



# Computational LEGO<sup>®</sup> Design

Student: YUAN Shaoxuan

Supervisor: Prof. Chi-Wing FU, Philip



## Introduction

LEGO model can display many shapes of different objects, which is a great decoration. However, to construct such a model, LEGO designers have to spend significant amount of time and energy. To improve the construction efficiency, we aim to use a computational strategy to generate LEGO models according to 2D shapes. In this project, we will show the construction and optimization method.

## Related Work

In recent years, many works related to LEGO construction have been explored. Zhou et al. [1] show a computational method to create LEGO sketch art. What is more, Luo et al. [2] and Liu et al. [3] present a process to analyse the stability of LEGO models. Based on these researches, we will come up a strategy to generate stable LEGO models using selected bricks.

## Task Definition & Methods

**Task definition:** Our aim is using a set of LEGO bricks to match the shapes in the input images; see figure below.

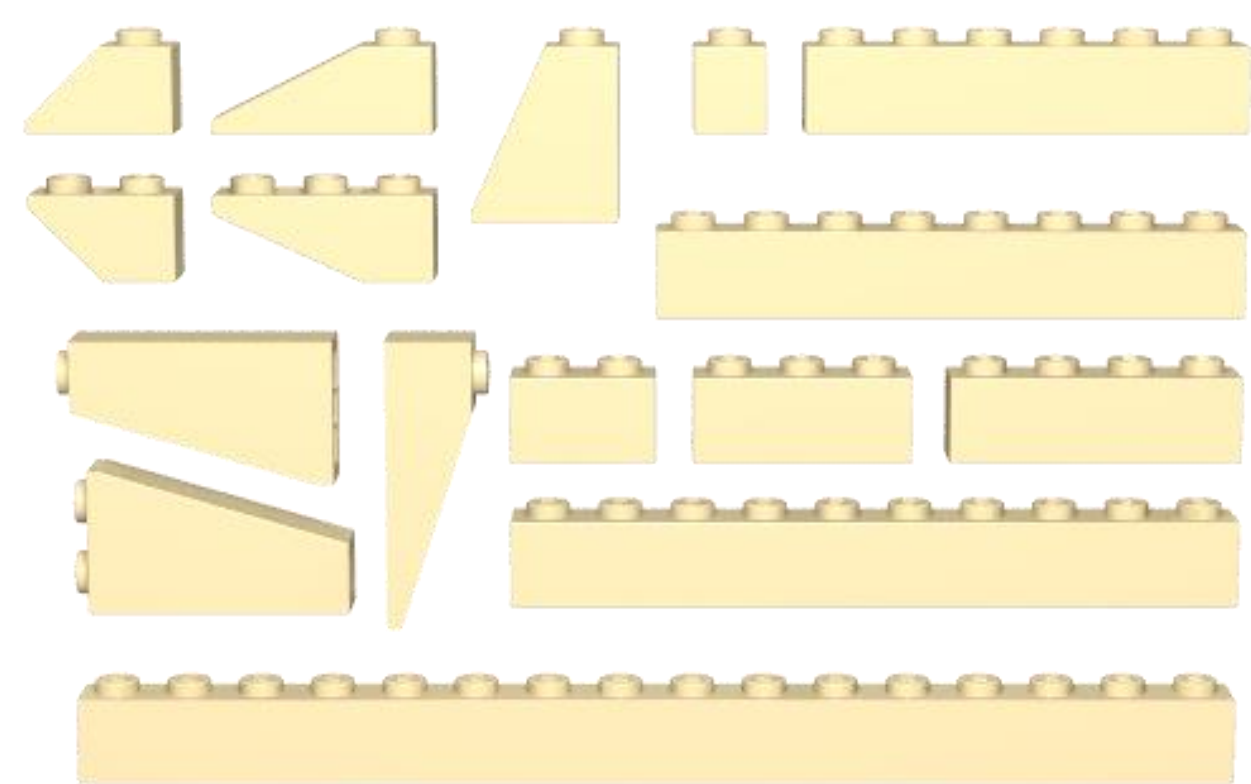


Figure: brick set

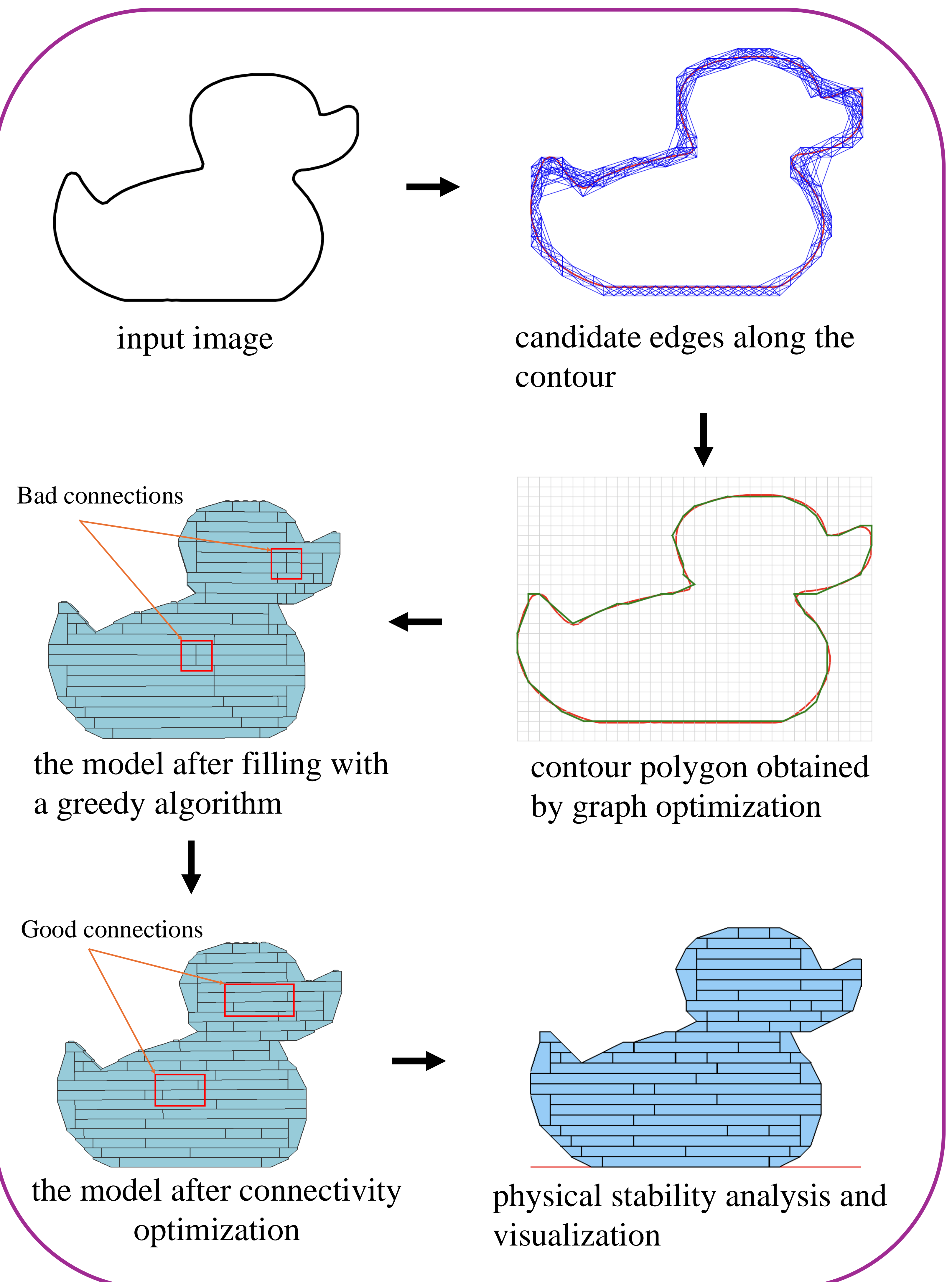
**Methodology:** Our method includes two main steps:

