Second Exam Study Sheet

The second exam is on Thursday, Dec. 5, in class. No notes, textbooks, electronic devices are allowed. The exam will focus on the topics covered in the course during the second part of the course including:

RRT path planners, Particle Filters, SLAM, Robotic Grasping, Tactile Sensing, Computer Vision, OpenCV, Reinforcement Learning, Followbot autonomous driving.

Some sample questions:

1. How do you subscribe to a camera image stream in ROS?
2. Given an image of an object to be picked up, a goal of computer vision is to find the location of such an object in another image. We can think of this as Shape Recognition.
    a. Briefly describe 2 methods to do this?
    b. For each of the methods above, describe how they account for object scale changes and object orientation (rotation)
3. What does Simultaneous Localization And Mapping (SLAM) software do? (include all correct answers)
    a. Estimates the location of features in the environment?
    b. Controls the robot's movement through the environment?
    c. Causes the robot to avoid obstacles in the environment?
    d. Allows navigation in a cluttered environment?
    e. Estimates the position and orientation of the robot with respect to the environment?
4. What is the difference between particle filter localization and particle filter SLAM?
5. What is Graph SLAM?
6. Why is grasping with a human hand a 20 + 6 Degree-of-Freedom problem?
7. What is an eigen grasp?
8. What is Data Driven grasping?

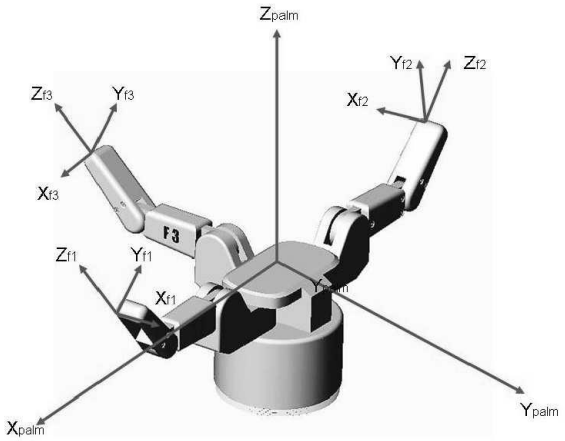


Figure 5: Robotic hand and coordinate frames

9. The hand above has 3 fingers, each with two revolute joints. What is the configuration space of this robotic hand?

9. (9 pts) Figure 5 shows a robot hand. The hand has 3 fingers, each with two revolute joints. It has 4 coordinate systems: a reference coordinate frame at the palm $Palm$, and a local frame for every finger f_1, f_2, f_3 whose origin is the end of the fingertip. We can transform points in each finger local frame to $Palm$ coordinates using 4x4 transforms $T_{f1}^{Palm}, T_{f2}^{Palm}, T_{f3}^{Palm}$.

   (a) (3 pts) Given 4x4 coordinate frames T_{f1}^{Palm} and T_{f2}^{Palm}, how would you tell if the two fingertips are in contact?

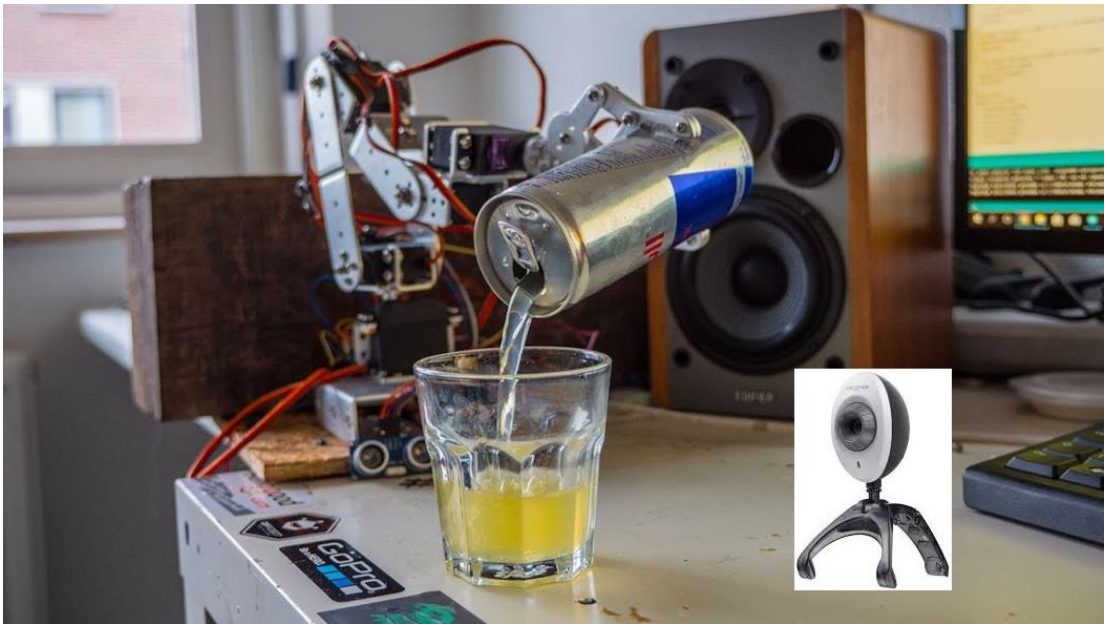
   (b) (3 pts) Given 4x4 coordinate frames T_{f1}^{Palm}, T_{f2}^{Palm}, and T_{f3}^{Palm}, how would you determine which fingertip (1 or 2) is closer in distance to fingertip 3?

   (c) (3 pts) Given the 4x4 transforms above, can you implement a full collision avoidance system for the three fingers? Explain your answer briefly.

10. See below:

11. What is camera calibration? How is it done using the Direct Linear Transform (DLT) or "lumped" method?
12. Stereo Vision:
    a. What is the epipolar constraint and why is it important in recovering depth from stereo?
    b. What is disparity?
    c. Given two feature points in a stereo pair, what is a measure we can use to see if they are the same point?
    d. How does the stereo cameras baseline affect disparity?
13. How can I improve a sub-optimal RRT planned path ?
14. How do you do color filtering in OpenCV?
15. In robot learning, what is kinesthetic teaching of a robot?
16. What are three advantages of reinforcement learning in robotic tasks? Three disadvantages?
17. How would you program a followbot to recognize a dog walking across the yellow road and immediately stop?

Robotic Pouring setup



18. Consider using reinforcement learning to have a robot manipulator learn to pour a liquid from a can into a glass as in the picture above. You may assume the robot is holding the can upright above the glass, and needs to simply tilt its wrist joint to pour the liquid into the glass. The setup also contains a camera on the table that can be used to a measure the amount of liquid poured in to the glass.

    In reinforcement learning, we have a state space **S** that represents the task state, a set of Actions **A** that the robot can perform which generate a new task state from its current state, and a reward **R** that measures how successful that action from the current state is towards accomplishing the task.

    a. What is the state space **S**?
    b. What are the actions **A**?
    c. What is an appropriate reward function **R**?
    d. How would you use computer vision with the camera on the table to measure how much liquid has been poured into the glass?
    e. How would you use the computer vision system to control the tilt angle on the robot at each time step?
    f. Learning this task is messy, slow, and may cause a lot of problems with spilled liquids in the lab. How can you alleviate these problems and guarantee no spill damage?