6.849: Geometric Folding Algorithms, Fall 2020

Prof. Erik Demaine, Martin Demaine, Yevhenii Diomidov, Klara Mundilova

Problem Set 1 Solutions

Due: Thursday, September 10, 2020

Problem 1.1 [Problem Invention]. Write a problem (solved or unsolved) related to folding or its applications. 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 that can be solved from the material covered in class, then we may adapt it 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.

Solution: Many interesting questions were asked.

Problem 1.2 [Polyomino Folding]. A ***polyomino*** is a polygon in the plane composed of unit squares that are connected edge-to-edge. Fold **at least one** of the three polyominoes with slits given in Figure 1, only along grid lines and only by fold angles of $\pm 90°$ or $\pm 180°$, into a unit cube. More precisely, in your folding(s), all faces of the cube must be covered by at least one unit square of the polyomino, and every square of the polyomino must lie on this cube. Submit photograph(s) of your folded cube(s), labeled by which polyomino (M, I, or T) it is a folding of.

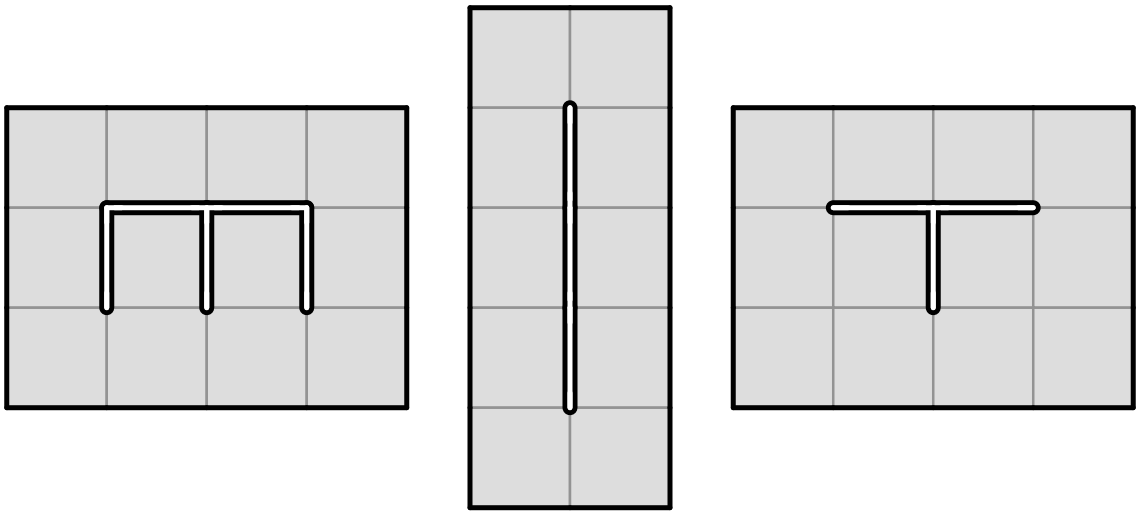

Figure 1: Polyominoes with slits.

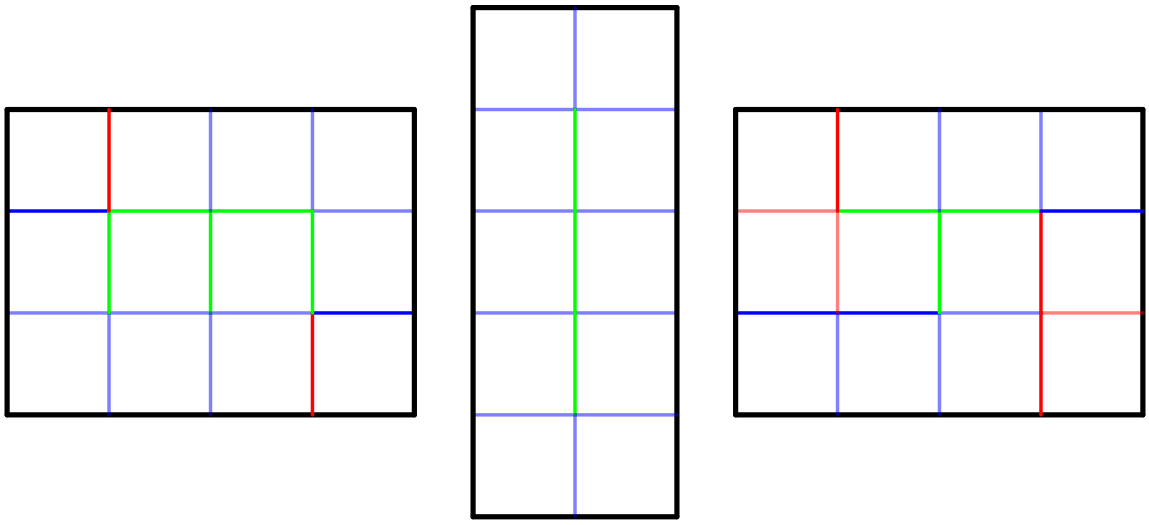

Figure 2: Crease patterns of valid polyomino foldings. The coloring corresponds to Origami Simulator input.

