

## 04

### **Man-Computer Symbiosis**

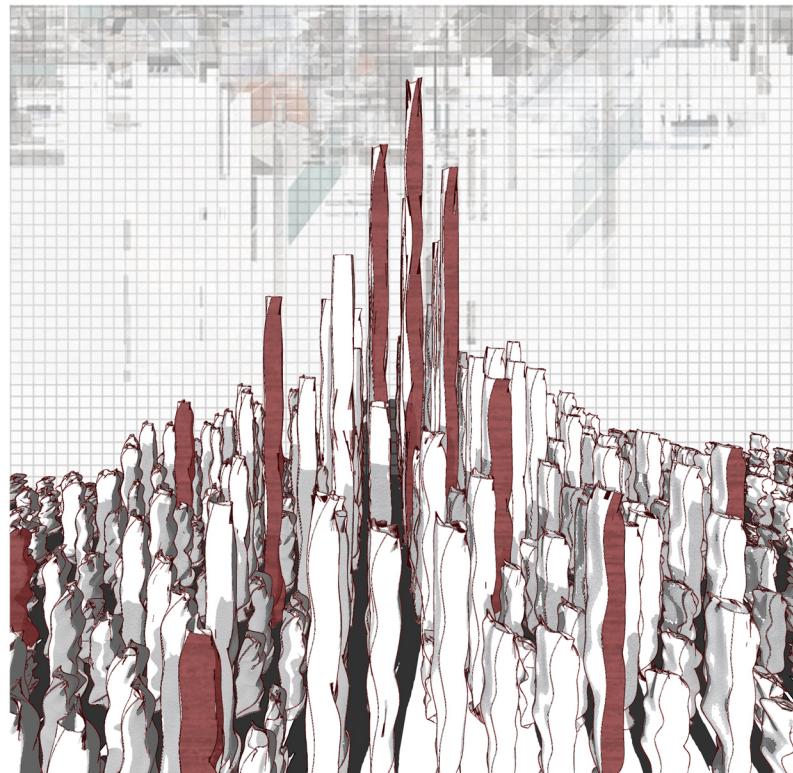
#### Form Finding Via Machine Learning

Academic Team Work  
The 9th DigitalFUTUREs International Workshop  
Date : Jul 2019  
Site : Shanghai, China  
Contributions: Technology and design part (model collecting, data simplification, and machine learning)  
Yang Li and Yue Ren are responsible for drawing performance.  
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(Collaborated with Chao Weng, Donglai Yang, Feng Shi, Hainan Yan, Hanyong Xu, Jiageng Chen, Jiewei Li, Qi Yang, Li Yang, Shilong Zhu, Shiqi Liang, Xiaobai Ji, Xinxing Chen, Xinyu Xia, Yibo Zhong, Yifan Huang, Yue Ren, Zhiming Niu )

This is a collaboration between computer science and architecture to complete an exploratory revolution in structure and space.

If one day, the computer can replace the architect to complete the intellectual level of architectural design, then where should the architecture go? Can architecture open up new design strategies and design areas in the highly computational future?

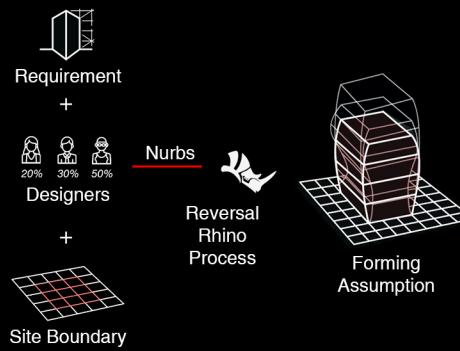
This project focuses on how designers use computational thinking to redefine designs and recreate designs. By using machine learning, we try to let computers learn the generation of architectural forms in three-dimensional space and explore the prospects of machine learning in the field of architectural form generation. Through data collection and data training in neural network, new architectural forms are created depending on the training output. These machine-designing forms are collected to form the future city scenarios.



