RASP: Revisiting 3D Anamorphic Art for Shadow-Guided Packing of Irregular Objects (Supplementary)

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https://soumyaratnadebnath.github.io/RASP/

The supplementary material contains the following components.

- Initialization
- Potential Future Directions
- Additional Qualitative Results + Supplementary Video
- Discussion

1. Initialization

Another essential factor in object packing through progressive optimization is the initial placement of the objects. We examine two straightforward strategies, avoiding complex heuristics

- *Single-Point Placement:* All objects are initially positioned at the center of the container, allowing them to move freely from this point to find an optimal arrangement.
- *Random Placement:* Objects are randomly positioned within the container to begin with, providing a diverse starting configuration for the optimization process.

We found that each initial placement option has distinct benefits. With single-point placement, all objects expand outward from the center, which helps reduce initial overlaps. However, this approach restricts spatial exploration and can result in early crowding, potentially prolonging convergence. Conversely, random placement offers a more diverse starting configuration, allowing faster separation, which is especially useful in irregular containers. Yet, this method may lead to unpredictable object movements and higher initial overlap, increasing computational costs as the framework resolves conflicts. Figure 1 visually demonstrates the optimization progress towards a fixed objective/arrangement over multiple iterations until convergence.

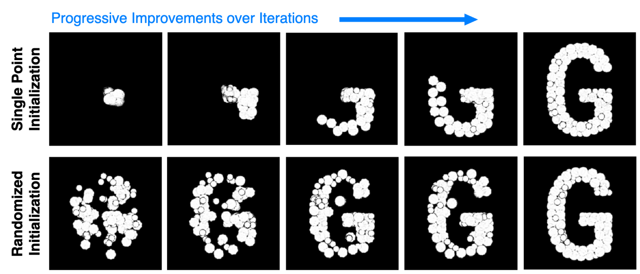


Figure 1. Illustration of optimization by two initialization strategies. Despite the distinct starting points, both approaches converge over the iterations to form a coherent structure that casts a silhouette of the letter 'G' when illuminated with a specific direction.

2. Potential Future Directions

While we have shown the potential of shadow guidance in packing and part assembly, we believe there are further interesting directions for this work.

(a) RASP for efficient partitioning Transporting complex, irregularly shaped objects often requires custom containers or heavy guards from multiple sides to ensure they remain intact during transit. This increases the material waste and transportation costs. Therefore, we intend to use the capabilities of RASP to disassemble objects into parts that interlock to form a more stable shape, like cubes or spheres. This will also allow multiple complex structures to be confined and transported in a single box, Figure 2 (a). We will explore the potential for partitioning objects such that when rearranged, the components can form entirely new objects, Figure 2 (b).

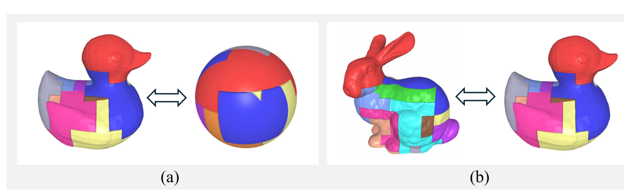


Figure 2. Concept of RASP for Reconfiguration of Complex 3D Objects into Simpler Structures

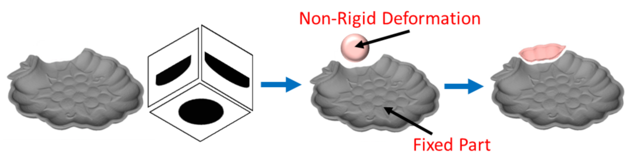


Figure 3. Concept of RASP for Reconfiguration of Complex 3D Objects into Simpler Structures

(b) RASP with non-rigid deformations. Currently, RASP is designed to handle rigid transformations to optimize the arrangement of objects in a 3D space. We further intend to explore non-rigid deformations of objects to address the problem of incomplete 3D shape filling. Figure 3 demonstrates the conceptual idea. With such a framework, we intend to optimize both the placement and the structure of a missing part from a broken object.

