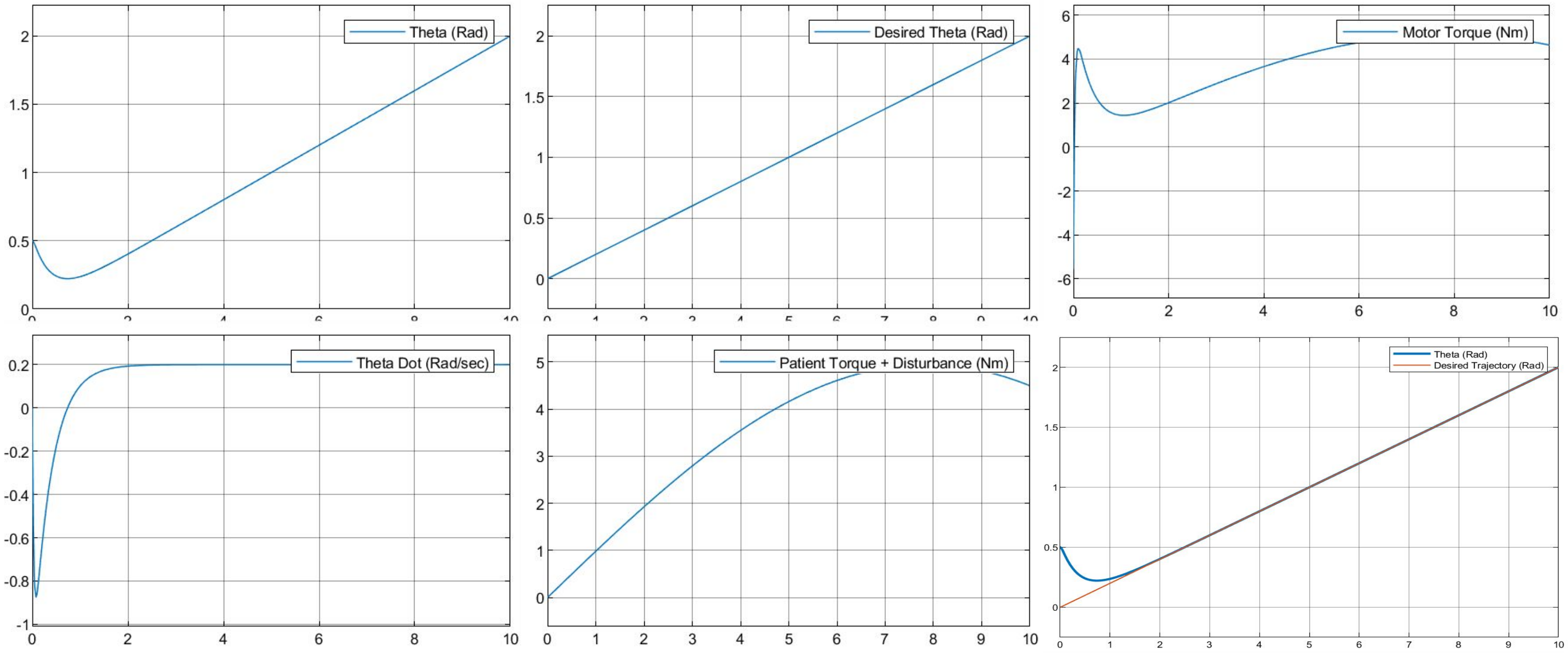


Key Results 2: 0% Patient Effort

$$u_m = K(\theta_d - \theta) + D(\dot{\theta}_d - \dot{\theta}) + (I_e + I_l)\ddot{\theta}_d + (C_e + C_l)\dot{\theta} + (G_e + G_l)$$



Additional results 1: 100% Patient Effort, Linear Trajectory



Additional results 2: 100% Patient Effort, Parabolic Trajectory