PORTFOLIO

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Cover Page
Photography work at 21_21 Design Sight
Tokyo, Japan
2017

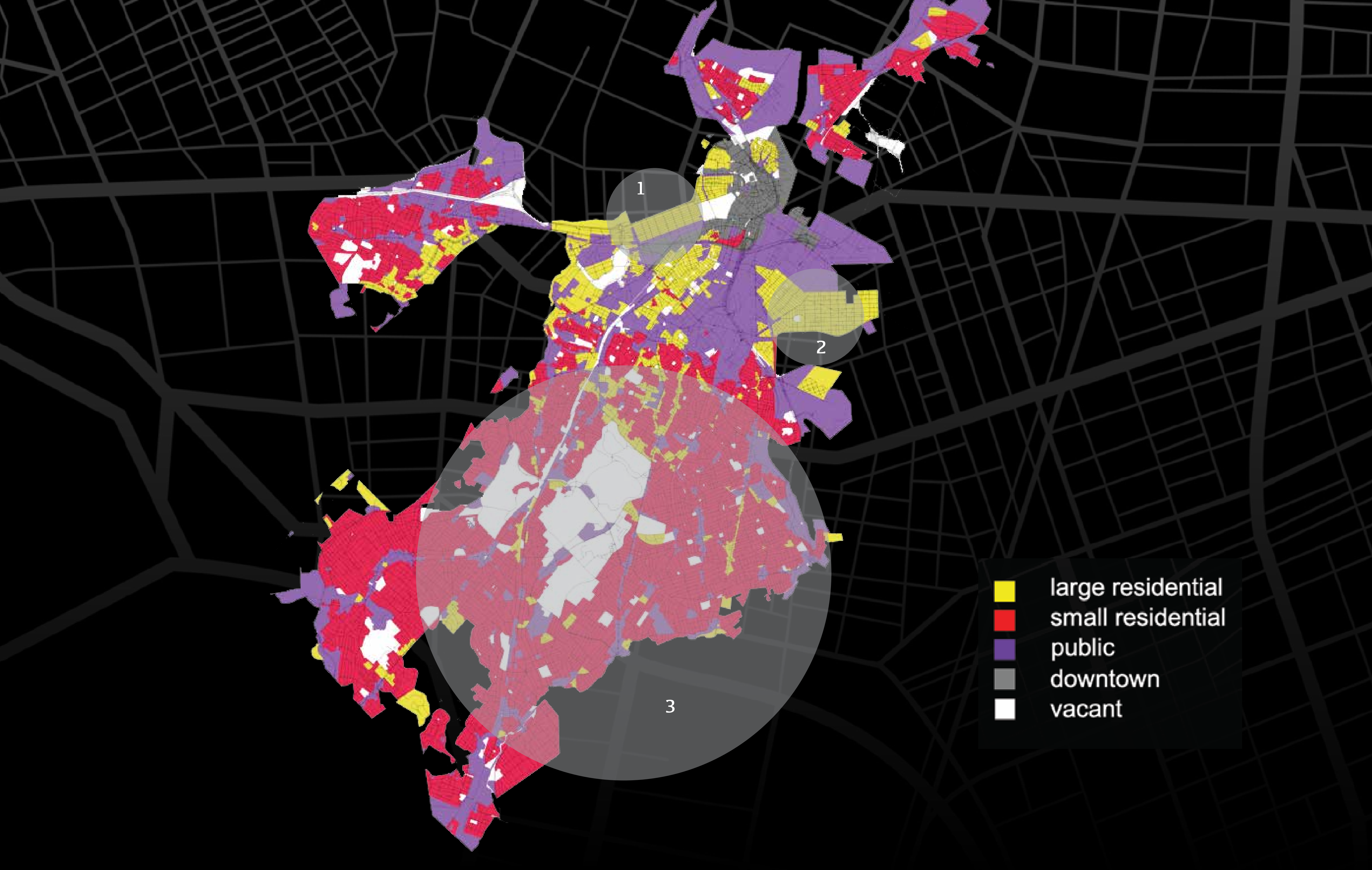
CONTENTS

01 Machine Learning Generated Urban Blocks

Individual work: May 2021 - May 2022
Supervisor: Prof Anand Bhojan
Layout generated using deep learning model & details procedually generated using blender.