3. Additional Qualitative Results

Figure 4 (next page below) showcases some additional results of packing objects from the complex *Kitchen* dataset [2] into arbitrarily shaped containers. Figure 5 (next page below) illustrates some additional results for 3D part assembly of broken objects from the Fantastic Breaks dataset [1]. We have included additional results and 3D visualizations of the results presented in the main paper in the supplementary video. Please refer to the same for a comprehensive view of RASP's performance.

4. Discussion

Working with shadows for optimization comes with its own set of challenges due to their unpredictable nature and reliance on external factors. Shadows can change with variations in lighting, surface textures, or object positions, making them difficult to model consistently. These factors make shadow-based optimization both computationally intensive and prone to errors in dynamic environments.

Through our research, we aim to push the boundaries of shadow-based optimization, addressing its current limitations and exploring new possibilities. Looking ahead, we plan to extend our efforts to include shadows cast by translucent objects, which present unique challenges and opportunities for advancing in 3D shape analysis.

References

[1] Nikolas Lamb, Cameron Palmer, Benjamin Molloy, Sean Banerjee, and Natasha Kholgade Banerjee. Fantastic breaks: A dataset of paired 3d scans of real-world broken objects and their complete counterparts. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pages 4681–4691, 2023. 2

[2] Hang Zhao, Zherong Pan, Yang Yu, and Kai Xu. Learning physically realizable skills for online packing of general 3d shapes. *ACM Transactions on Graphics*, 42(5):1–21, 2023. 2

