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Combinatorial 3D Shape Generation via Sequential Assembly

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Introduction

- 3D shape generation via *sequential assembly* mimics a human assembling process.
- We solve a sequential problem with Bayesian optimization-based framework of *combinatorial 3D shape generation*
- It creates a 3D shape with a set of *geometric primitives*.
- We also introduce a new *combinatorial 3D shape dataset* that consists of 14 classes and 406 instances.

Sequential Assembly with Unit Primitives

- Usually, one of popular 3D representations such as point clouds, meshes, and voxels is used to generate a 3D shape.
- In this work, we create a 3D shape, composed of a sequence of unit primitives such as 2 × 4 LEGO bricks.
- 2 × 4 LEGO bricks make our problem more combinatorial and more complex, compared to other primitives.

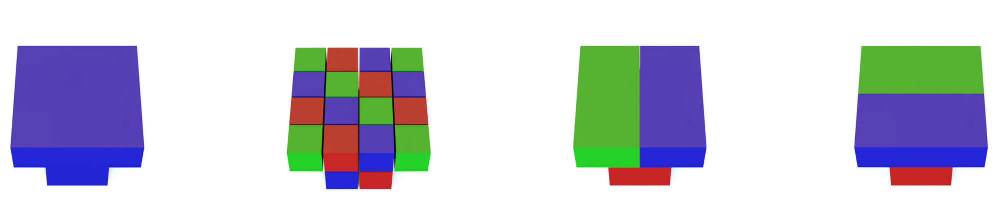


Figure 1: Motivating examples

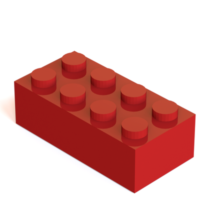
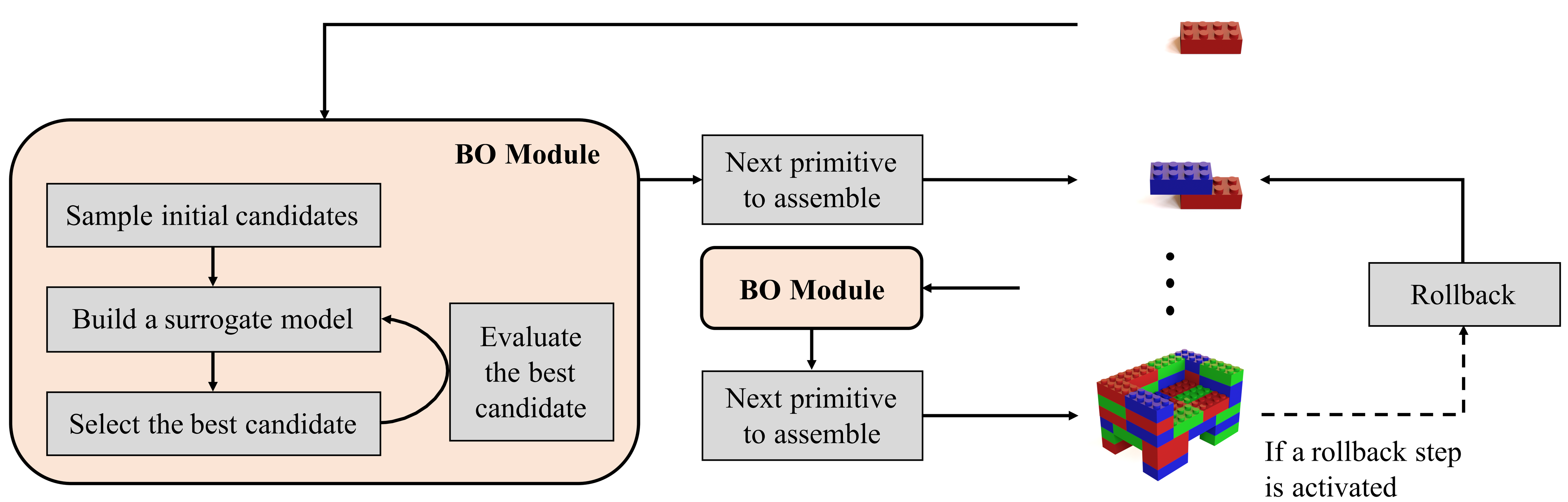


Figure 2: 2 × 4 LEGO brick.



