ECE 590: Assignment #4

Due on Tuesday, September 27, 2016

Lofaro 19:20

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Contents

Problem 1

Make the Hubo (not the DRC-Hubo) squat so its waist is 0.5m off the ground, then make it stand up straight so it is 0.8m off the ground. Have it repeat this 4 times. Use IK methods to complete assignment.

Using the notation and examples from "Introduction To Robotics Mechanics and control" by John Craig:

$$ {}^0_1T = \begin{bmatrix} c\theta_1 & -s\theta_1 & 0. & l_1 \\ s\theta_1 & c\theta_1 & 0. & 0. \\ 0. & 0. & 1. & 0. \\ 0. & 0. & 0. & 1. \end{bmatrix} $$

$$ {}^1_2T = \begin{bmatrix} c\theta_2 & -s\theta_2 & 0. & l_2 \\ s\theta_2 & c\theta_2 & 0. & 0. \\ 0. & 0. & 1. & 0. \\ 0. & 0. & 0. & 1. \end{bmatrix} $$

$$ {}^2_3T = \begin{bmatrix} c\theta_3 & -s\theta_3 & 0. & l_3 \\ s\theta_3 & c\theta_3 & 0. & 0. \\ 0. & 0. & 1. & 0. \\ 0. & 0. & 0. & 1. \end{bmatrix} $$

If we are looking for the hip joint of the Hubo robot then we are looking for the $[x\ y\ z]^T$ of the center of mass above the hip. Solving for the full forward kinematics reveals:

$$ {}^0_3T = \begin{bmatrix} c\theta_1 & -s\theta_1 & 0. & l_1 \\ s\theta_1 & c\theta_1 & 0. & 0. \\ 0. & 0. & 1. & 0. \\ 0. & 0. & 0. & 1. \end{bmatrix} \begin{bmatrix} c\theta_2 & -s\theta_2 & 0. & l_2 \\ s\theta_2 & c\theta_2 & 0. & 0. \\ 0. & 0. & 1. & 0. \\ 0. & 0. & 0. & 1. \end{bmatrix} \begin{bmatrix} c\theta_3 & -s\theta_3 & 0. & l_3 \\ s\theta_3 & c\theta_3 & 0. & 0. \\ 0. & 0. & 1. & 0. \\ 0. & 0. & 0. & 1. \end{bmatrix} $$

From class we know that the following is true:

$$ \theta_1 = \cos^{-1} \frac{x^2 + y^2 - d_1^2 - d_2^2}{2d_1 d_2} $$
$$ \theta_2 = \tan^{-1} \left(\frac{y(d_1 + d_2\cos(\theta_2)) - x(d_2\sin(\theta_2))}{x(d_1 + d_2\cos(\theta_2)) - y(d_2\sin(\theta_2))} \right) $$

Since the top part of the robot (above the hip) must be at $y = 0$ (in robot coordinate system if x is positive forward and rotation is around z) for the duration of the movement, it is then inferred that:

$$ 0 = \theta_1 + \theta_2 + \theta_3 $$
$$ \theta_3 = -\theta_1 - \theta_2 $$

By plugging in the x and y desired values θ_1, θ_2, θ_3 were solved.