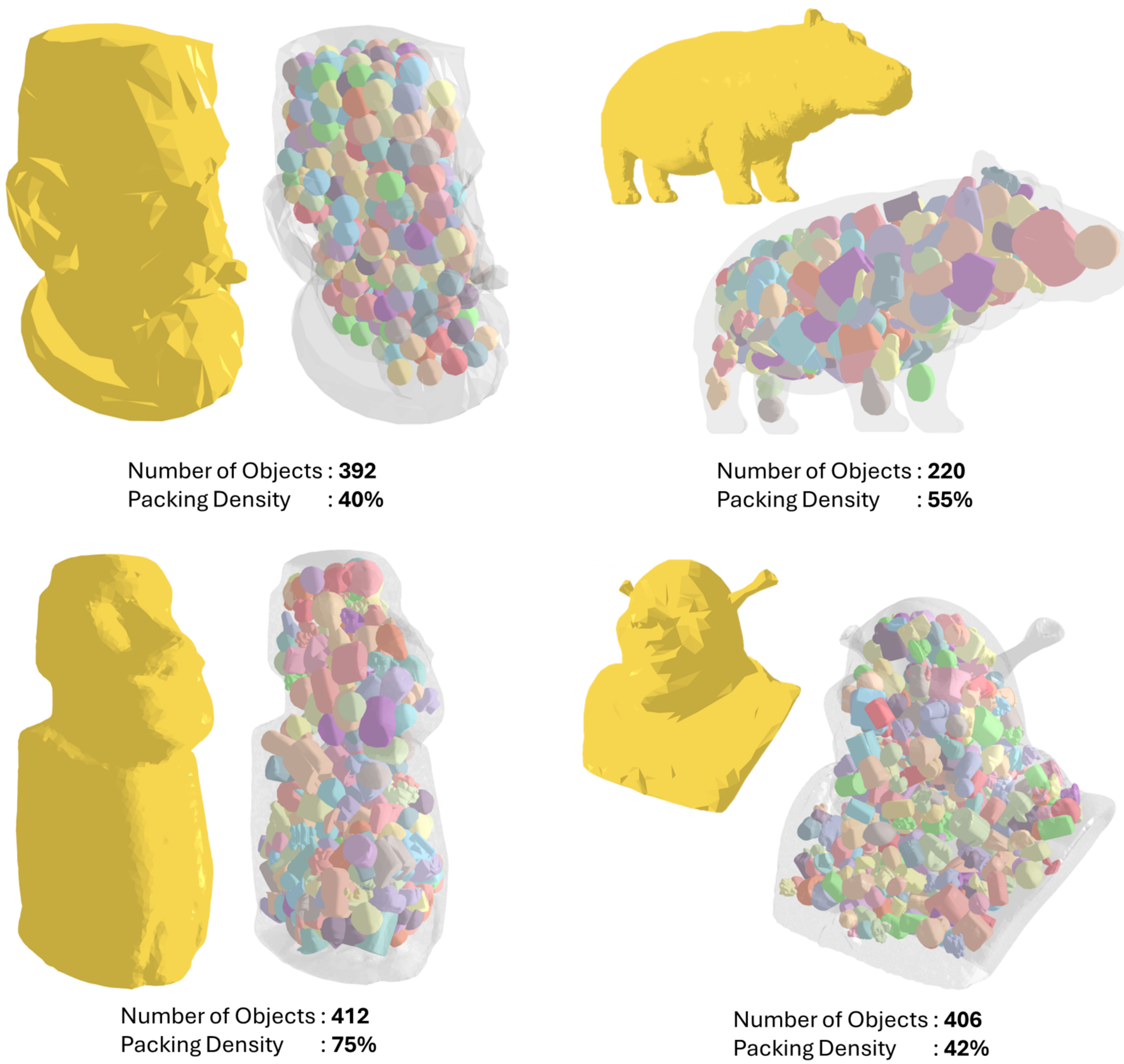
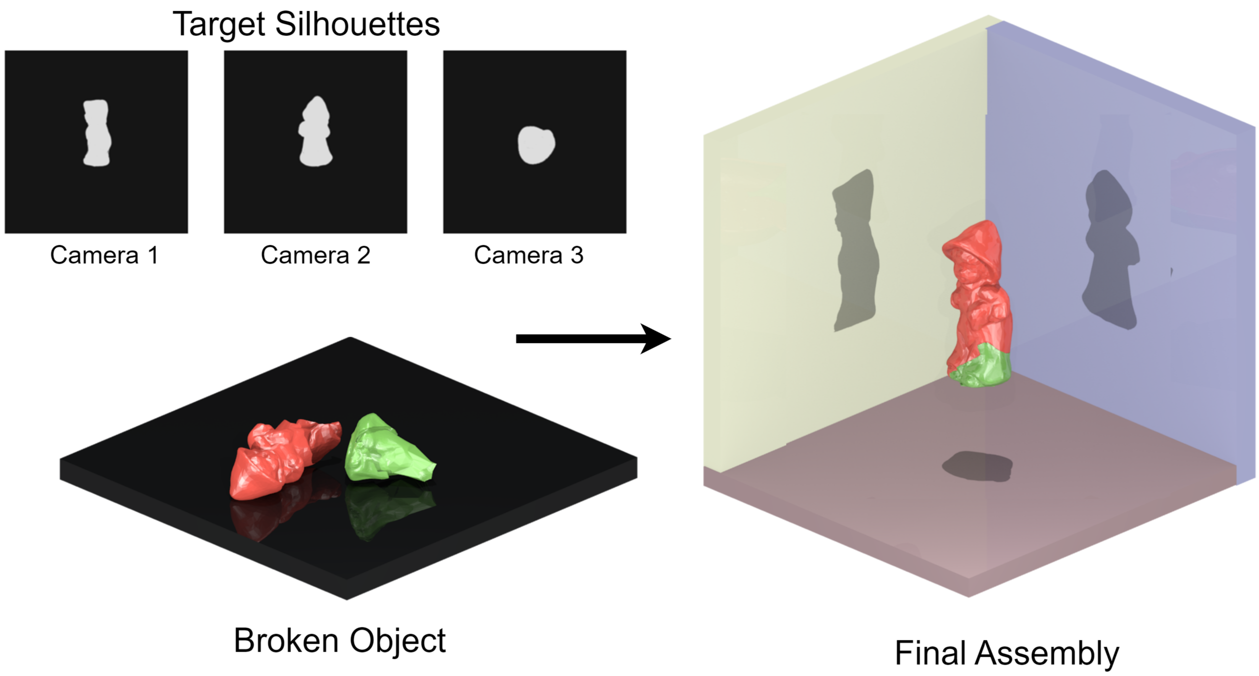


