2009_final

Tuesday, May 06, 2008
1:59 PM

Robotics II Final - Spring 2009

True / False Questions (14 pts total. 2 pts per question)

(1.) Assume $C = \mathbb{R}^2$ and C_{obs} is a polygon. Vertical decomposition of C_{free} will yield a simplicial complex covering C_{free}.

(2.) C-space of a rigid body free to move in space ($\mathbb{R}^3$) is <u>not</u> $SE(3) = \mathbb{R}^3 \times SO(3)$.

(3.) Some constraints of a Linear Complementarity problem are not linear in the unknowns.

(4.) A^* search with cost-to-come function equal to zero, is equivalent to best-first search.

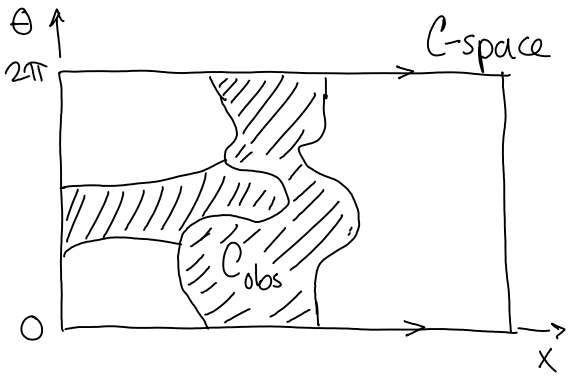
(5.) Semi-Algebraic sets are composed of a finite # of unions & intersections of polynomial inequalities.

(6.) Randomized potential field methods are

particular nice to use for a wide range of problems, because they do not require parameter tuning.

⑦ The C-space at the right is $I' \times S'$ ($S' = [0, 2\pi] \setminus \sim$).

C_{free} has two components.



Short Answer Questions (21 pts total. 3 pts per question)

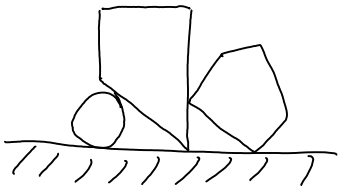
① (a) In words, what is the configuration space of a system of bodies?

(b) Assuming no obstacles, what does a curve in C-space represent?

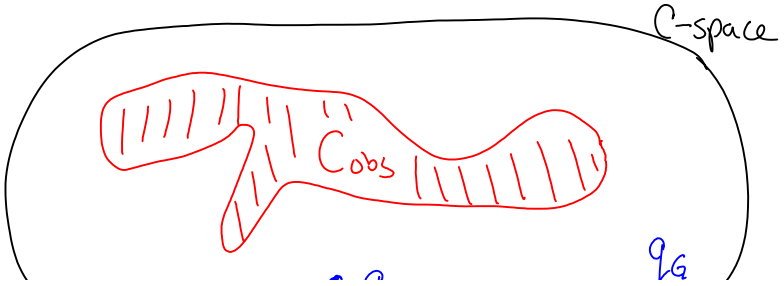
② Someone claims to have a form closure grasp of a cylinder using 7 contacts.

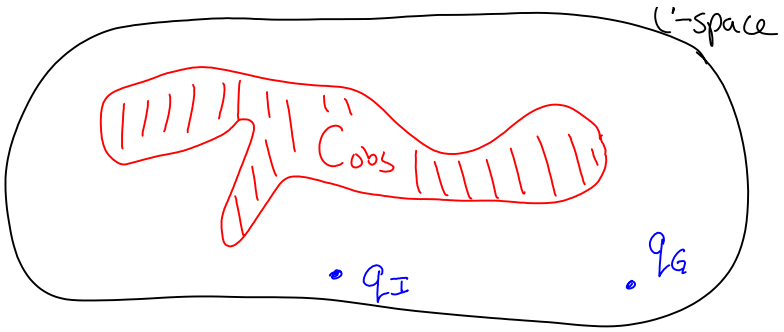
Is there a way to think about this problem such that the claim makes sense? Explain.

③ For the planar multibody system shown below, what are the unknown vectors and their sizes when applying the standard LCP (Stewart-Trinkle) time-stepper? (There are 5 unilateral contacts)

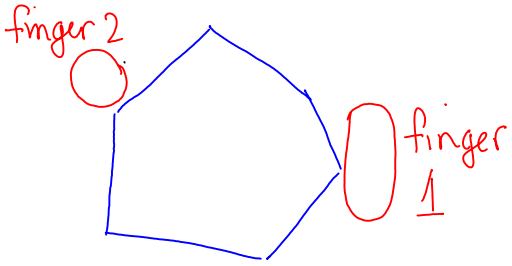


④ In the 2D C-space shown, sketch solutions from at least three different homotopy classes.