## Methodology

Through machine learning of big data, the design logic hidden behind data will be revealed, thus creating an artificial intelligence model to predict the architectural forms that match the form-finding goals.

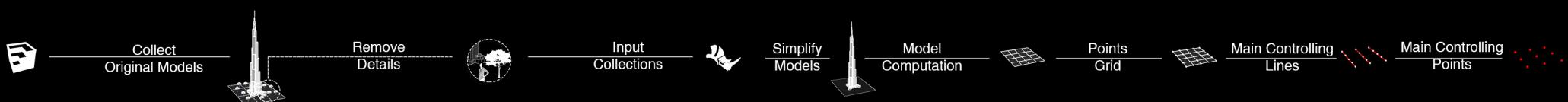
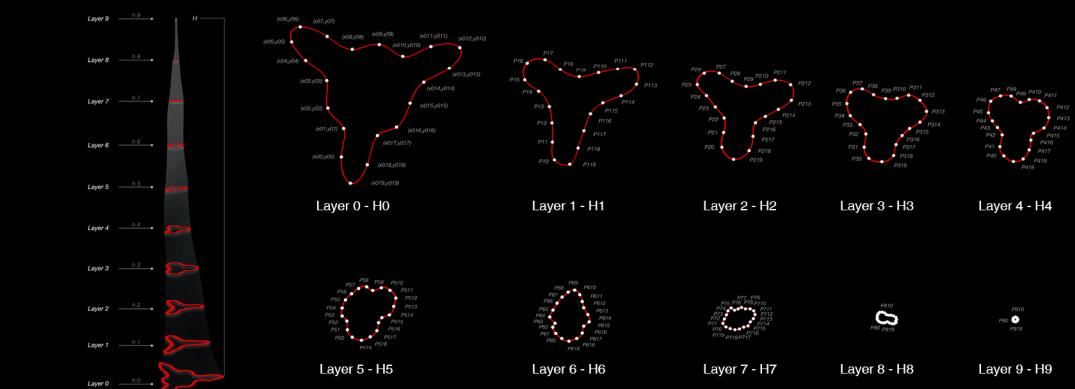
