

HW 3: Grasping

Due March 3, 2019

We don't mind if you work with other students on your homework. However, each student must write up and turn in their own assignment (i.e. no copy & paste). If you worked with other students, please **acknowledge who you worked with** at the top of your homework.

1. Force-Closure and Part Orienting

Consider the part below

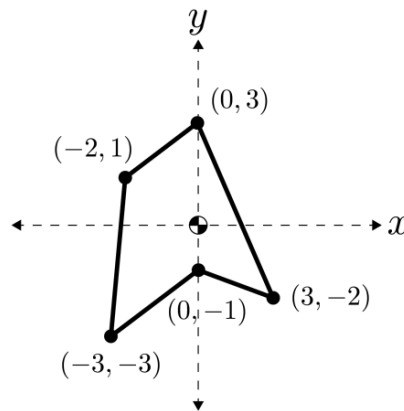


Figure 1: Concave part with CoM at (0, 0)

- Construct a frictionless force closure grasp of the part with four contacts using instantaneous construction (showing that no valid centers of rotation exist).
 - Construct the radius function of the part from 0 to 2π . Feel free to do this programmatically.
 - Draw the convex hull of the part.
 - Bonus:** Skim [this paper](#). Describe a plan to orient the part using the backchaining method the paper describes.
2. **Task-based Grasping** While force closure considers the ability of a grasp to resist any wrench, in some real world cases we may desire to resist only a specific set of wrenches.
- Let's say you want to resist some wrench F_e using a grasp G . In this case you would need to find f_c such that $Gf_c = -F_e$. How do we solve for f_c using least-squares?
 - Regression can be formatted as a minimization of square error

$$\min_{variables} F(f_c)$$

What does adding this second term do?

$$\min_{variables} (F(f_c) + \lambda \|f_c\|^2)$$

- Is least-squares the best way to solve for f_c ? What would you use instead?

3. Short Problems

- (a) *MLS 5.13* Give an example of two surfaces in contact which has a singular relative curvature form.
- (b) *Static Equilibrium* Let's say you have three non-zero forces applied to a 2D object. What condition must apply for the net force on the object to be zero?
- (c) *Convex Hulls and Force Closure* For a grasp to be in force closure, the convex hull of the forces must contain the origin of the part.
 - i. Explain what this means intuitively, supplementing your explanation with pictures.
 - ii. What is the minimum number of frictionless contacts needed to put a 2D object in force closure?

4. Research Comprehension

Read this [paper](#) and answer the following questions:

- (a) What grasp quality metric are they using. Explain how it works intuitively.
- (b) What is Thompson sampling and how is it used in DexNet?