### Construction

- Graph creating
- Graph optimization
- Bricks filling

### Optimization & Analysis

- Connectivity optimization
- Stability analysis

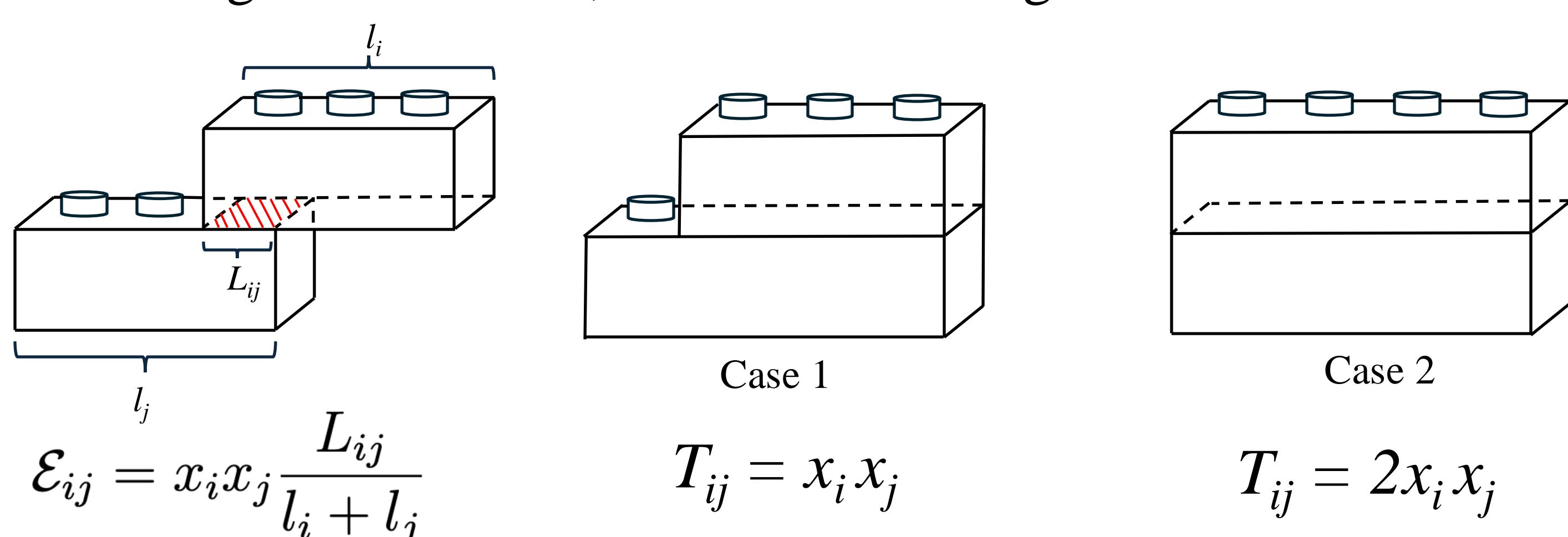


## Optimization Method

**Graph Optimization:** In this step, we follow the strategy of Zhou et al [1]. We use the objective function below to measure the effect of fitting.

$$W = w_d L_d + w_v L_v + w_s L_s$$

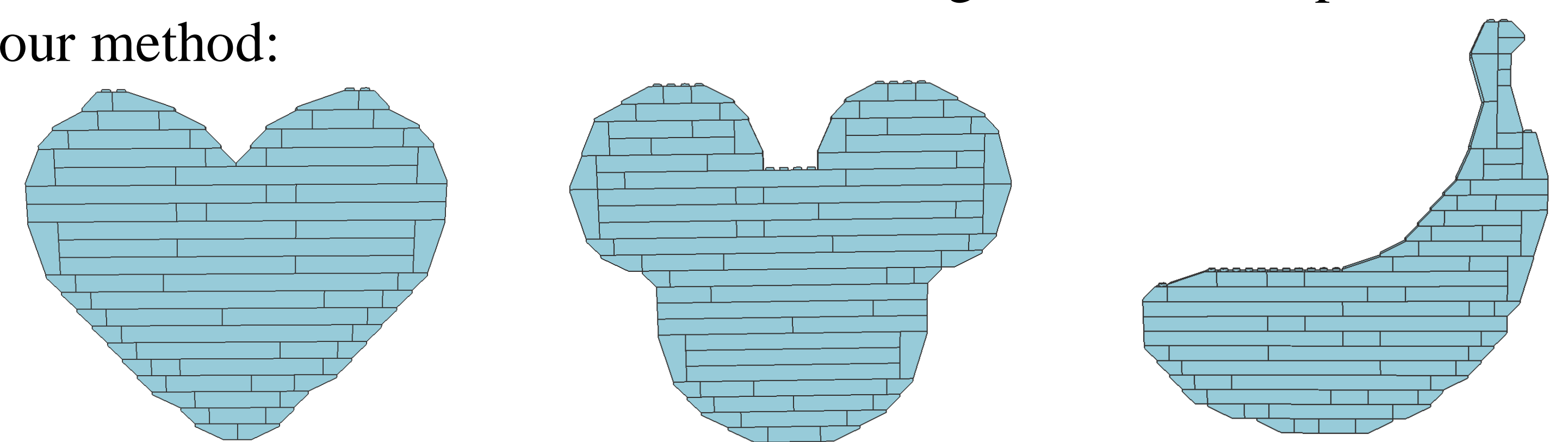
**Connectivity Optimization:** We aim to use less bricks to generate more connections. We associate each brick with a binary variable  $x_i$ . We will consider a structure consisting of two bricks; see left structure below. And we prefer interlaced structure and try to avoid aligned structures; see middle and right structures below.



