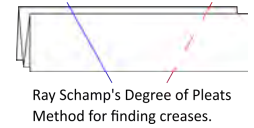


The Reflection Method of Corrugation Design

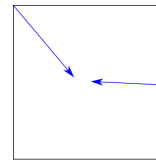
Ben Parker

There are a few methods for creating original corrugation designs. Ray Schamp folds through layers of pleats, a method analogous to the Fold-and-Cut Problem (Martin Demaine and Erik Demaine) in that it "cuts" the paper with a single fold and finishes with what is effectively a sink fold. Others use grids with trial and error to come up with designs. My tactic is reflection, and it can often result in forms that are very surprising.

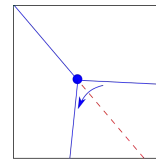


Ray Schamp's Degree of Pleats Method for finding creases.

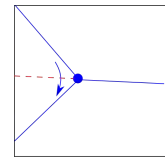
Imagine you pinch two creases of the same parity (mountain or valley) on a trajectory toward each other. When they intersect, if you wish the form to be flat-foldable, the easiest way to do this is with a 4-crease intersection (either three mountains and a valley or vice-versa) with the unique crease bisecting its neighbors. This requires one of the traveling creases to reflect over the other with the line of reflection continuing straight. I call the reflecting crease a *multi-path* and the crease that determines the reflection a *structural crease*.



Two creases travelling toward each other.

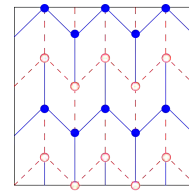


Reflection Option A

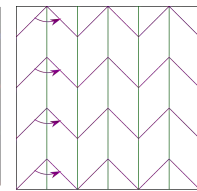


Reflection Option B

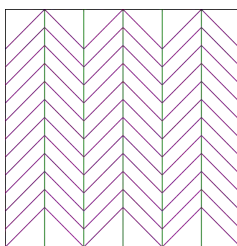
In a common target of dissection, the miura-ori, the multi-paths are the zig-zag patterns that do not change parity and the structural creases are the straight lines that change from mountain to valley or back each time they hit a multi-path. Changing the angles and frequency of the structural crease(s) affects how the multi-paths reflect. The beauty of the miura-ori and similar corrugations comes (in my opinion) from the alternation of mountain multi-paths and valley multi-paths and how the planes between then interact with direct lighting. The closer the multi-paths are to each other, the more subtle and surprising the light and shadow effect. But the amount of variety is much more complicated and beautiful than a simple grid system. Multi-paths can also have different starting angles as well. You can combine both and sometimes a multi-path can reflect off another multi-path.



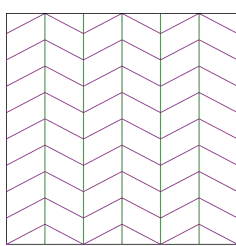
Miura-Ori with full crease pattern



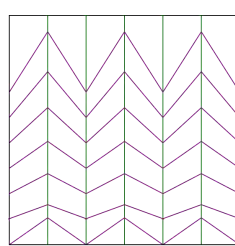
Miura-Ori with Green Structural Creases and Purple Multi-Paths



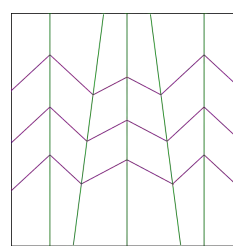
Different Frequency/Density of Multi-paths



