Simulation of Triangle-based Axisymmetric Rigid Origami

Yan ZHAO, Yoshihiro KANAMORI, and Jun MITANI

筑波大学 University of Tsukuba

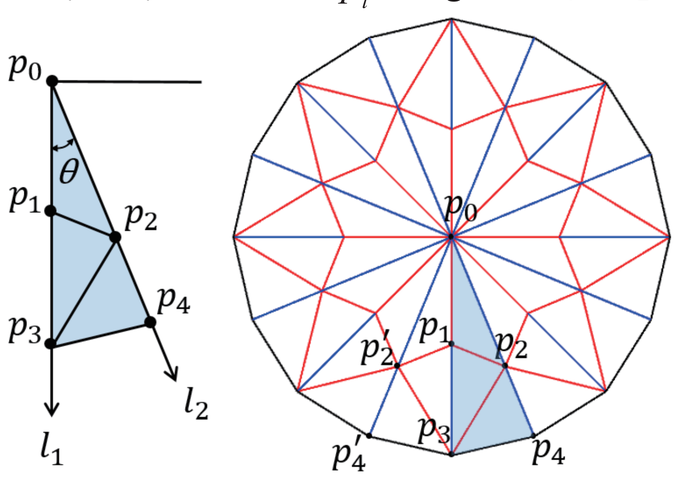
Overview

We focus on a category of origami that is constructed with triangle facets with axisymmetric structure. Our method generates a rotationally-symmetric crease pattern (CP) and then calculates the shape of 3D origami. Our prototype system enables us to **simulate the deformation of the 3D origami axisymmetrically** by changing one parameter. By changing another parameter, our system **simulates a folding motion called "along-arc flat-folding," to flatten the shape along the arc**. Several 3D origami pieces and folding sequences are presented to demonstrate the validity.

Design Process for Triangle-based Axisymmetric Origami

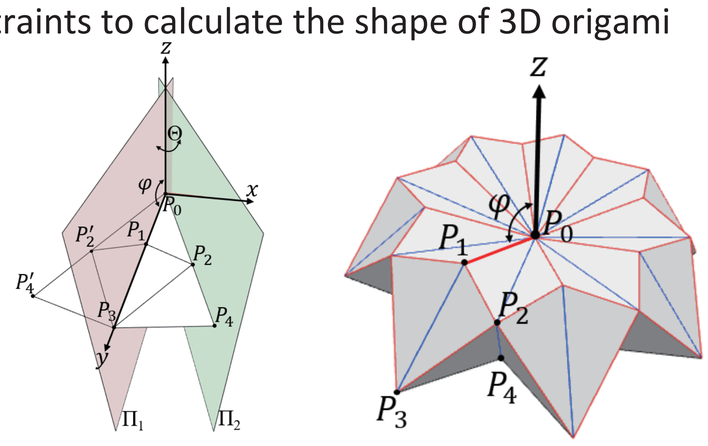
1. Generate CP based on its part

The CP can be interactively designed. Specifically, we can move, add, and delete p_i along lines l_1 or l_2



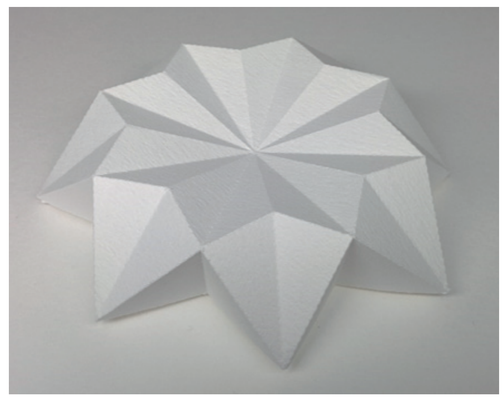
2. Calculate 3D geometry

We take the CP as input, and use geometric constraints to calculate the shape of 3D origami



- P_i with **odd** indices lie on the plane Π_1
- P_i with **even** indices lie on the plane Π_2

3. Fabricate origami piece

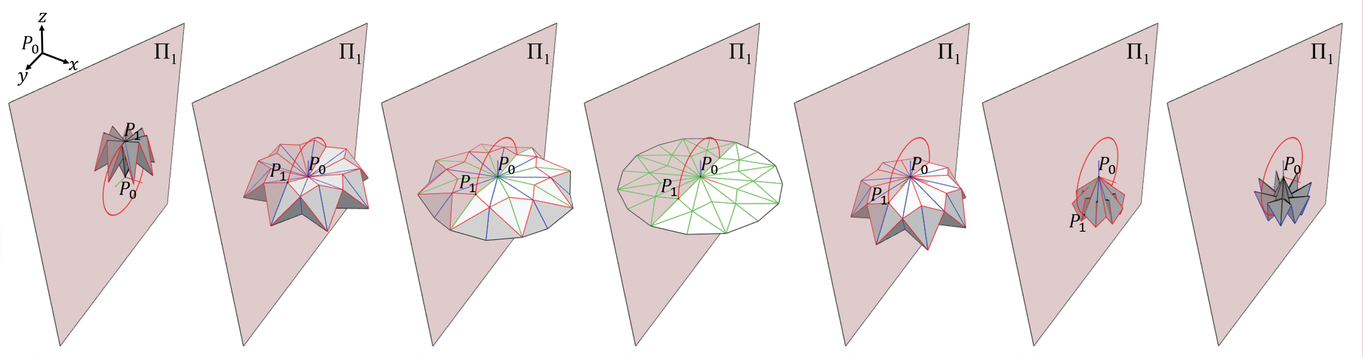


Simulation by Changing Two Parameters

1. For angle φ

- φ is the angle between P_0P_1 and z-axis
- The change in φ only affects P_1 directly
- Each subsequent P_i $(i>1)$ is to be recalculated