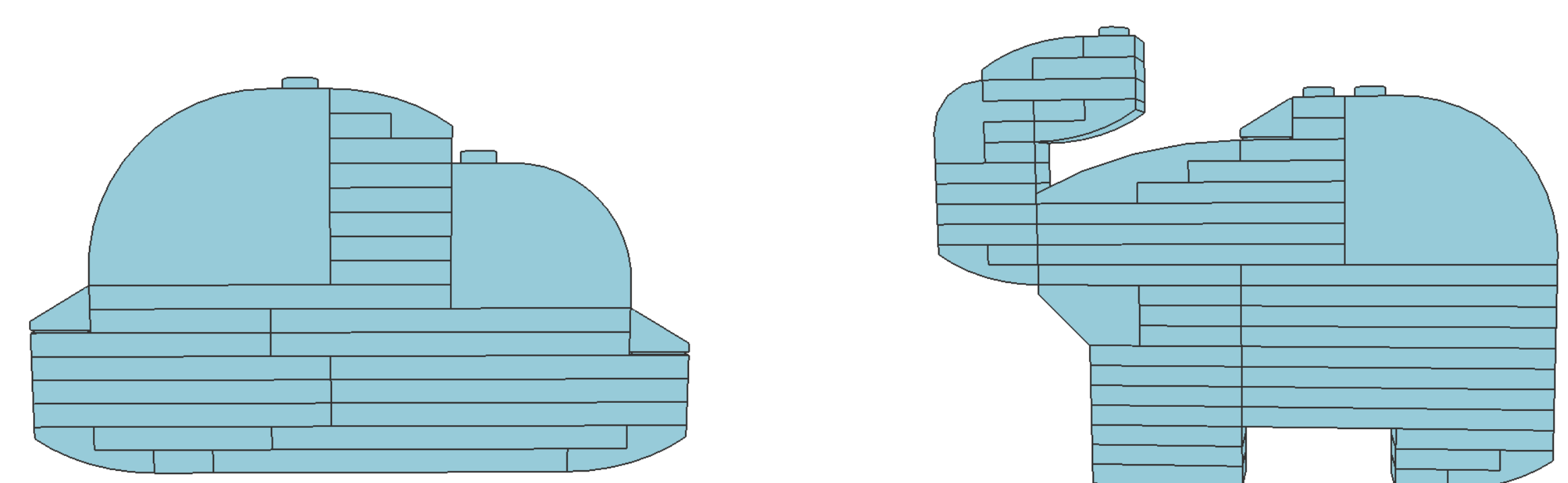
$$\mathcal{C} = \sum_{i < j} \mathcal{E}_{ij} + \sum_{i < j} T_{ij}$$

## Results & Extension

**Results:** Below are some LEGO models generated and optimized by our method:



**Extension:** Based on previous work, we have enlarged our brick set by adding curved bricks and plates to generate better models. There are some preliminary results. In the future, we will consider constructing LEGO models in smaller sizes and multi-orientations.



## Reference

- [1] ZHOU, M., GE, J., XU, H., AND FU, C.-W. Computational design of lego sketch art. *ACM Transactions on Graphics (TOG)* 42, 6 (2023), 1-15.
- [2] LUO, S.-J., YUE, Y., HUANG, C.-K., CHUNG, Y.-H., IMAI, S., NISHITA, T., AND CHEN, B.-Y. Legolization: Optimizing lego designs. *ACM Transactions on Graphics (TOG)* 34, 6 (2015), 1-12.
- [3] LIU, R., DENG, K., WANG, Z., AND LIU, C. Stablelego: Stability analysis of block stacking assembly. *arXiv preprint arXiv:2402.10711* (2024).