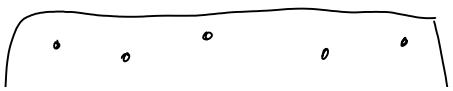


⑤ For the two-finger grasp of the object below, determine an approx range of placements of finger 2 (finger 1 remains fixed), such that the grasp has frictional form closure.

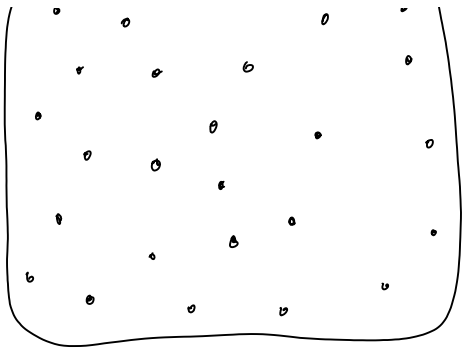


Assume $\mu = 1.0$

⑥ For the samples

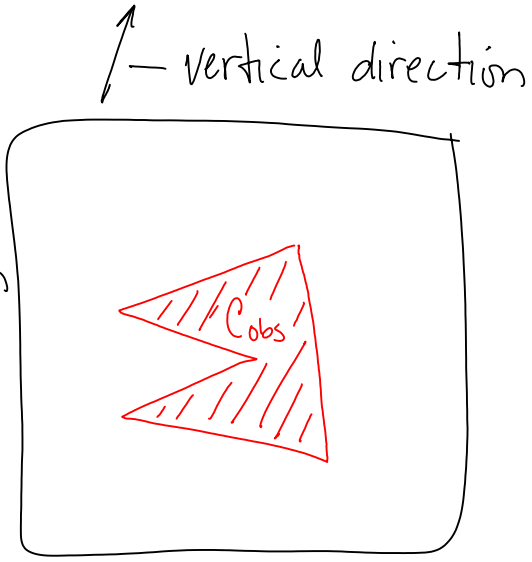


(6) For the samples shown in the unit "square" on the right, what is the approximate dispersion corresponding to the L_∞ norm?



(7) (a) For the C-space shown, apply the vertical cell decomposition method,

(b) Add edges so that the decomposition of C_{free} is a simplicial complex.



Analysis Questions (65 pts total)

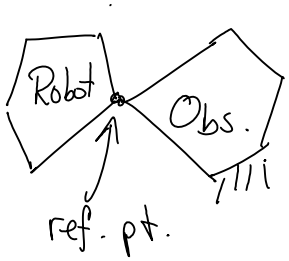
1. (16 pts) Let P_1 and P_2 be convex polygons in a plane. Let n_1 and n_2 be the number of edges of P_1 & P_2, respectively. Assume one polygon is a fixed obstacle and the other is moveable.

The C-space of the system is $SE(2) = \mathbb{R}^2 \times S^1$

a.) Determine the number of 2-dimensional facets of C_{obs} in $SE(2)$. (Hint: 2-d facets arise from EV and VE contacts)

b.) Suppose the reference point on the robot is one of the vertices.

Derive a 1-D edge of C_{obs} corresponding to the ref. pt. in contact with a vertex of the obstacle



c.) Suppose one of the polygons is nonconvex quadrilateral shown here →

Determine lower and upper bounds on the # of 2-D facets of C_{obs}.

(2) Let $\overline{X}$ be a space and let $x, x', x'' \in \overline{X}$ be points.

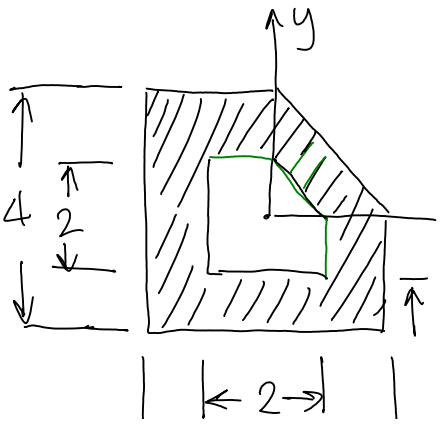
(16 pts) Show that $\rho(x, x')$ defined below <u>is</u> or <u>is not</u> a metric

$$\rho(x, x') = (\Delta x)^2 + \Delta x$$

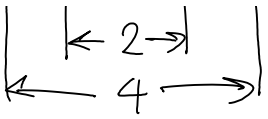
where $\Delta x = x - x'$

(3) Derive primitives from linear inequalities and combine them with intersections and unions to represent the shaded area.

(16 pts)



to represent the shaded area.



(4) For the LCP (M, b), with $M = \begin{bmatrix} 0 & 1 \\ 2 & 1 \end{bmatrix}$ and $b = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$, determine the values of b for which the LCP has no solution.

(17 pts)