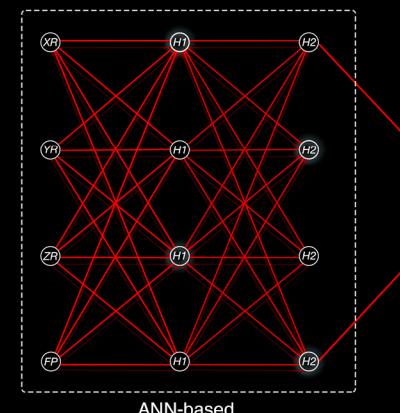
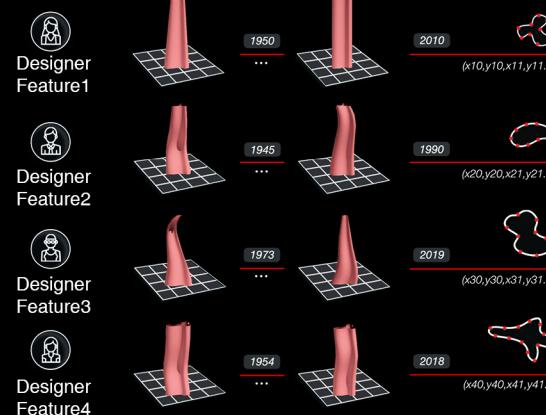
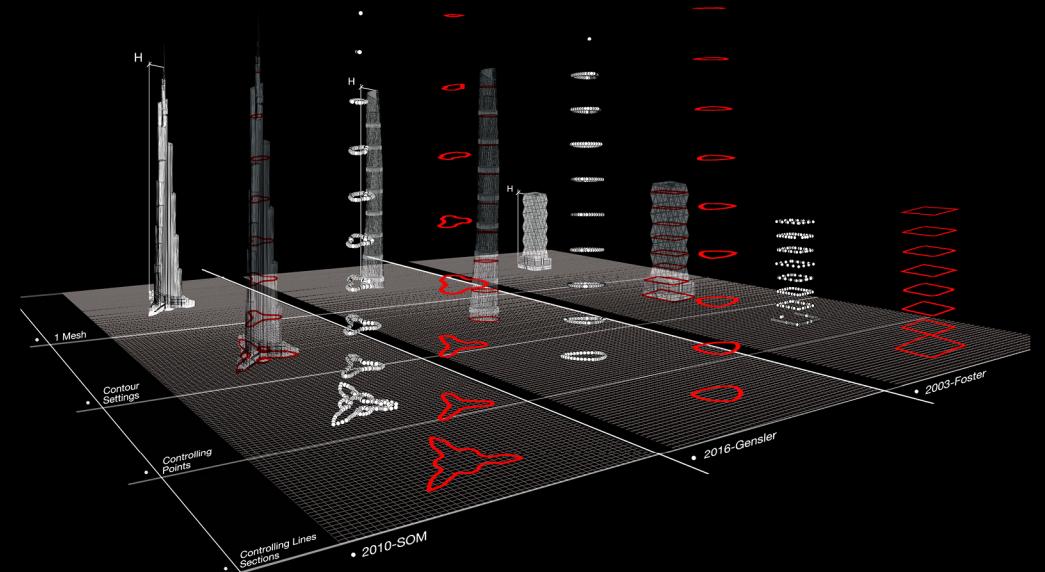
This neural network model concludes design strategies from learning procedure, storing design rules, and generating architectural forms by recalling the parameters.



