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# Edible Chromatic Caustics: Designing Colored Caustics of Jelly via Differentiable Rendering

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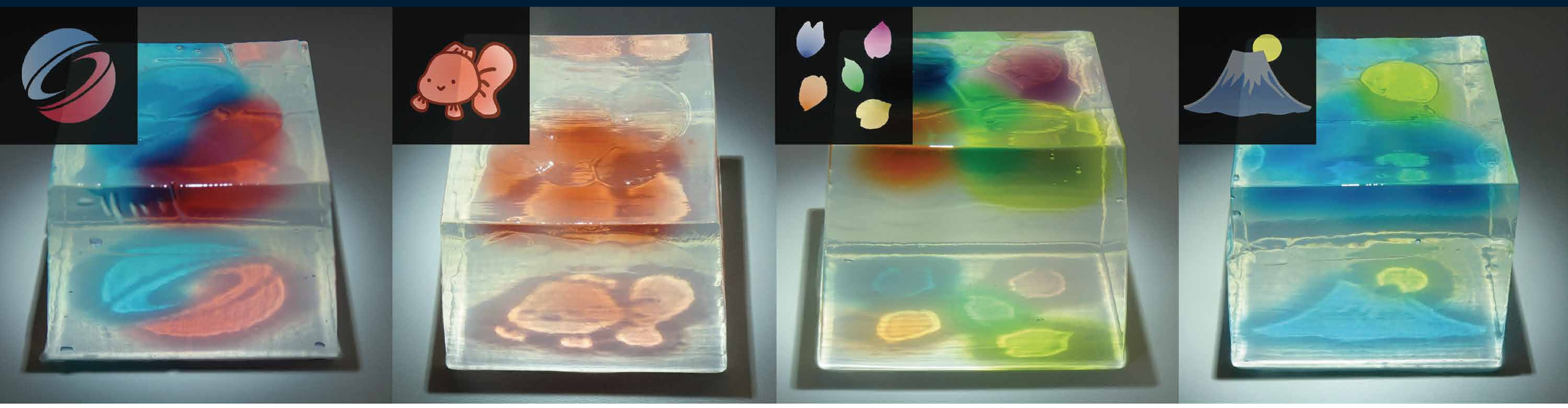


**Backgrounds:**
- Transparent jellies generate caustic patterns on surfaces beneath them.
- Prior studies designed jelly shapes to control caustics but did not support colored caustics [1].

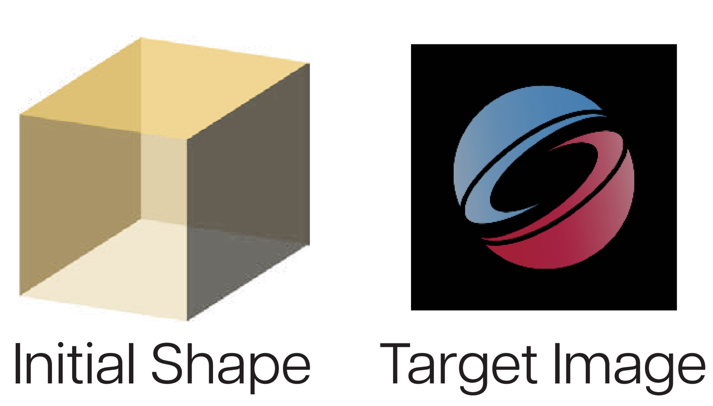
**Goal:**
- To create jellies with desired colored caustic patterns.

**Approach:**
- We optimize jelly shapes using differentiable rendering to produce desired colored caustics.

## Method

### A Input

- Initial jelly shape.
- Target color image (hue assumed piecewise-constant).