→Deform 3D shape rigidly while changing φ

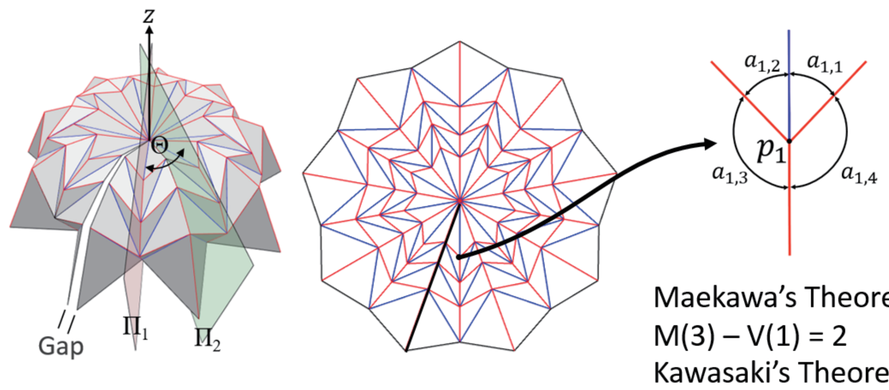


(a) φ = 0° (b) φ = 66° (c) φ = 83° (d) φ = 90° (e) φ = 97° (f) φ = 135° (g) φ = 180°

2. For angle Θ

- Θ is the angle between planes Π_1 and Π_2
- Add a cut in CP to maintain the consistency
- Verify flat-foldability with locally flat-foldable conditions

→Flatten 3D shape along arc while decreasing Θ



Change Θ

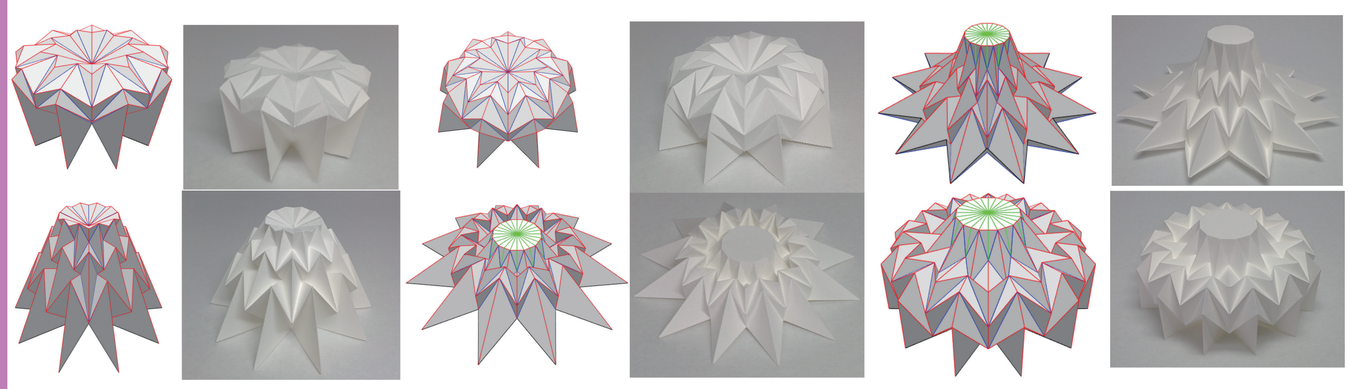
Add a cut in CP

Maekawa's Theorem:
M(3) – V(1) = 2
Kawasaki's Theorem:
$a_{1,1} + a_{1,3} = a_{1,2} + a_{1,4}$

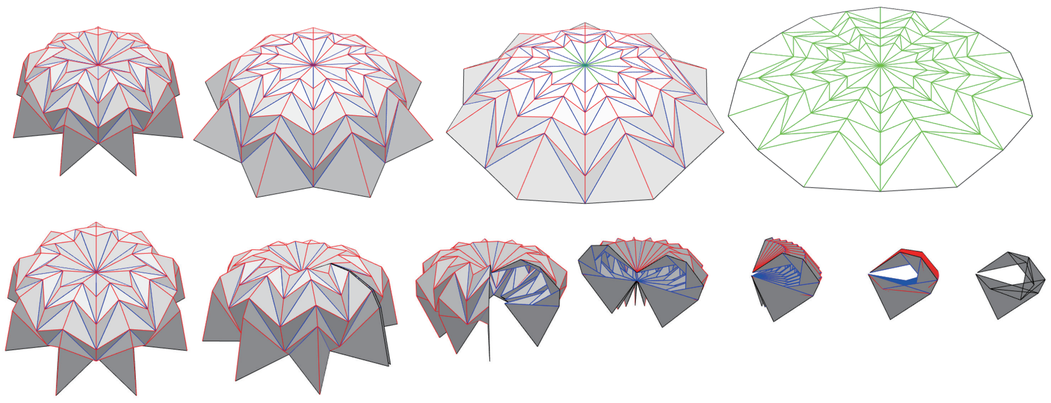
Locally flat-foldable conditions

Results

- Results of 3D origami



- Simulation



Conclusion & Future Work

- We described a design method for the triangle-based axisymmetric origami
- We simulated the effects on geometry by changing two parameters: angles φ and Θ
- Directly editing the shape of 3D origami would be one of our future work