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Computational Design of Shape-Aware Sieves

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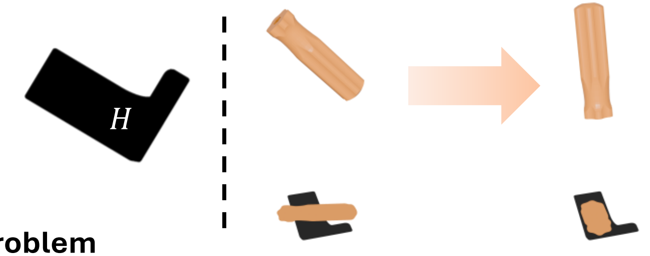
Problem

Our tool generates sieves to sort sets of objects of arbitrary shapes and sizes.

Definitions

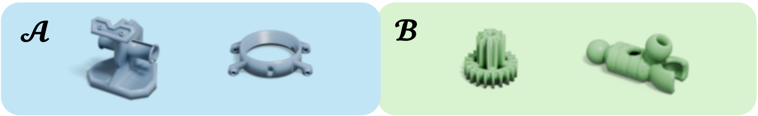
For a 3D object M, denote $\mathrm{proj}(M)$ to be its 2D orthographic projection onto the xy-plane.

Given a 2D hole H on the xy-plane, if there exists a rigid transformation mapping M to M' such that $\mathrm{proj}(M') \subseteq H$, then say H *admits* M. Else, H *blocks* M.

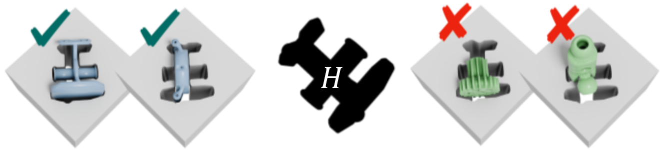


Problem

Input: Set of 3D shapes $\mathcal{A}$ to admit and set of 3D shapes $\mathcal{B}$ to block.



Output: A 2D sieve hole H that achieves this.



Method

Admit/Block Optimization

The area of $\mathrm{proj}(M')$ outside of a hole H is

$$f_H(M') = \mathrm{area}\big(\mathrm{proj}(M')\big) - \mathrm{area}\big(\mathrm{proj}(M') \cap H\big)$$

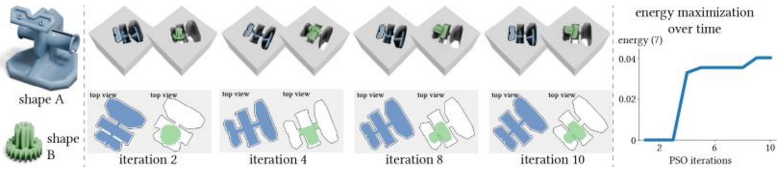
Note that $\min_{M'} f_H(M')$ is zero if and only if H admits M and is positive if and only if H blocks M.

Sieve Hole Design

For simplicity, let $H = \mathrm{proj}(A')$ so that shape A is always admitted. To ensure the hole blocks shape B, we solve

$$\max_{A'} \min_{B'} f_{\mathrm{proj}(A')}(B')$$

- *Inner min opt:* Differentiable rendering
- *Outer max opt:* Particle swarm optimization



Fabrication Considerations

- Floating pieces: Solved by filling all holes in $\mathrm{proj}(A')$
- Friction: Solved by optimizing with shape A dilated

Results