2011_final_soln

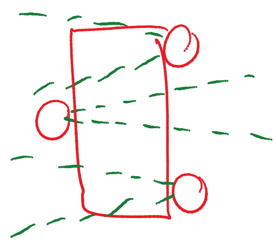
Wednesday, May 18, 2011
8:04 AM

Robotics II Final, Spring 2011.

T/F 4 points each

1. In all friction form closure grasps, every contact point see can at least one other contact point in its friction cone.

F



This has force closure.

2. Unit quaternions have 4 elements, but only three degrees of freedom.

T since there is a constraint $h_1^2 + h_2^2 + h_3^2 + h_4^2 = 1$

3. Some LCPs arising in the Stewart-Trinkle time stepping method have nonunique solutions.

T

4. A* search with cost-to-come = 0 is equivalent to Best-First search

F it is equiv to Dijkstra's alg.

5. Sample-based methods are preferred in motion planning, because the number of samples needed for a given resolution is independent of the dimension of C-space.

F it is exponential in dimension

6. A robot with 7 joints and a position-controlled parallel-jaw gripper has an 8-dimensional C-space.

T

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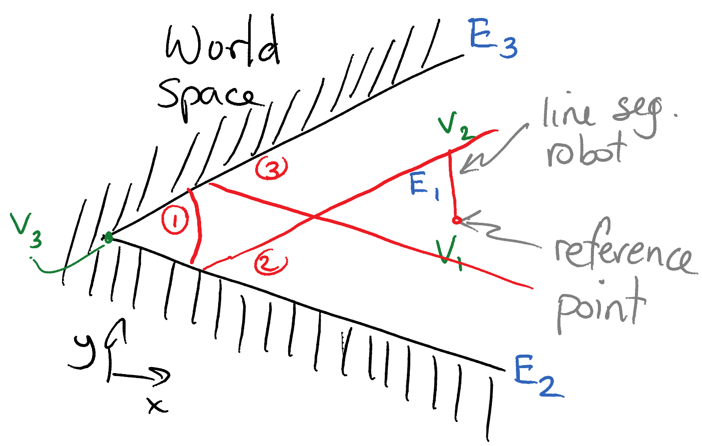
8 points each

Short Answer Questions



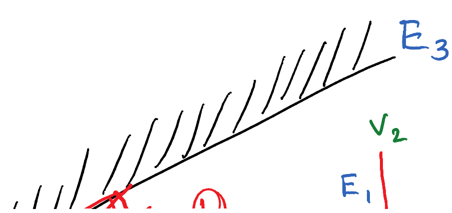
1. Sketch the curves in the workspace when the radar plots change qualitatively (these are known as critical curves). Label the curves (E_1, V_1), etc

① $(V_1, V_3) = (V_1, E_2) \wedge (V_1, E_3)$

② (V_2, E_3)

③ (V_2, E_2)

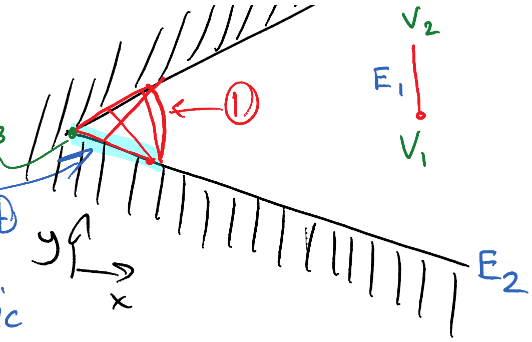
There are also two others that are harder to draw:



There are also two others that are harder to draw:

④ $(V_1, E_2) \wedge (V_2, E_3)$ The highlighted blue arc is ④

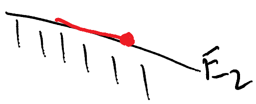
⑤ $(V_1, E_3) \wedge (V_2, E_2)$ ⑤ is symmetric

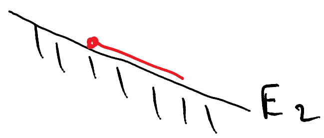


Critical curves ④ & ⑤ start on V_3 & end on ①.

There are still more:

$(V_1 E_2) \wedge (V_2 E_2)$ also $(V_1 E_2) \wedge (V_2 E_2)$ flipped





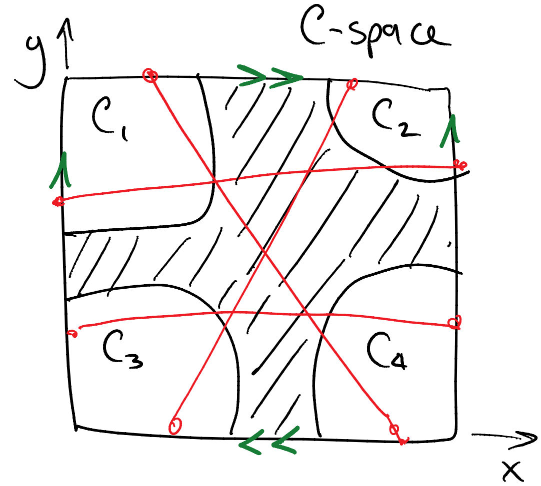
Similarly, $(V_1 E_3) \wedge (V_2 E_3)$ also $(V_1 E_3) \wedge (V_2 E_3)$ flipped

2. Describe how a randomized potential field method works and how it escapes local minima. Under what circumstances does it fail?

