

Computer Engineering Department
ROBOTICS
LIST OF HOMEWORKS AND THEIR SOLUTION
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Homework No 1 (Due on March 12, 2008)

Bipedal Humanoid Geometric Motion

1. Simplify the following matrix expression:

$$(ROTZ(\theta_1)ROTZ^t(2\theta_1)[ROTY(\theta_2)ROTZ^t(\theta_3)]^{-1}ROTY(\theta_4))^t$$

2. Consider the KONDO KHR-1 which has the following five joints in each leg:

Link-1 (Revolute (Z), Y(L1=0))

Link-2 (Revolute (X), Y(L2))

Link-3 (Revolute (X), Y(L3))

Link-3 (Revolute (X), Y(L3))

Link-3 (Revolute (z), Y(L3))

where Revolute(Z) and Y(L1) means that this dof is revolute and its rotation is about its Z axis and the link itself is along the Y axis. Each link definition refers to its frame of reference. The Z axis is oriented forward in the horizontal plane, the Y axis is oriented downward along the vertical axis, and the X axis is oriented outward along the right side of the KONDO. We assume a fixed frame R_0 is attached to the robot body, where link-1, link-2, etc are arranged in series one after the other. Initially the frames R_0 and R_1 have the same origin, i.e. the length from O_0 to O_1 is nil. The last link (link-5) is attached to the robot foot. Therefore, a walking motion consists of moving R_5 by its origin and its rotation.

Answer each of the following questions:

- (a) Give the general two equations (rotation and position) for iteratively finding the forward geometric model(FGM).
- (b) Apply the FGM iterative equations to the above robot arm to determine the expression of the position and orientation of each link $O_iO_{i+1,0}$ for i in $[1, \dots, 5]$ as function of the joint parameters such as $\theta_1, \dots, \theta_5$. The model is to give the position and orientation of the foot frame which the fifth frame R_5 and the coordinate of its origin.
- (c) Indicate a method to obtain the Inverse geometric model (IGM) for the KONDO roboto leg, i.e. given the frame R_5 orientation matrix and its origin evaluate the joint solution $(\theta_1, \theta_2, \theta_3, \theta_4, \theta_5)$.

- (d) In order to let the KONDO walking each leg must follow a specific trajectory. Answer the following: (1) Determine the control parameters for the walking of the Kondo humanoid and explain how each parameter is to be controlled, and (2) Find how R_5 should be moved to provide the robot some walking mechanism.
- (e) Generate the trajectory of the joint solution when the robot is walking for a few steps. Plot the solution and attach the graphics with your comments.