Final Exam

Tuesday, May 06, 2008
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Robotics II Final - Spring 2008

True / False Questions

(1.) Cylindrical algebraic cell decomposition is equivalent to vertical cell decomposition.

(2.) C-space of a triangle 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-go function equal to zero, is equivalent to Dijkstra's algorithm.

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

⑥ Randomized potential field methods were developed because deterministic potential field methods get stuck.

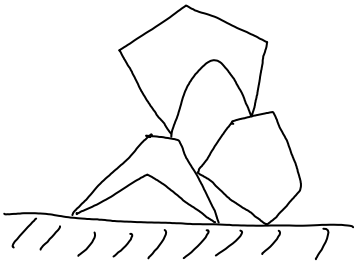
⑦ Sampling-based planning methods are particularly effective when C-space contains narrow passages between C-obstacles

Short Answer Questions

① In words, what is the configuration space of a system of bodies? (Hint: how would you decide if you had enough parameters & what is the dimension of C-space?)

② Someone claims to have a form closure grasp of a sphere using only 4 contacts. Is there a way to think about the C-space of a sphere such that this claim is reasonable?

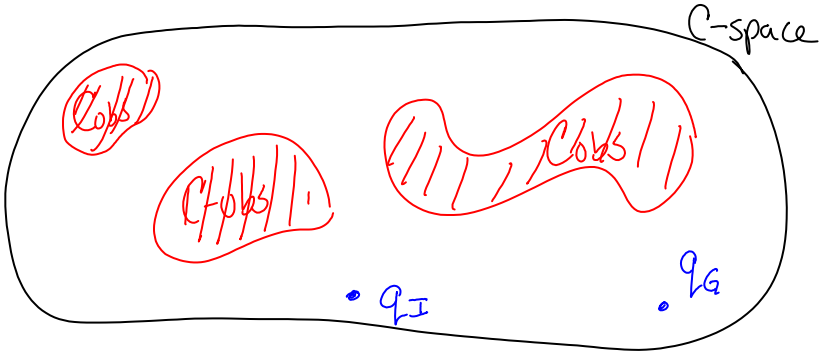
③ What is the size of the LCP needed to predict the motion of the planar system of bodies piled on the right? The three bodies are moveable and there are 6 contact points.



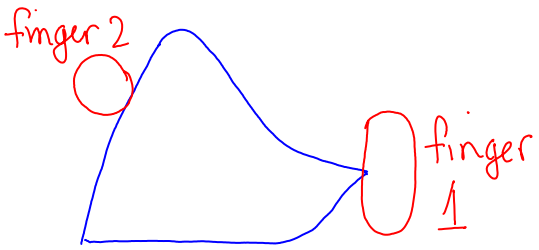
④ Why is the mobius strip a manifold (with boundary)?

⑤ In the 2D C-space shown, sketch solutions

from at least three different homotopy classes.

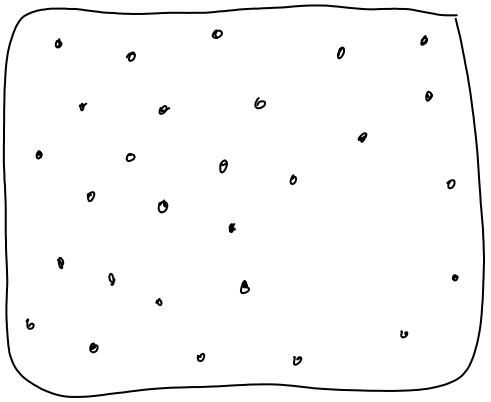


(6) For the two-finger grasp of the object below, determine an approx range of placements of finger 2 (finger 1 remains fixed), such that the grasp has frictional form closure.

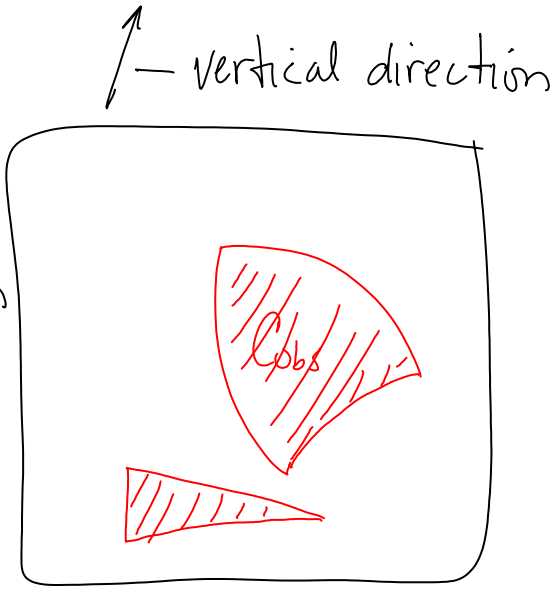


Assume $\mu = 1.0$

(7) For the samples shown in the unit "square" on the right, what is the approximate dispersion corresponding to the L_2 norm?



(8) For the C-space shown, apply the vertical cell decomposition method, then construct a roadmap of C-free.



Analysis Questions

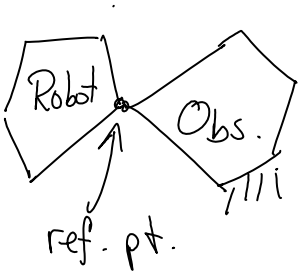
(1.) Let P_1 and P_2 be convex polygons in a plane. Let n_1 and n_2 be the number of edges of P_1 & P_2, respectively. Assume one polygon is a fixed obstacle and the other is moveable.

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

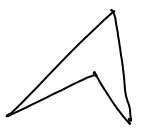
a.) Determine the number of 2-dimensional facets of C_{obs} in $SE(2)$. (Hint: 2-d facets arise from EV and VE contacts)

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

Derive a 1-D edge of Cobs corresponding to the ref. pt. in contact with a vertex of the obstacle



c.) Suppose one of the polygons in nonconvex with shape shown →

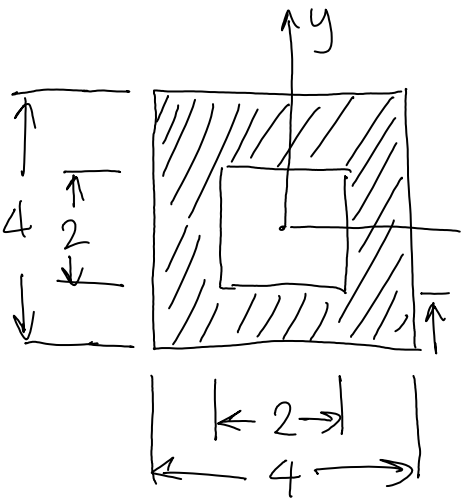


Determine lower and upper bounds on the # of 2-D facets of Cobs.

(2.) Let $\underline{X}$ be a space and let $x, x', x'' \in \underline{X}$ be points.
Is the following a metric on $\underline{X}$?

$$\rho(x, x') = \begin{cases} 1; & \forall\ x \neq x' \\ 0; & \text{if } x = x' \end{cases}$$

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



(4) For the LCP (M, b), with $M = \begin{bmatrix} 3 & 2 \\ 2 & 1 \end{bmatrix}$ and $b = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$, determine the values of b for which the LCP has no solution.