3D Printing — Spring 2017 — Dan Halperin

Assignment no. 4

due: July 3rd, 2017

Work on and submit this assignment **individually**.

Notice that your final project plan (Exercise 4.3 below) needs to be submitted earlier on Friday **June 23rd, 2017**.

Additional technical information about the exercises will appear in the course's website.

Exercise 4.1: Minimizing the area of the convex hull of two parts

In various manufacturing processes, like 3D printing and stock cutting, we wish to minimize the volume occupied by the parts to be produced. Here we will deal with a variant of this problem where we get two convex polygonal parts P and Q in the plane, and we wish to put them one next to the other so that they do not overlap (namely keep their interiors disjoint) and such that their joint convex hull has minimum area. We will assume that P is fixed and we allow Q to translate, but not to rotate. Let Q^t denote the polygon Q translated by the vector t. Our goal is to find t such that the area of $\mathrm{CH}(P \cup Q^t)$ is minimal over all possible translations of Q, where the parts are non-overlapping.

Design an efficient algorithm to find a translation of Q that minimizes the area of their joint convex hull subject to the rules above. Analyze the complexity of the algorithm. The problem can be solved in time that is linear in the total number of vertices of P and Q.

Hint: Let $\mathrm{excess}(t)$ denote the region $\mathrm{CH}(P \cup Q^t) \setminus (P \cup Q^t)$, namely $\mathrm{excess}(t)$ is the extra region in the joint convex hull that is not inside the original polygons. Assume that Q translates in contact with P such that a fixed vertex of Q slides along a fixed edge of P (or vice versa). Triangulate $\mathrm{excess}(t)$. Pick up one triangle in $\mathrm{excess}(t)$, say a triangle that has two consecutive vertices p_i, p_{i+1} in P and one vertex q_j in Q. Observe how the area of the triangle $\Delta(p_i, p_{i+1}, q_j)$ changes as Q slides along P while maitaining the contact.

Exercise 4.2: 3D printing a mechanism with gears

Design and 3D print on our Ultimaker a simple mechanism that has (at least) two gears. The mechanism should be stable and hold the gears together without additional non-printed parts, and should allow to rotate one gear by manually rotating the other.

You may use the Gear Generator website for designing the gears: `http://geargenerator.com`. You can also be inspired by models from the Internet. Do not however print ready-made models.

One of the advantages of additive manufacturing over more traditional manufacturing methodologies, is the possibility to do *part consolidation*, namely the ability to merge several parts in an object and produce them as a single part. It is not mandatory, but it is desirable to print the mechanism as one assembly, rather than to assemble it manually from several printed parts.

Notice that there is an additional exercise on the other side of the page.

Exercise 4.3 (due June 23nd, 2017): Brief description of your final project

Write a one page proposal for your final project. The project needs to be approved by the instructor, ideally, prior to submitting this description. The one pager should include a succinct description of the goal of the project, the tools that will be used to carry it out, the outcome of the project, and possible milestones in the development of the project.