## Data Preparation

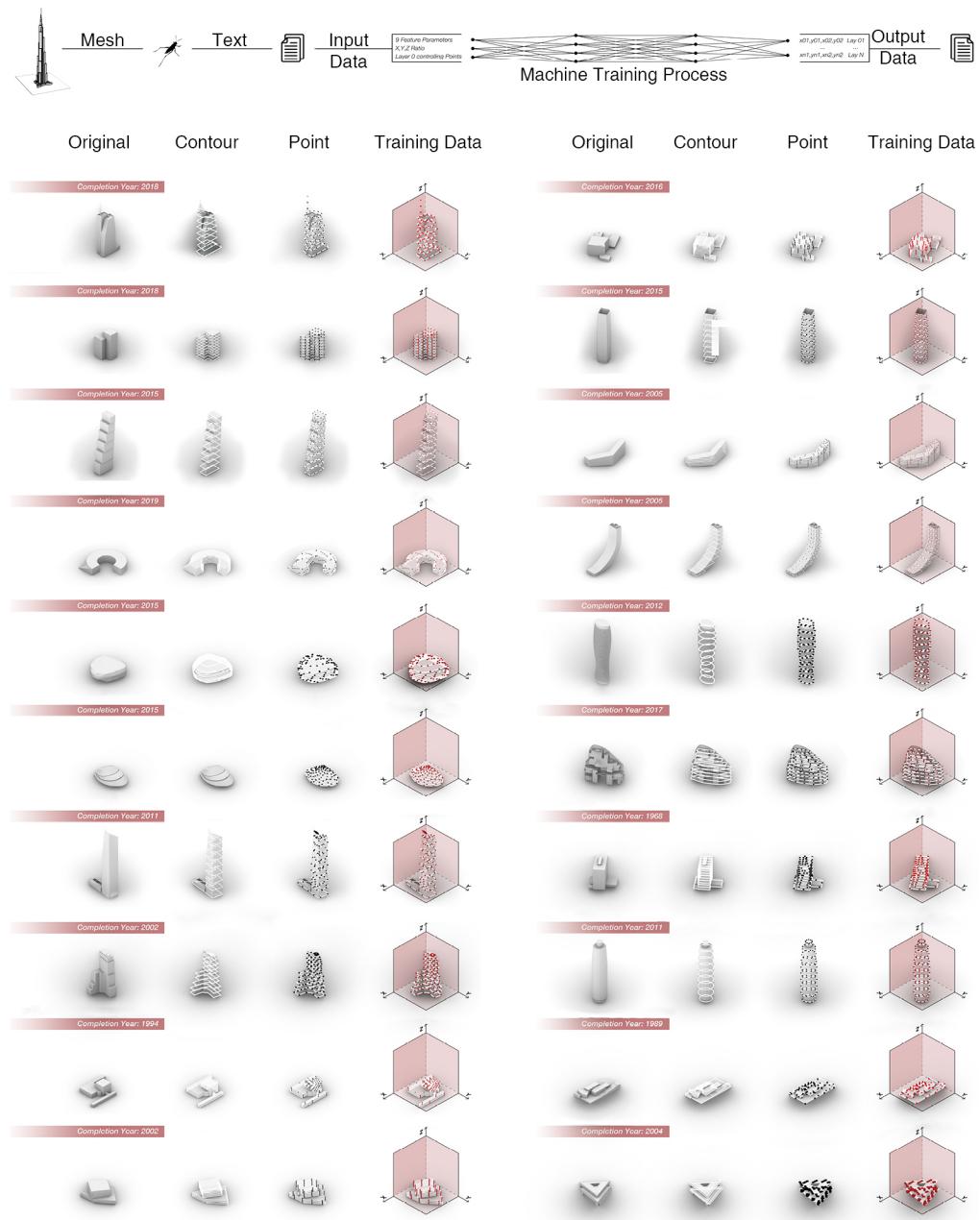
To match with the feasible data structure for machine learning. Details that have little effects on the overall forms will be removed. Simplified models can be built by extracting the main section curves and lofting them together.