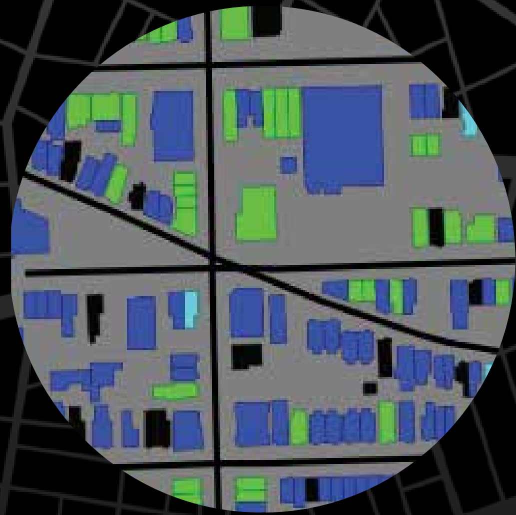
This is my first attempt to examine the potential of deep learning model in understanding urban patterns. A modified version of CycleGAN was used to learn the building footprints in different zones of Boston.

Case Study: Boston Landuse Map



In many city, buildings exhibit unique style that is intereting to model after.
The goal is to focus on regions where the houses exhibit clear pattern in terms of footprints and height.
I picked three categories as shown below. Varying heights are represented using different colors.

Region 1: Back Bay



Region 2: South Boston

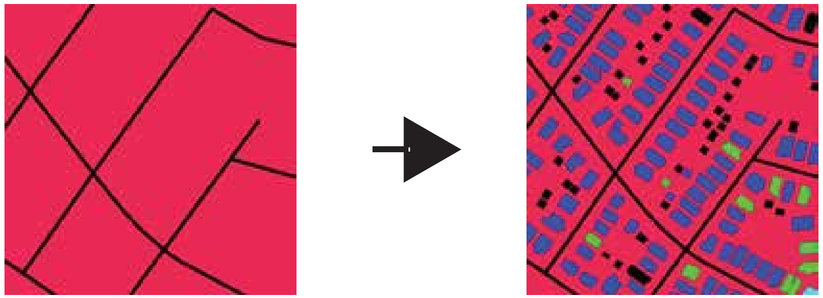
Lorem ipsum

Region 3: A large areas of residential zones predominated with landed houses

Ganerative Adversarial Networks for Architects

A generative adversarial networks consist of two parts: a generator and a discrimiantor.

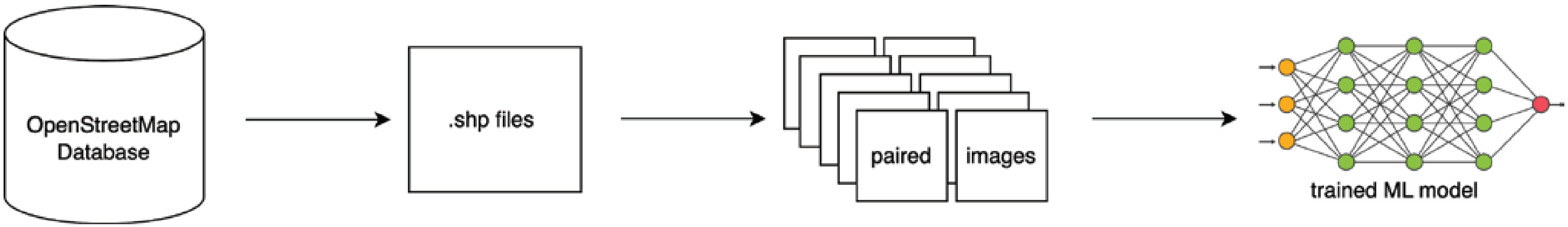
The generator learns the distribution in the training data. In this case, the generator learns the mapping from the roads & the landuse information to the footprints and heights of the buildings.