Combinatorial 3D Shape Generation

- To determine the position of the next primitive, we define two evaluation functions regarding *occupiability* and *stability*.
- Occupiability encourages us to follow a target shape:

$$y_{\text{o}} = f_{\text{o}}(\mathbf{p}_{n+1}; \{\mathbf{p}_l\}_{l=1}^{n}) + \epsilon_{\text{o}}. \qquad (1)$$

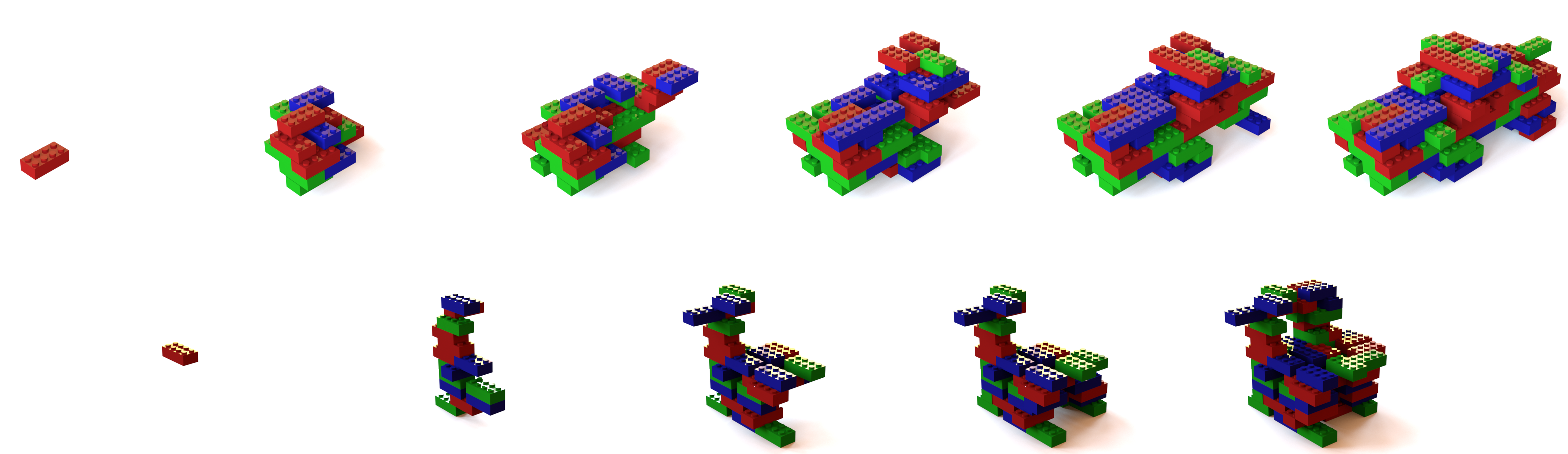
- Stability helps to create a physically stable combination:

$$y_{\text{s}} = f_{\text{s}}(\mathbf{p}_{n+1}; \{\mathbf{p}_l\}_{l=1}^{n}) + \epsilon_{\text{s}}. \qquad (2)$$

- We determine the position of the next primitive via *Bayesian optimization*.
- To avoid a suboptimal sequence, our framework includes a *rollback step*.

Experimental Results

- We assemble a new sequence of geometric primitives by following a target 3D shape.
- We apply our framework in optimizing specific explicit functions.
- Please check the paper for the experimental settings and other results.



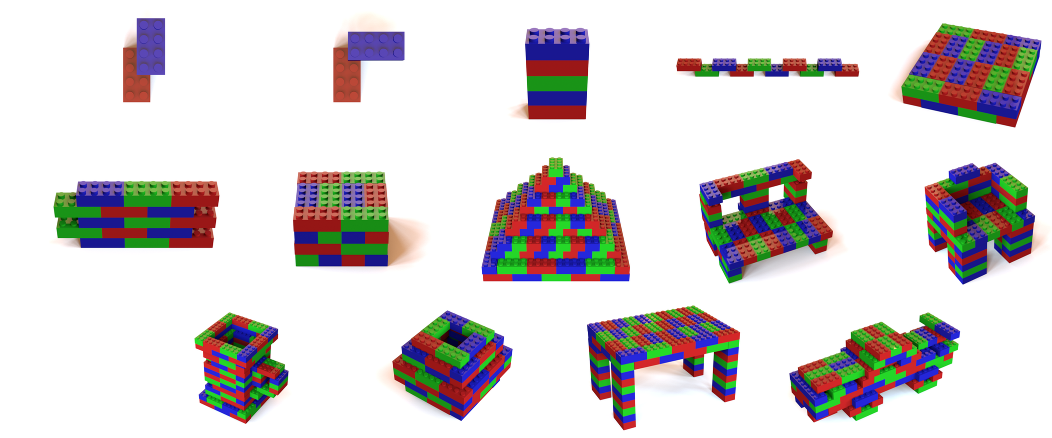


Figure 3: Selected examples from our dataset.

Combinatorial 3D Shape Dataset

- The characteristics of our combinatorial 3D shape dataset are *combinatorial*, *sequential*, *decomposable*, *manipulable*.

Conclusion

- We propose a sequential assembly method for combinatorial 3D generation.
- We also create a new dataset for combinatorial 3D models.

Available on arXiv/GitHub

arXiv GitHub

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