The basic idea is to translate a surface into a series of real number by extracting the coordinates of the controlling points to match the data structure of the machine learning network. The collection of the real numbers together represent the form of the tower, showing a more efficient data structure than 3D volumes with a large number of voxels.



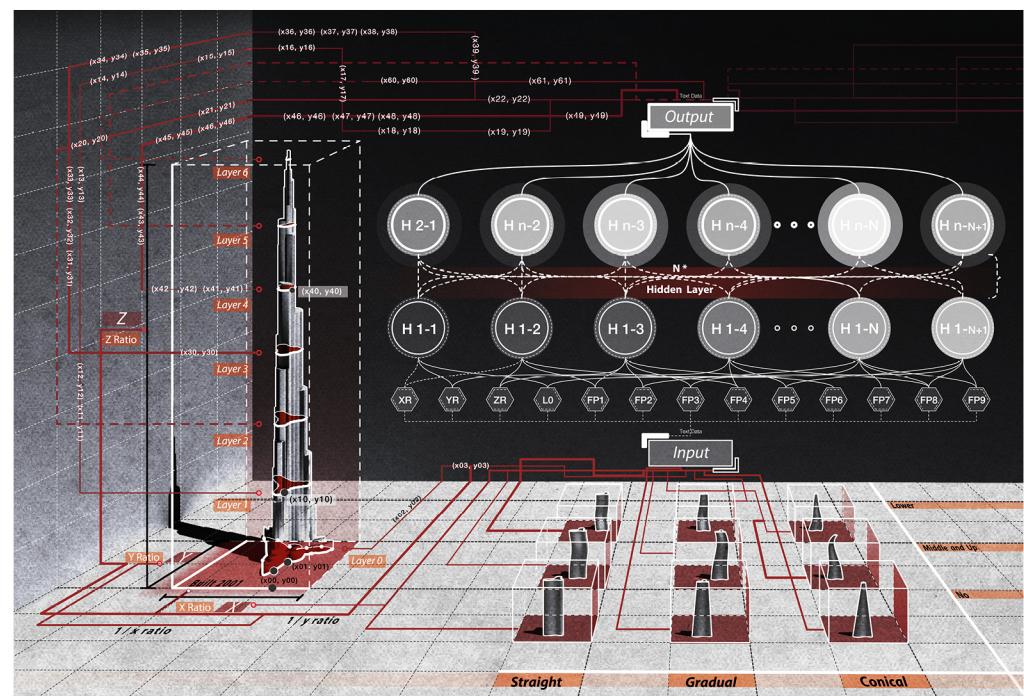
## Collecting Process

In order to test the performance of the idea of the network with real-world forms, 300 models of the towers built by different designers were collected and used as a dataset for training in the next step. Similarly to the designed methodology, the real-data of the coordinate system were extracted from the collected models

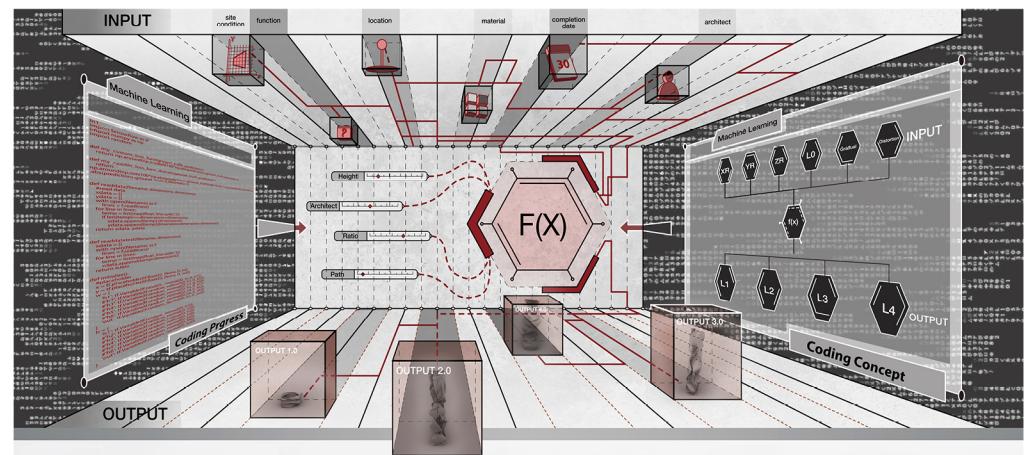


## Data Training

The input neurons contain the required information to start a design. In this case, the input data is the boundary curvature and the height of the building, and the feature parameters showing the design style. The output data is the generated form under the input condition, showing the predicted design outcome from a given architect or a combination of styles from different architects. The hidden layer works to map the input and output data, mathematically expressing the design rules.