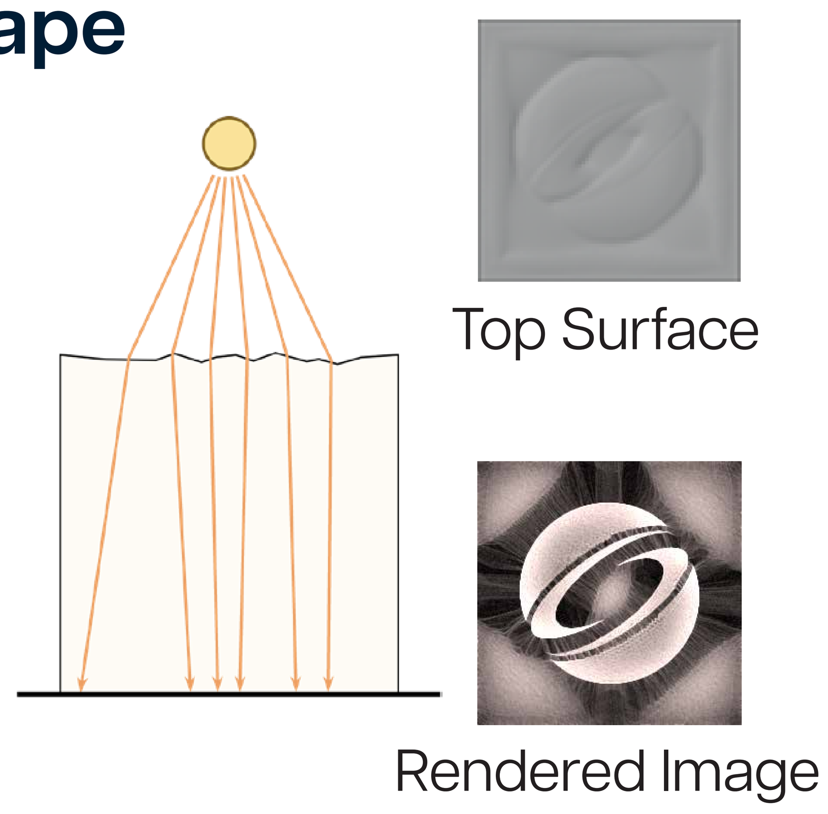



### B Optimize Base Jelly Shape

We iteratively update the top surface π using Mitsuba 3 [2] to minimize the following function.

$$\underbrace{\arg\min_{\pi} \|R(\pi) - I^t_{gray}\|^2}_{\text{image MSE}} + \underbrace{\lambda_1 \sum_{v_i} \|L(v_i)\|^2}_{\text{smoothing(Laplacian)}}$$

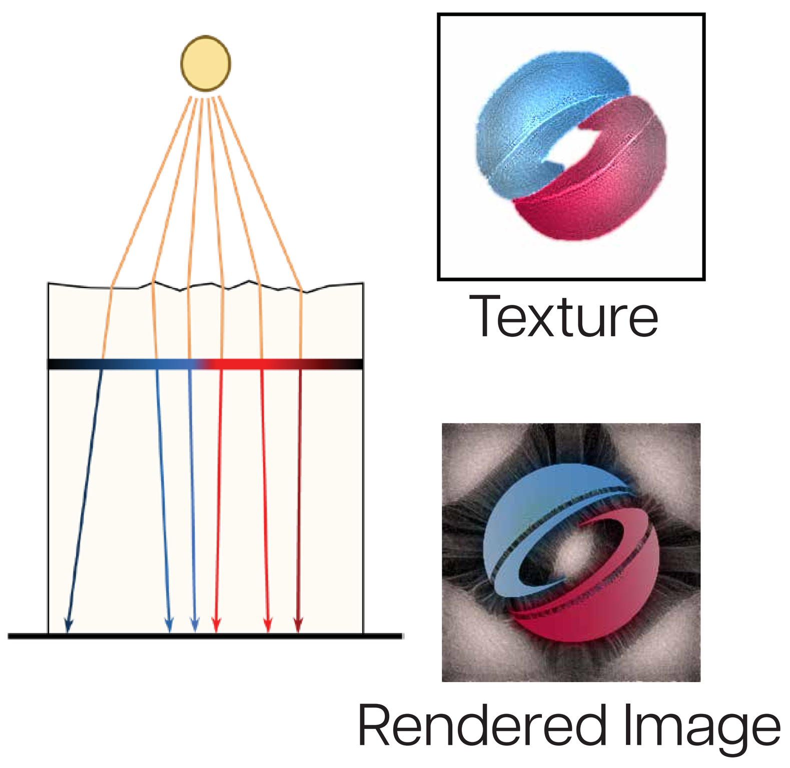
- The jelly refractive index is 1.35.




