University of Hamburg
Faculty of MIN, Department of Informatics, Group TAMS
J. Zhang, H. Bistry

Secretary: T. Tetsis
Room: F-311
Phone: 42883-2430

Introduction to Robotics (SS2013)

Assignment #3

Due: 15.05.2014, 14.00

Task 3.1: (5 points) Consider a simple gripper that is being used to loosen/open a screw cap (illustrated in figure 1). The thread height of the screw cap is given as $h/rotations$.

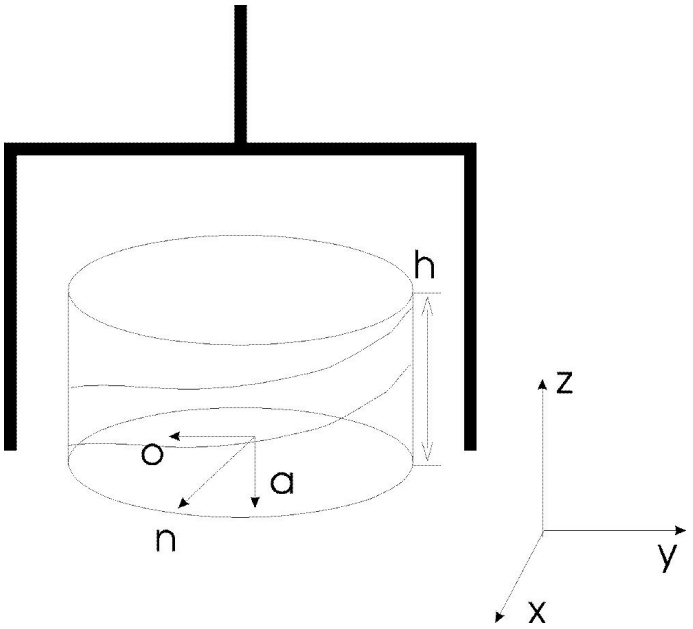

Figure 1: Loosening of a screw cap.

Determine the time-dependent homogeneous transformation

$$T(t) = \begin{bmatrix} n_1(t) & o_1(t) & a_1(t) & d_1(t) \\ n_2(t) & o_2(t) & a_2(t) & d_2(t) \\ n_3(t) & o_3(t) & a_3(t) & d_3(t) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

that describes the motion of the manipulator. Ignore the acceleration and deceleration phases and choose the z-axis to be the axis of the rotating motion. Furthermore, assume the angular velocity ω_z to be constant.

Task 3.2: (5 points) Figure 2 shows the workspace of a robot manipulator. Objects transported on a conveyor belt are evaluated by the vision system (a camera) and based on the results of the evaluation the manipulator is used to place the object into either the "*Pass*" or the "*Reject*" area.

The transformation between the object coordinate frame and the camera coordinate frame is known based on camera calibration:

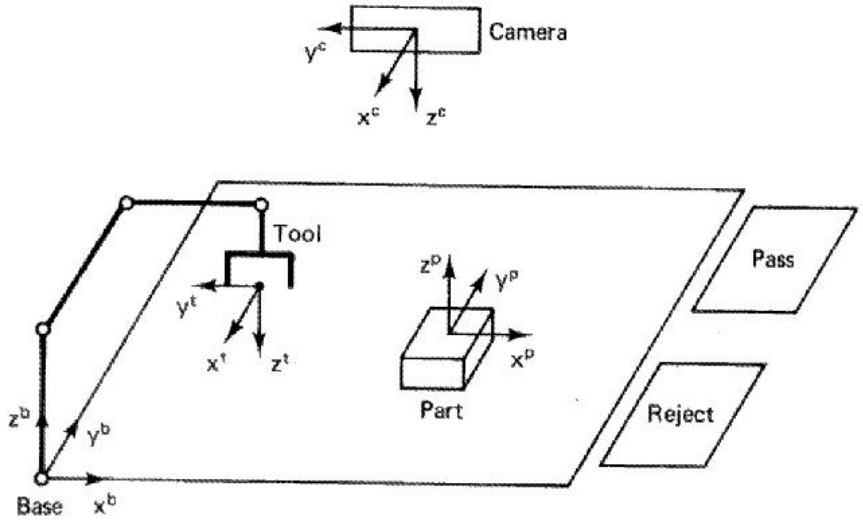

Figure 2: A robot workspace.

$$^{camera}T_{object} = \begin{bmatrix} 0 & -1 & 0 & 0 \\ -1 & 0 & 0 & -5 \\ 0 & 0 & -1 & 19 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The transformation between the base of the robot manipulator and the camera coordinate frame is known as well:

$$^{camera}T_{base} = \begin{bmatrix} 0 & -1 & 0 & 15 \\ -1 & 0 & 0 & 25 \\ 0 & 0 & -1 & 20 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3.2.1: Determine the homogeneous transformation $^{base}T_{object}$.

3.2.2: Determine $^{base}T_{tool}$ considering that the manipulator is grasping the object using the front and the back surface of the object. (Hint: the origins of the object and the tool coordinate frames coincide during the grasp).

Task 3.3: (2 points) Various manufacturers of robot manipulators specify the trajectory precision of the manipulator based on the repeatability derived from a series of recorded joint angles. Multiple applications (e.g. previous task) on the other hand require knowledge of the positioning accuracy in order to reach a position in cartesian space based on information from the vision system. What factors does the positioning accuracy depend on? What can be considered a limit of the positioning accuracy?