The the discriminator evaluates how likely the generated result is from the original distribution. The two are trained together in a competitive setting. Randomly initialised genrator and disccriminator wil converge eventually.

Imagine the generator as an art foger who wishes to copy the style of certain painter, and the discriminator as an expert in identifying art forger. Although initially they may not be experts in their field, as they compete with each other, both grow in their expertise.

The Workflow of Machine Learning Pipeline - Model Preparation

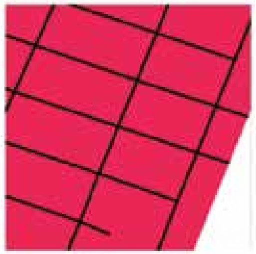


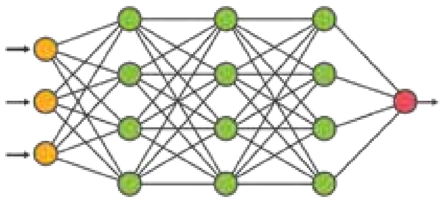
Retrieve the buildings, roads and landuse data from open source database such as OSM

Process the .shp files into images using GIS tools (e.g., QGIS). Use different colors to present information so that the computer can understand.

Generate image pairs and feed it into a modified version of CycleGAN for training.

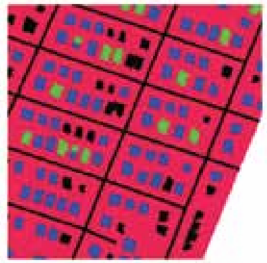
The Workflow of Machine Learning Pipeline - Model Usage





trained ML model

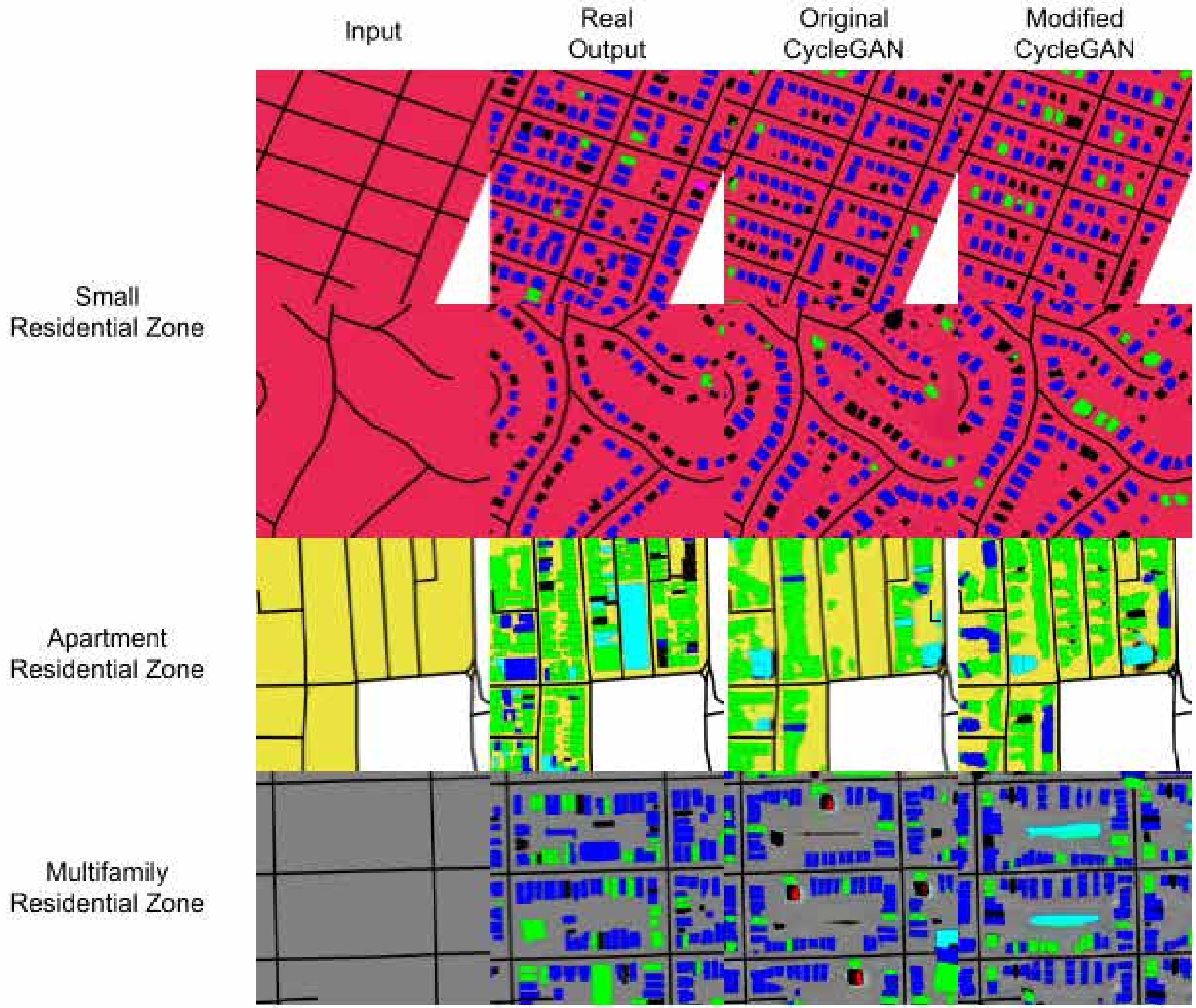
Prepare an image containing roads and landuse infor-mation. Feed the image into the trained model