### C Optimize the Color of Inclusion

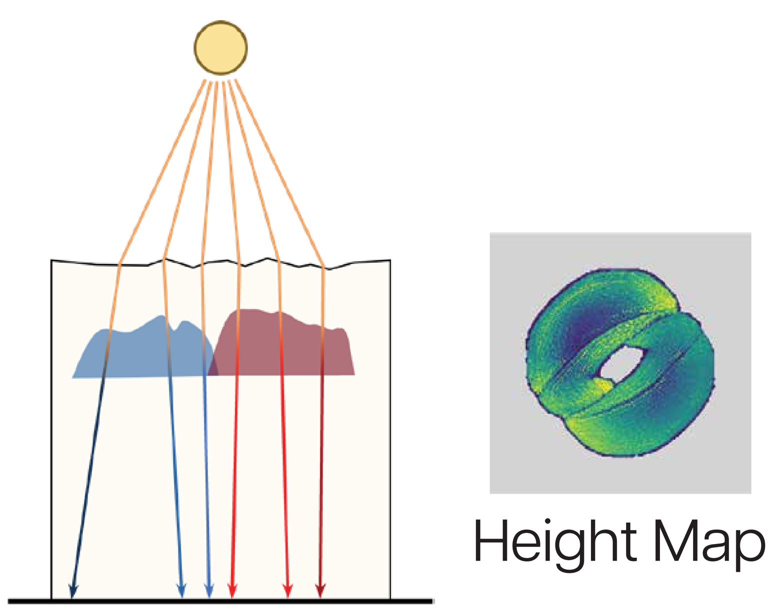
We place colored jelly inclusions inside the base jelly.
- We optimize the RGB texture to reproduce the target caustics.
- Optimization is performed using differentiable rendering (Mitsuba 3 [2]).

$$\arg\min_{\tau} \underbrace{\|M \odot (R(\pi^*, \tau) - I^t)\|^2}_{\text{masked image MSE}} + \underbrace{\lambda_2 \|L(\tau)\|^2}_{\text{smoothing(Laplacian)}}$$



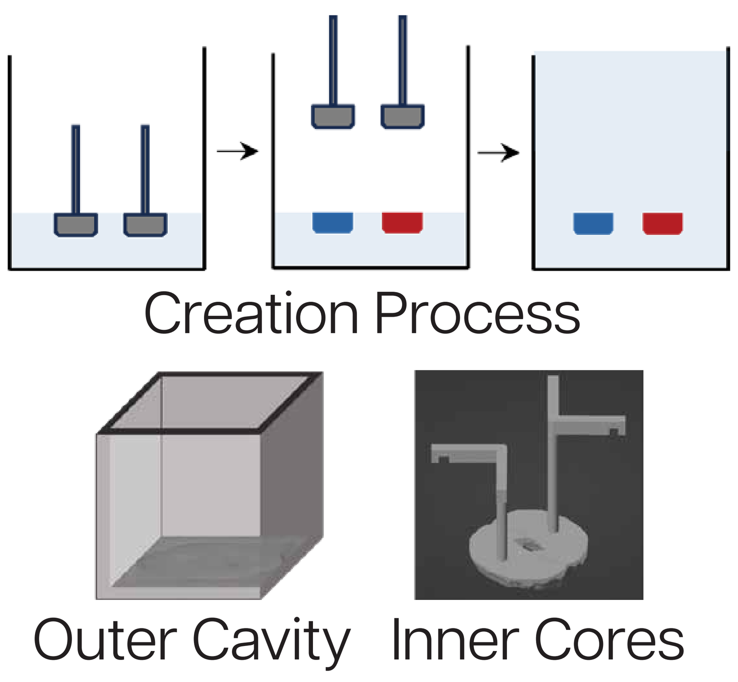

### D Compute Height of Inclusion

The optimized RGB texture is converted into a heightmap for the colored jelly inclusions.
- Pixels are clustered by hue and smoothed within each cluster.
- Absorption coefficients are estimated per cluster to compute the final inclusion heights.




### E Create Jelly

We fabricate a jelly mold (outer cavity + inner cores), and produce the jelly.
- The mold is 3D-printed.
- Jelly mixture: water, agar, sugar (100 g : 4 g : 15 g)




## Results and Discussion

- We fabricated jellies that produce various colored caustic patterns (see above).
- Our method is limited to piecewise-constant hues.
- Future work includes automating dye mixing and generating smoothly colored jelly inclusions.

**References**

[1] D. Inokoshi, Y. Yabumoto, J. Fujikawa, Y. Dobashi, and T. Ijiri. 2024. Edible Caustics: Designing Caustics of Jelly via Differentiable Rendering. In ACM SIGGRAPH 2024 Posters. 30:1–30:2.

[2] W. Jakob, S. Speierer, N. Roussel, and D. Vicini. 2022. DR.JIT: A Just-in-Time Compiler for Differentiable Rendering. ACM ToG 41, 4 (2022), 124:1–124:19