Figure 4. Additional results for packing into arbitrarily shaped containers using RASP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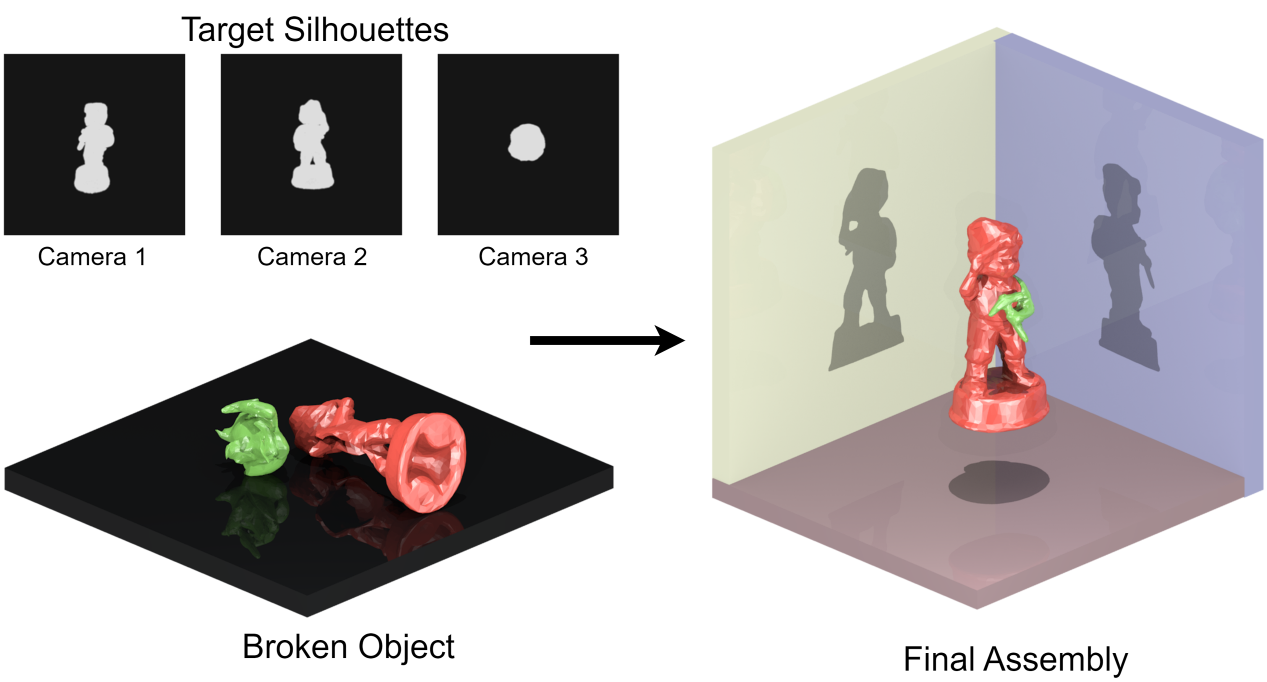
Camera 1
Camera 2
Camera 3
Broken Object
Final Assembly