Solution: See Figure 2 for crease patterns of valid polyomino foldings. You can download the SVG files that import into Origami Simulator[1] to produce a (self-intersecting) animation, or watch videos of (non-self-intersecting) real-life foldings, at the following page:

http://courses.csail.mit.edu/6.849/fall20/psets/ps1-solutions/

Problem 1.3 [Puzzle Folding]. Print or draw the pattern in Figure 3 (left) on a square piece of paper and cut out the varying-size square holes. Color the opposite side of each square the same color as the front. By folding only along the grid lines, fold this 3×3 square into a flat 1×1 square packet so that the coloring of the layers matches the coloring displayed in Figure 3 (right). Equivalently, fold the square so that the layer ordering corresponds to the small numbers next to the holes. Submit a photograph of both sides of your packet.

This puzzle is based on Erik and Martin Demaine's puzzle for the CSAIL Annual Meeting 2019.[2]

Solution: You can watch a video of a real-life folding motion here:

http://courses.csail.mit.edu/6.849/fall20/psets/ps1-solutions/3x3-folding.mp4

[1] https://origamisimulator.org/

[2] http://erikdemaine.org/puzzles/CSAIL2019/

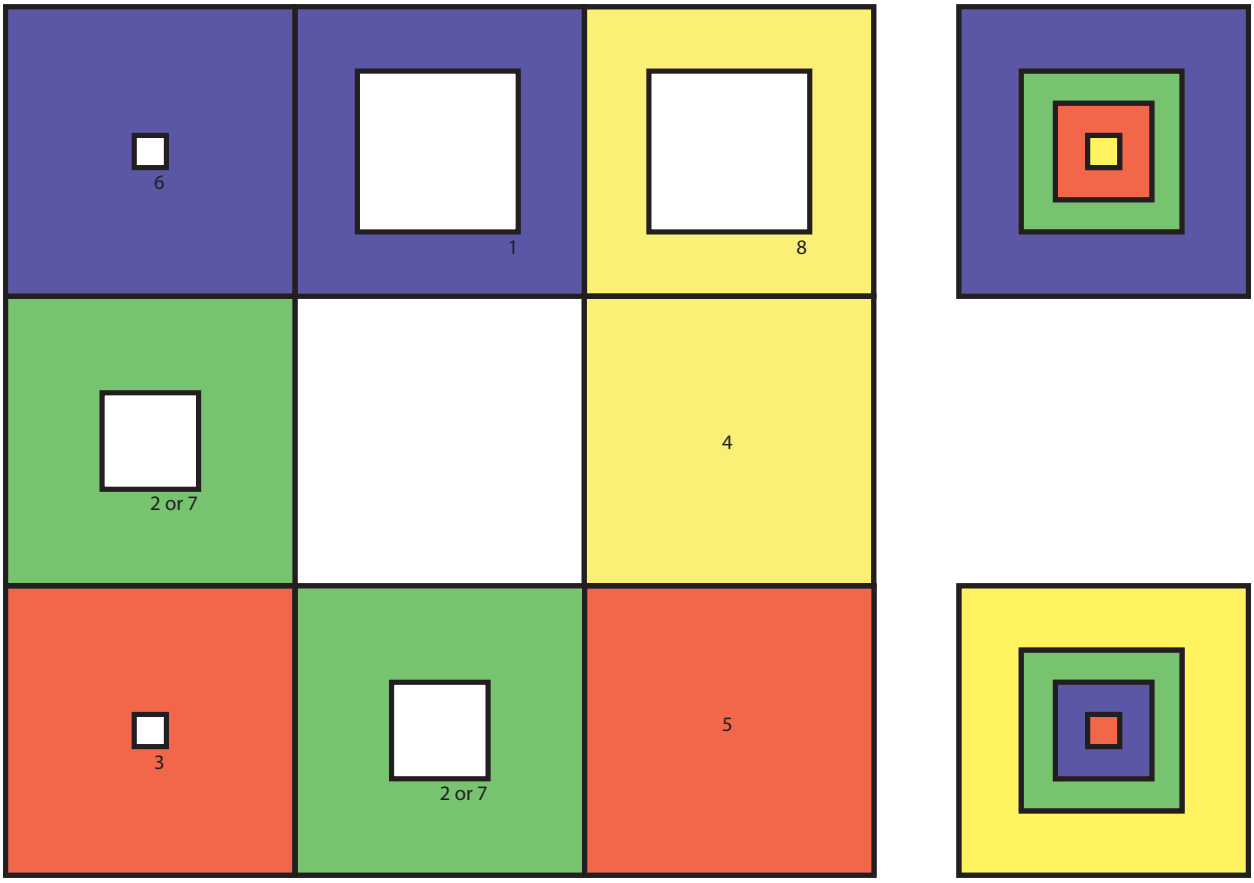

Figure 3: Crease pattern (left) and front and back side of flat folded state (right).