Robotics II Exam Spring 2008

Thursday, February 28, 2008
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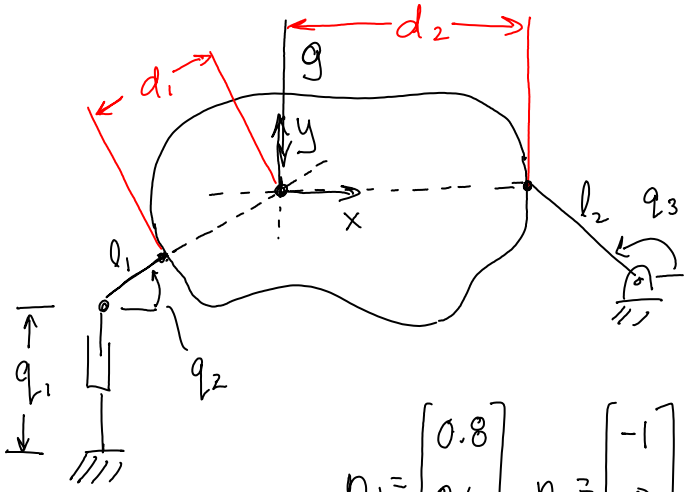
1.) A two-fingered hand is grasping an object in the plane.



Assume hard finger contacts.

a.) Ignoring the structure of the hand, could the fingers, if sufficiently mobile, cause the object to move with any twist, $v \in \mathbb{R}^3$? Support your answer mathematically.

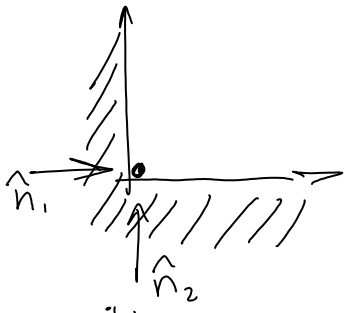
b.) Considering the configuration of the hand shown, could the hand control the wrench applied to the object, to be any wrench, $g \in \mathbb{R}^3$? Support your answer mathematically.

c.) Determine a configuration of the hand

c.) Determine a configuration of the hand (leave the object in place and move the base of one or more fingers, but maintain the 2 contacts) such that your answer to 1.b. would be reversed.

2. Consider the (somewhat trivial) problem of form closure of a particle in the plane.

Since the particle has 2 d.o.f., 3 contacts are required for form closure.



a.) Determine analytically, the possible directions of the 3rd contact normal $\begin{bmatrix} a \\ b \end{bmatrix}$ satisfying the form closure

$$\begin{bmatrix} 1 & 0 & a \\ 0 & 1 & b \end{bmatrix} \begin{bmatrix} \lambda_{1n} \\ \lambda_{2n} \\ \lambda_{3n} \end{bmatrix} = g_{ext} \quad \forall\, g_{ext} \in \mathbb{R}^3$$

$$\lambda_n \geq 0$$

b. Check your answer analytically by showing that the following implication is true:

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that the following implication is true:

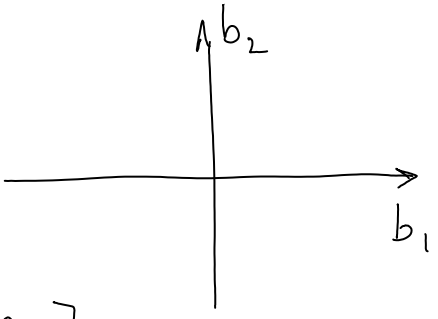
$$G_n^T \nu \geq 0 \implies \nu = 0$$

3.) Suppose the following LCP arises in one time step of a dynamic simulation:

$$0 \leq \begin{bmatrix} p_1 \\ p_2 \end{bmatrix} \perp \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} p_1 \\ p_2 \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} \geq 0 \quad .$$

The vector $\begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$ can be thought of as the external impulse applied to the system.

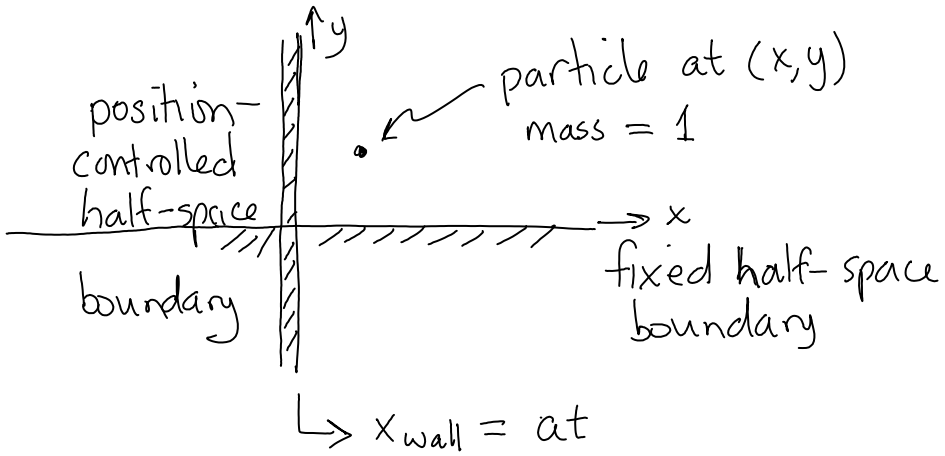
a.) Determine the set of impulses consistent with each of the 4 LCP solution cases $\left[\begin{array}{c|c|c|c} +\ 0 & +\ 0 & 0\ + & 0\ + \\ +\ 0 & 0\ + & +\ 0 & 0\ + \end{array}\right]$ and sketch the sets on the space of (b_1, b_2)



b.) Is there at least one consistent case for each (b_1, b_2)?

c.) Are there any (b_1, b_2) such that the LCP has more than one solution? If so, sketch the set of (b_1, b_2) for which this is true.

4. Formulate an LCP for one time step for the system below. Assume that contact is imminent and that contact is frictional.



Note: You don't have to load everything into the huge matrix. Just define $G_n, G_f, \psi_n^l, \frac{\partial \psi_n^l}{\partial t}, E, U$.