COMS W4733, Computational Aspects of Robotics, Fall 2015

HOMEWORK 2, DATE DUE: . Individual part due in class Oct. 15 programming team part due electronically Wednesday, Oct.14, 11:59PM.

Note: This is a two part assignment. Part I is an INDIVIDUAL assignment, to be done only by yourself. Part II is a a team problem to work on with your lab partners on the Create robot.

PART I:

1. (8 pts) Given 3 coordinate frames, $o_1x_1y_1z_1$, $o_2x_2y_2z_2$, $o_3x_3y_3z_3$. If

$$R_2^1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{2} & -\frac{\sqrt{3}}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{1}{2} \end{bmatrix} ; R_3^1 = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} \tag{1}$$

   Find the matrix R_3^2.

2. (8 pts) Consider the following rotation matrix. What is the axis of rotation (X,Y, or Z) and what is the angle of rotation?

$$\begin{bmatrix} 0.5 & 0 & -0.866 \\ 0 & 1 & 0 \\ 0.866 & 0 & 0.5 \end{bmatrix} \tag{2}$$

3. (4 pts) Draw a standard world coordinate frame w. Then draw the resulting coordinate frame described by the transform below:

$$\begin{bmatrix} 0 & 0 & 1 & 2 \\ 0 & 1 & 0 & 4 \\ -1 & 0 & 0 & 5 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{3}$$

4. (4 pts) Fill out the missing items in the 4x4 homogeneous transform below:

$$\begin{bmatrix} ? & 0 & -1 & 5 \\ ? & 0 & 0 & 3 \\ ? & -1 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{4}$$

5. Below is the Cartesian coordinate frame of a robot's final position:

$$\begin{bmatrix} 0.354 & -0.674 & 0.649 & 4.33 \\ 0.505 & 0.722 & 0.475 & 2.5 \\ -0.788 & 0.160 & 0.595 & 8 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{5}$$

   (a) (8 pts) Show the ZYZ Euler angles and translational components that will achieve this position.

   (b) (8 pts) Show the Equivalent axis rotation and axis direction that will achieve this position.

6. (10 pts) Consider the diagram of fig. 2.14. A robot $base$ frame $o_0x_0y_0z_0$ is set up 1 meter from a table. The table top is 1 meter high and 1 meter square. A $table$ frame $o_1x_1y_1z_1$ is fixed to the edge of the table as shown. A cube measuring 20 cm on a side is placed in the center of the table with $cube$ frame $o_2x_2y_2z_2$ established at the center of the cube as shown. A camera is situated directly above the center of the block 2 meters above the table top with $camera$ frame $o_3x_3y_3z_3$ attached as shown.

   (a) Find the homogeneous transformations relating each of these frames to the $base$ frame $o_0x_0y_0z_0$: T^{base}_{table}, T^{base}_{cube}, T^{base}_{camera}

   (b) Find the homogeneous transformation relating the $cube$ frame $o_2x_2y_2z_2$ to the camera frame $o_3x_3y_3z_3$: T^{cube}_{camera}

PART II:

Implement a BUG2 algorithm to move the create from a designated starting point to a goal point in an environment. Your robot should start out along the straight line path from start to goal (the M Line). If it hits any obstacles along the way, it will invoke a wall following behavior until the M Line is reacquired and the robot again starts out for the goal point along the M Line. When goal point is reached, robot will stop.

(30 points) Test your code in the simulator. Assume a trajectory from a start point to a goal point exactly 4 meters in front of the robot. Add test obstacles in the simulator that impede the path, requiring the create to invoke BUG2 behavior.

(20 points) Now, test your code on physical obstacles in a real environment. Assume the goal point is exactly 4 meters in front to the robot's starting point.

(5 points) Extra Credit: Map out your robot's progress graphically, showing posiiton and robot orientation as it moves. Note: this may slow down your communication and affect performance of your robot. If you are experiencing this, then cache the pose information and map it out after the robot stops.