Target Silhouettes
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Camera 3
Broken Object
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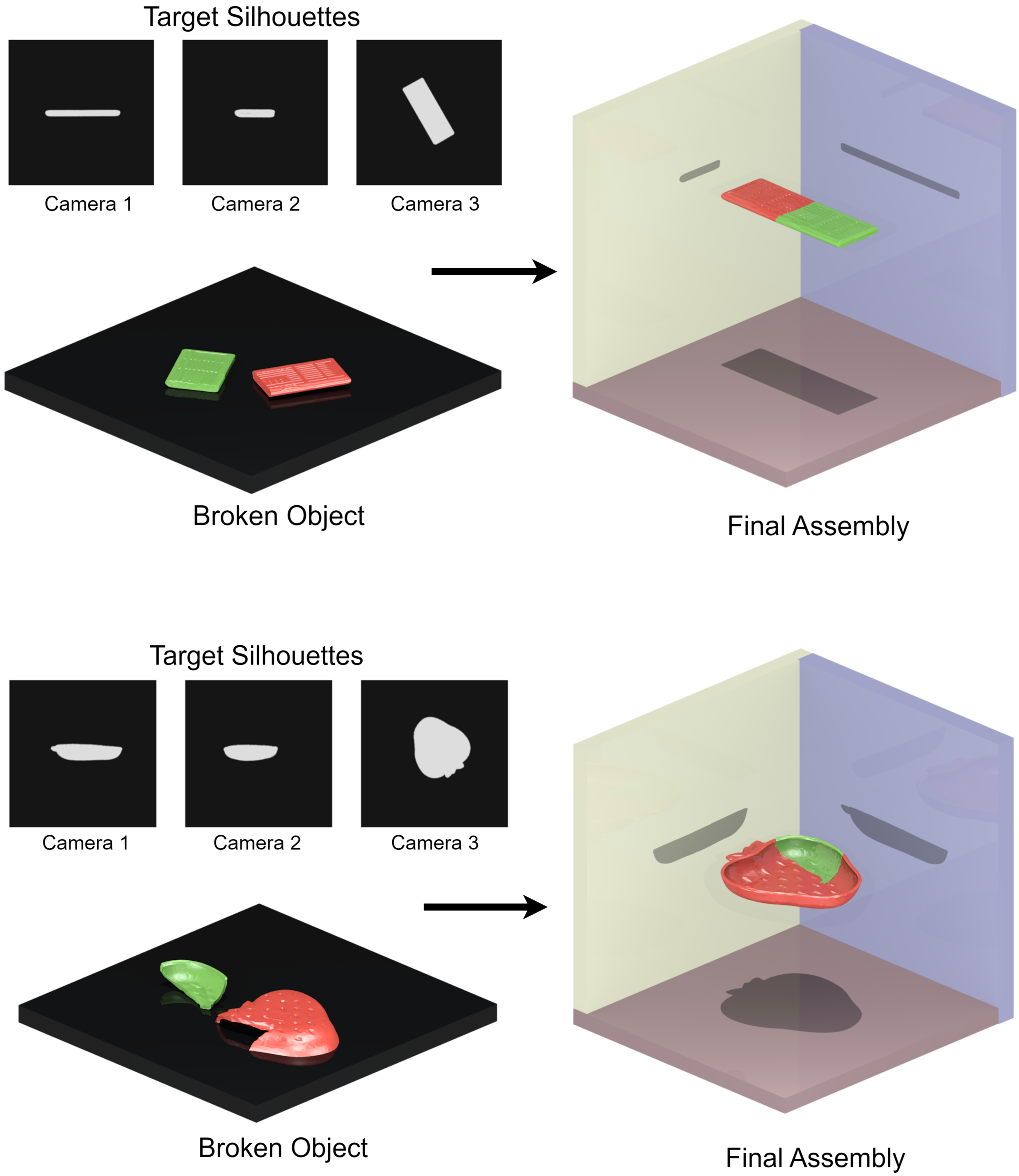

Figure 5. Additional results of RASP for 3D Part Assembly