6.849: Geometric Folding Algorithms, Spring 2017

Prof. Erik Demaine, Martin Demaine, Adam Hesterberg, Jason Ku, Jayson Lynch

# Problem Set 4

*Due: Wednesday, March 8, 2017*

**Solve Problem 4.1 and *either* Problem 4.2 or 4.3.**

**Problem 4.1 [Mandatory, Collaboration OK].** On each problem set, we will ask you to write a problem (solved or unsolved) related to the material covered in class. The problem should be original to the best of your knowledge, so be creative and diverse! Folding can be applied to mathematics, computation, engineering, architecture, biology, and beyond, so write a problem that is related to a field that interests you. If you write a problem whose solution can be solved from the material covered in class, then we may adapt your problem for future problem sets. If you pose a problem whose solution is not yet known, we may try to solve it in class during our open problem sessions, or it may become inspiration for a class project. Feel free to include solutions or commentary for your problem. While writing a problem is required, your submission will be graded generously, so have fun and share with us your exploration of the course material.

**Solve ONE of the two problems below.**

**Problem 4.2 [Collaboration OK].** Design and fold (but do not cut) a fold-and-cut model using the straight-skeleton method. Submit a PDF of your design (including crease pattern, in vector format) on Gradescope, and submit the folded version physically. We highly recommend that you use a vector drawing program that can compute accurate intersections, such as Inkscape (free), Cinderella (mostly free), Adobe Illustrator (commercial), AutoDesk Fusion 360 (free for students), or Rhino3D (commercial). Use your judgment of reasonable complexity to work within your folding ability.

**Problem 4.3 [Collaboration OK].** Consider a convex polygon $P$ whose vertices $(x_1, y_1)$, $(x_2, y_2)$, ..., $(x_n, y_n)$ satisfy $-1 \leq x_i, y_i \leq 1$. You seek an efficient algorithm describing how to fold and cut $P$ from a square piece of paper with vertices $(\pm 1, \pm 1)$.

(a) Show that there exists a crease pattern with $O(n)$ creases which can be folded so that one cut produces $P$.

(b) Find as efficient an algorithm as you can to compute such a crease pattern. Any correct algorithm will earn at least partial credit. Can you get $O(n \log n)$ or even $O(n)$ time?