RBE 500 Group Assignment #3

Joshua Gross, Arjan Gupta, Melissa Kelly

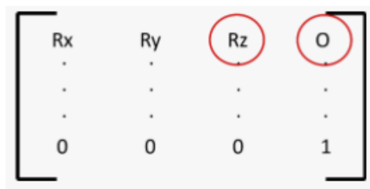
Velocity Kinematics

Calculations

Solving for both the forward and inverse velocity kinematics are centered around solving the Jacobian matrix. In order to solve for the Jacobian, we first need to establish the linear and angular velocity components in all directions for each of the joints. These expressions will vary dependent upon whether the joint is revolute or prismatic. Once these determinations are made, a matrix of the form seem in the figure below is created, where, each of the elements is a 3×1 matrix. This matrix comes from the lecture slides.

$$J = \begin{bmatrix} z_0 \times (o_3 - o_0) & z_1 \times (o_3 - o_1) & z_2 \\ z_0 & z_1 & 0 \end{bmatrix}$$

As clearly seen in the above figure, the following elements are needed in order to solve the Jacobian in its entirety: $z_0, z_1, z_2, o_0, o_1, o_3$. These values are found by using elements of the individual transformation matrices found when solving the forward position kinematics. The image below shows what elements of the transformation matrix are extracted in order to solve for Jacobian.



Velocity Controller

The process of creating a controller for this application stems from the previous position controller as well as other controllers created throughout the course. The goal velocity of each joint, V_r is is received through a service response. The name of the service is `velocity_inv_kin_service`. Suppose our current velocity is given as V. The error for each joint is then calculated as follows:

$$E = V_r - V$$

When paired with the proportional gain value, we now have one of the terms of the controller. In order to get the other term, the derivative of the error is also needed, and is calculated as shown:

$$\dot{E} = \frac{V - V_{prev}}{\Delta time}$$

This derivative of the error is paired with the derivate gain and now completes the controller. Our controller takers on the form:

$$F = K_p E + K_d \dot{E}$$

Where F is the effort that will be applied in Gazebo and will cause the joints to move.