Note: Your BUG2 algorithm should also be aware when it is trapped inside of an obstacle and report this,

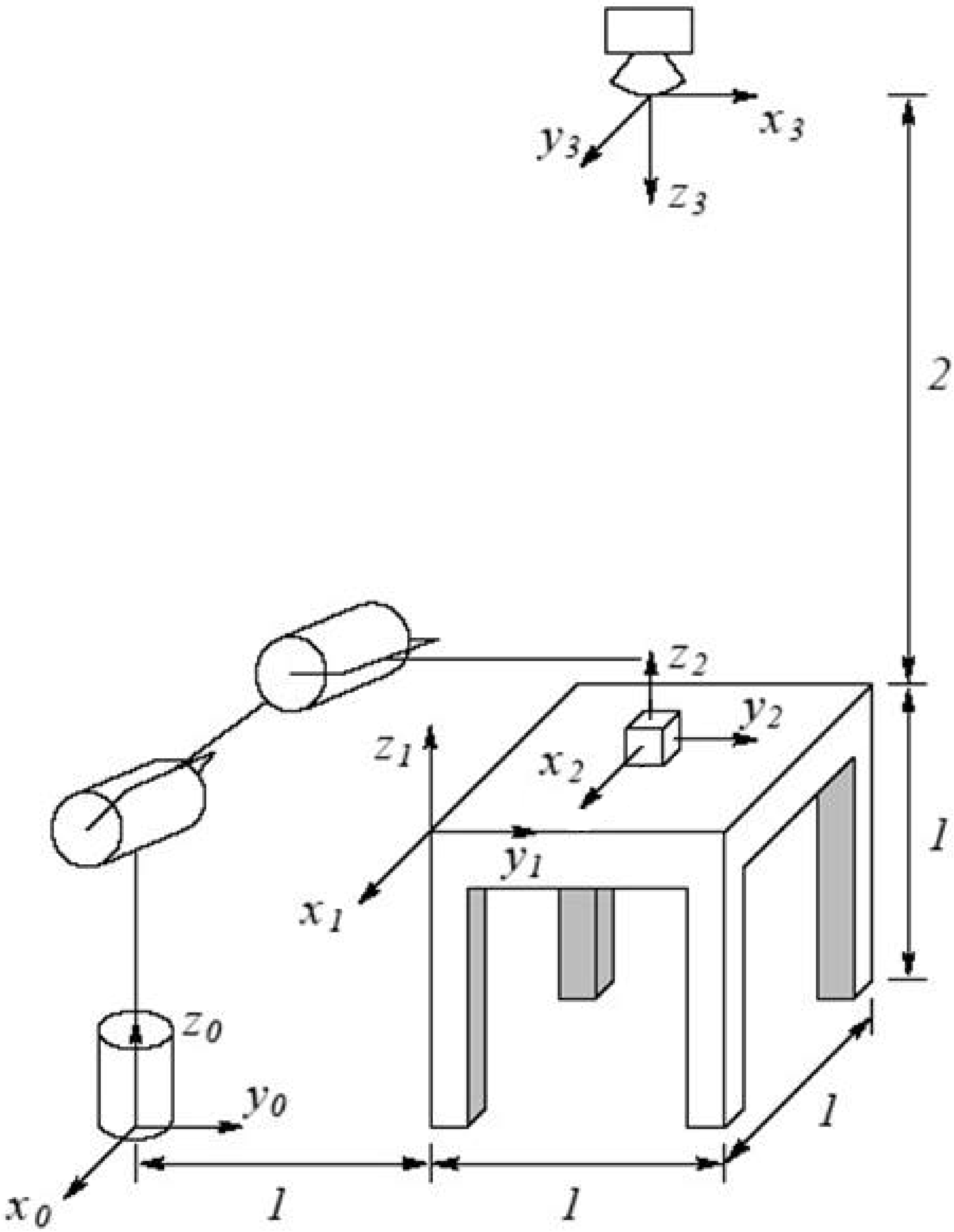

Figure 2.14: Diagram for Problem 2-39.