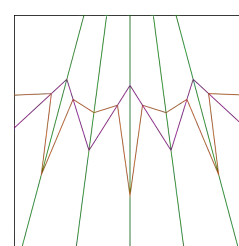
Different Starting Angle of Multi-paths



Progression of Multi-Path Angles

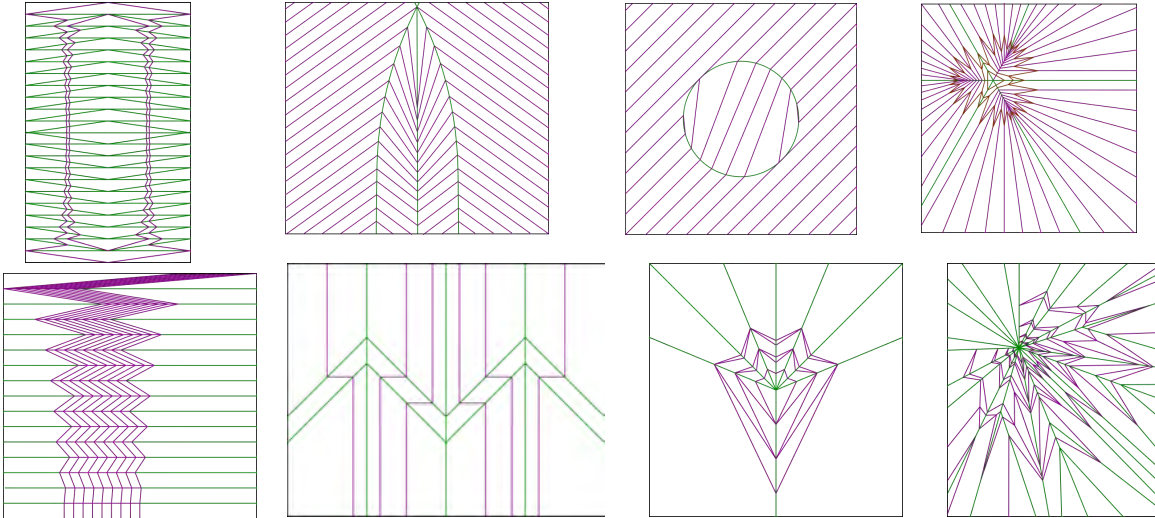


Modification of Structural Crease Angles

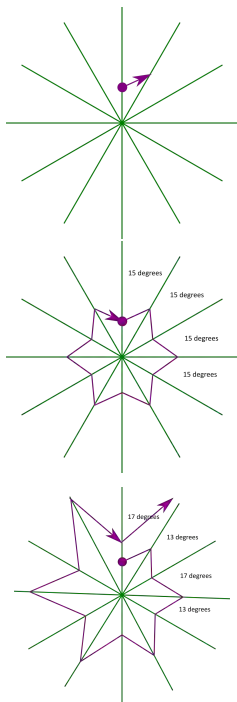


Example of a Multi-Path (brown) reflecting off another Multi-Path

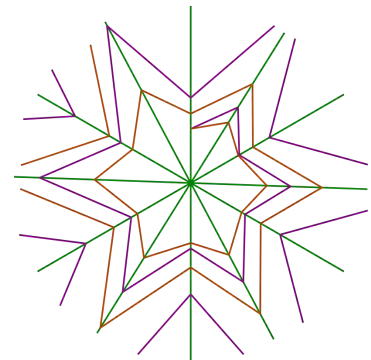
This method can be used to design a large variety of compositions, a few studies of which are below. In these, I do not differentiate between mountain and valley folds, but rather the multi-paths and the structural creases since those are more relevant to the piece's design. Once one crease is assigned mountain or valley status, it will generate the remainder of the creases' statuses throughout the paper (and render the opposite on the reverse). Note that not all of these are flat-foldable (or even easily-folded without the use of a CNC plotter/scorer of some sort). The reflection method simply gets the process started, and the artist can modify at leisure.



I intend to talk about a specific study within this larger methodology. Given a radial set of creases that alternate between mountain and valley around a vertex, draw the starting vector of a multi-path at a non-right angle to one of the radial creases. Continue to reflect the multi-path around the vertex until it cannot reflect anymore (either because it runs off the paper or hits another intersection and you have to decide what to do with it next). What happens?



If the radial angles are consistent, the multi-path extends outward a certain distance. Then it extends inward the same distance, back and forth, until it eventually hits the point where it started, resulting in a star form. The next step in the progression is to modify the angles of the radial creases to gauge how that affects the reflection. I changed the angle of every other radial crease by two degrees clockwise so they alternate between 17 and 13 degrees. It ended with the path circling around the center the same as before. When it completed a full rotation, it was farther away from the center than the origin of the path and had to continue. I then filled out the piece with a second multi-path starting from the same origin point at a different angle to the first one. This is because the first multi-path would have continued inward as well as outward, and the inward path would have led to folding ambiguities. Also, the spiral is more striking if there is a mountain next to a valley multi-path, and a single multi-path would have resulted in creases of like parities being adjacent as the spiral grew.



There is a great deal more to study with this series and other similar series of corrugations. By focusing on specific progressions, we can learn about the functions that drive geometric origami forms.