

Robotic Manipulation, Fall 2015

Homework 2 (4752/4750: 100 points, 5752/5750: 125 points)
Differential Kinematics and Motion Planning
or: How I Learned to Stop Worrying and Love the Jacobian

Due at the start of class, Wednesday, Oct. 28, 2015

Objective: Demonstrate understanding of the theory of differential kinematics and motion planning.

Instructions: This assignment can be discussed as a group. There is no limit to this group size. Each student is responsible for working the problems, writing them up, and submitting their own PDF containing the answers to the questions below. You may find that it is helpful to use L^AT_EX to typeset the equations. Write your name and the names of all people (in the class or not) with whom you discussed any part of the homework.

Assignment: Answer the following problems. SHV is the textbook by Spong, Hutchinson, and Vidyasagar. Show your work.

1. (5 points) SHV Problem 4-15
2. (20 points) SHV Problem 4-17
3. (20 points) SHV Problem 4-25
4. (10 points) Referring to SHV Problem 4-25, the expression $(I - J^+J)b$ projects the vector b onto the *null space* of the Jacobian. Thus, no choice of b will alter the end-effector velocity. Why would you want to do this? Give some examples.
5. (10 points) Under what circumstances is a motion planner that uses artificial potential fields guaranteed to reach the goal?
6. (10 points) Where are the advantages of a probabilistic planner like PRM or RRT over a deterministic planner? What are the disadvantages?
7. (10 points) What is the narrow passage problem? Give an example from everyday experience that causes a narrow passage problem for a robot motion planner.
8. (5 points) What's the problem with using motion planners to solve manipulation problems?
9. (10 points) Which kind of robot is more likely to use a motion planner: an industrial robot in a factory or a personal robot in a home? Explain your answer.

The remaining problems (on P. 2) are optional extra-credit for 4000-level students. They involve the *exponential map*, which is yet another way to describe rotations.

10. (5 points) SHV Problem 4-8
11. (5 points) SHV Problem 4-9
12. (5 points) SHV Problem 4-10
13. (5 points) SHV Problem 4-11
14. (5 points) SHV Problem 4-12