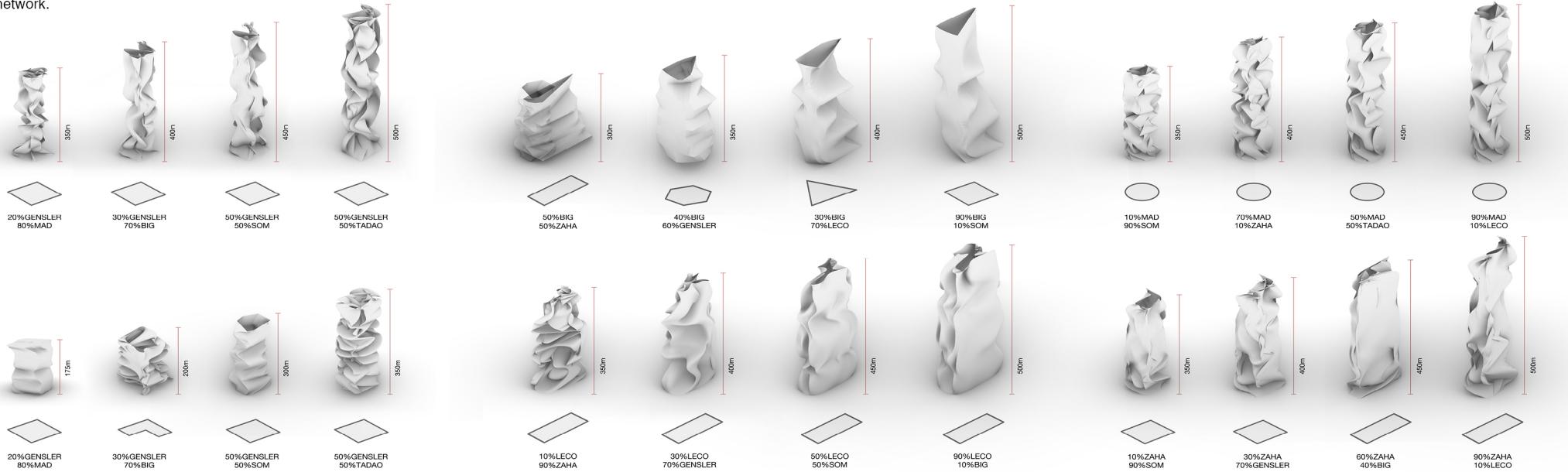


Different from the traditional algorithmic design, data-driven machine learning based design finds the design rules  $f(x)$  from the data rather than from the unpredictable personal intuition of the designer. This is the reason why it provides more reasonable generation results.



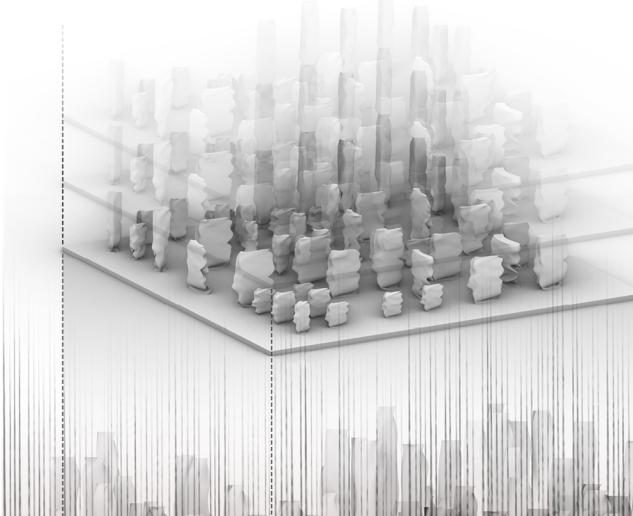
## Testing Process

To test the performance of the network, the testing dataset was generated and inputted to the network. In the training process, the network will only update itself by learning the training dataset without loading the testing dataset, so comparing the expected forms and the predicted forms of the testing dataset is the best way to evaluate the performance of the network.

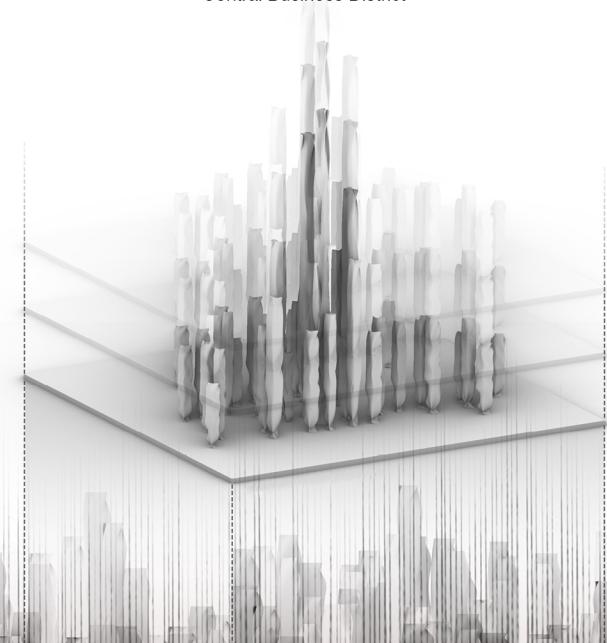


## Modular Design

Residential Area



Central Business District



Industrial Area