Obstacles are assigned force fields that repel the robot. The initial and goal configs are assigned repulsive and attractive force field as well. The two are added to create a force field on C-space that hopefully makes the goal the unique global minimum, but this is typically not the case.

In the potential field method, one searches along the field's gradient until q_{goal} is reached or q is trapped. If trapped, random walk for a while. Follow gradient again. No guarantee that a random walk will escape a trap!

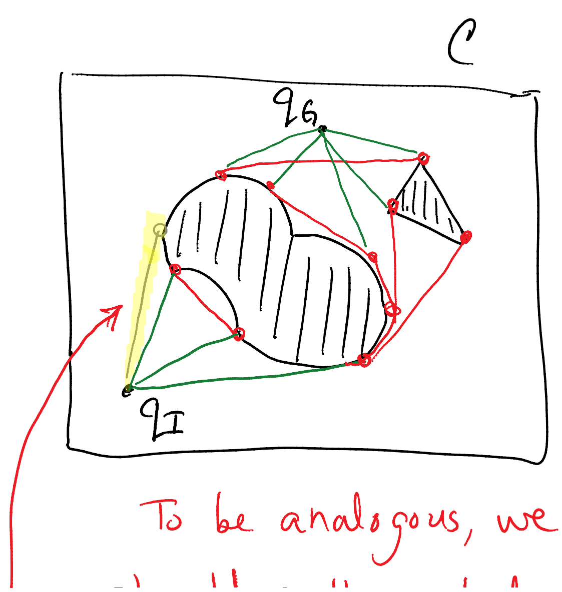
3. Let C be the "disk" shown on the right. Without the identifications shown, C_{free} has 4 components. How many components exist with the identifications shown?



1. C_1 connects to C_4 & C_2. C_2 connects to C_3.

4. For the C-space shown on the right, extend the idea of a visibility graph to curved objects.

Draw the graph for the



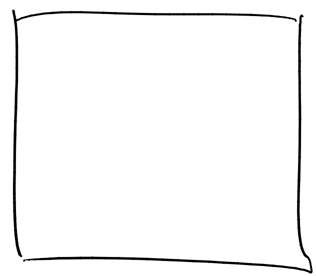
To be analogous, we

Draw the graph for the obstacles and q_I and q_G.

To be analogous, we should really include this extra arc & node

5. Give pseudo-code defining a van der Corput sequence on a disc in $\mathbb{R}^2$.

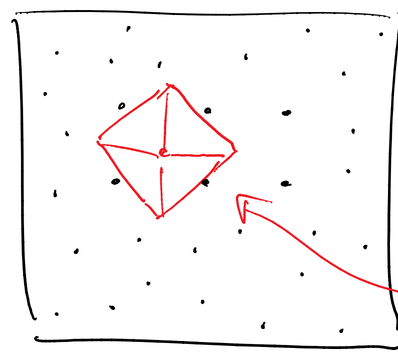
$I' \times I'$



6. Find the points of maximum dispersion in the region shown on the right.

Compare results for two metrics: L_1 and L_∞

L_1

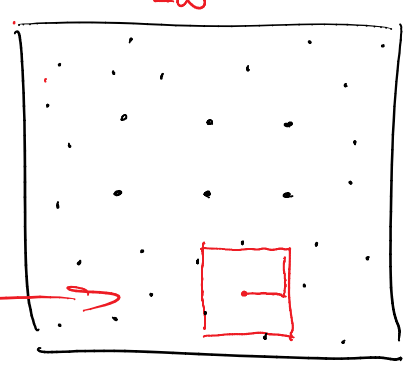


Max L_1 is shown

$L_1 \Rightarrow$ max coord change

$L_\infty \Rightarrow$ Manhattan distance

L_∞



Max L_∞ is sum of the 2 legs from middle to corner

7. Describe the main differences between sampling-based

and combinatorial motion planning methods.

Sampling-Based

We only approx C_{free}

Combinatorial

We compute C_{free} explicitly

Analysis Questions (10 points each)

1. Let X be a vector space and let x & x' be points in X.

Prove that $\rho(x, x') = abs(x - x')$ is or is not a metric.

Note that abs = absolute value, which applies to each element of a vector.

ρ is a vector & $\therefore$ not a metric.

If you considered $x \in \mathbb{R}^1$, then abs(·) satisfies the properties required of a metric:

nonnegativity: $\rho(x, x') \geq 0 \quad \forall\ x, x'$

reflexivity: $\rho(x, x') = 0$ iff $x = x'$

Symmetry: $\rho(x, x') = \rho(x', x)$

Triangle ineq: $\rho(x, x') + \rho(x', x'') \geq \rho(x, x'')$

2. Define the most impressive analysis problem you prepared for, but I didn't ask. Then solve it.