The model will produce an image with the generated buildings

Process the generated buildings with QGIS to extract the foot-prints and height info into a .shp files. We could make the genrat-ed buildings more realistic by adding details using external procedual generation tools (e.g., geometry node in blender).

Results



Input
Real Output
Original CycleGAN
Modified CycleGAN
Small Residential Zone
Apartment Residential Zone
Multifamily Residential Zone

Evaluation Metrics

Table 6.1: Evaluation on the distance from buildings to the nearest road (unit: km)

	Training Data				**Generated Data**				**T-test**	
zoning category	size	mean	median	s.d.	size	mean	median	sd	t-statistics	p-value
apartment-res	5501	0.008772	0.008762	0.004382	257	0.009936	0.009279	0.005188	3.536819	0.000238
multifamily-res	4109	0.008571	0.007536	0.005625	251	0.009244	0.007030	0.006594	1.581692	0.057441
small-res	12595	0.014295	0.011380	0.008394	266	0.015916	0.012303	0.013813	1.907250	0.028777

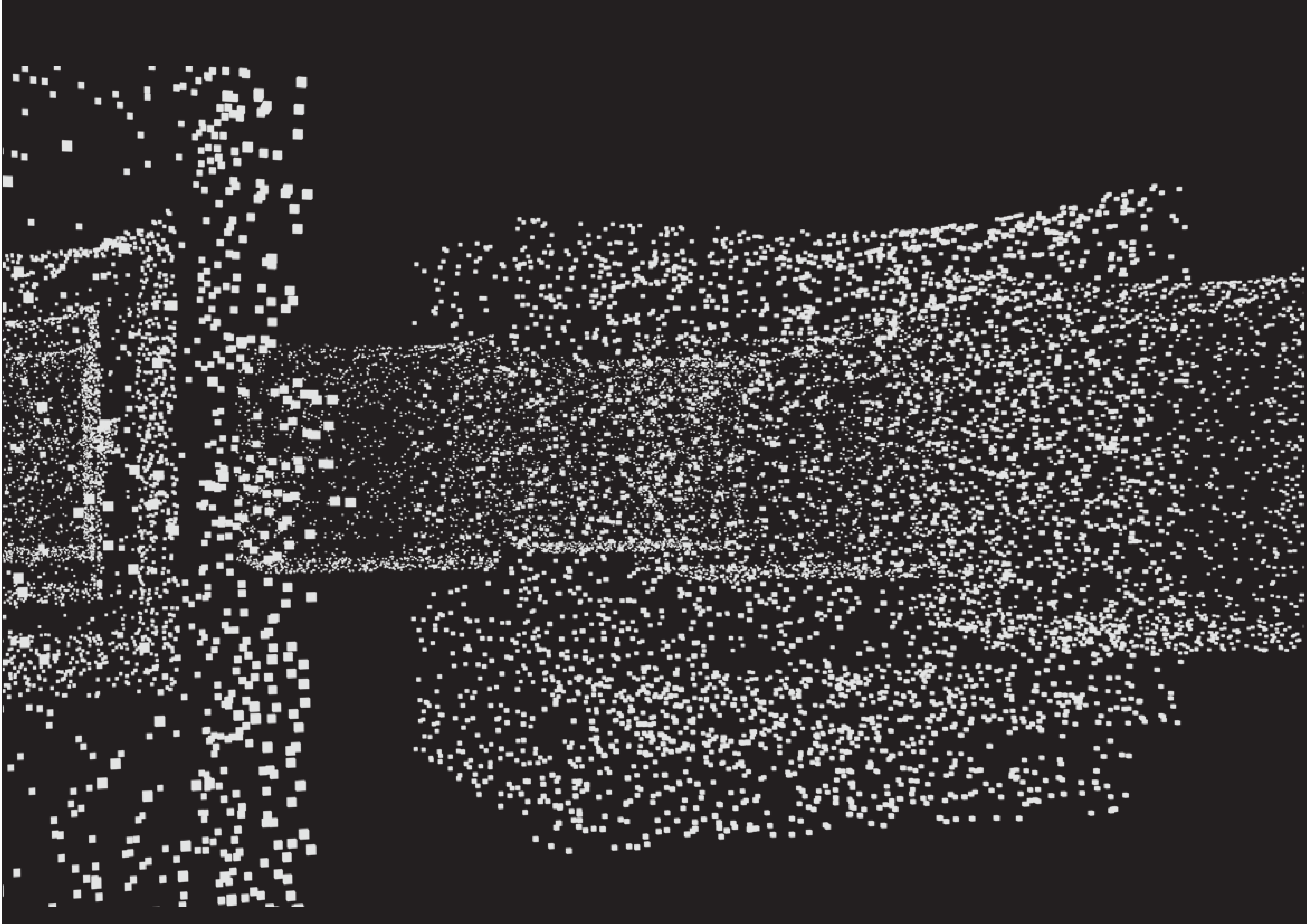
Table 6.2: Evaluation on the size of the buildings (unit: meter square)

	Training Data				**Generated Data**				**T-test**	
zoning category	size	mean	median	s.d.	size	mean	median	sd	t-statistics	p-value
apartment-res	5501	132.53739	95.55550	139.49698	257	274.90661	115.00000	409.14779	5.56322	0.00000
multifamily-resi	4109	117.06215	90.11780	156.99926	251	183.59212	133.41803	184.60762	5.58749	0.00000
small-res	12595	116.69473	109.88330	102.70262	266	104.61224	94.56700	58.71599	-3.25270	0.00064

Table 6.3: Evaluation on the height of the buildings (unit: floor)

	Training Data				**Generated Data**				**T-test**	
zoning category	size	mean	median	s.d.	size	mean	median	sd	t-statistics	p-value
apartment-res	5501	3.420651	3	1.095728	257	3.525292	3	1.992286	0.836122	0.201923
multifamily-resi	4109	2.199562	2	0.878388	251	2.450199	2	1.849009	2.132899	0.016940
small-res	12595	1.776340	2	0.687953	266	1.799228	2	0.656303	-0.271877	0.607041

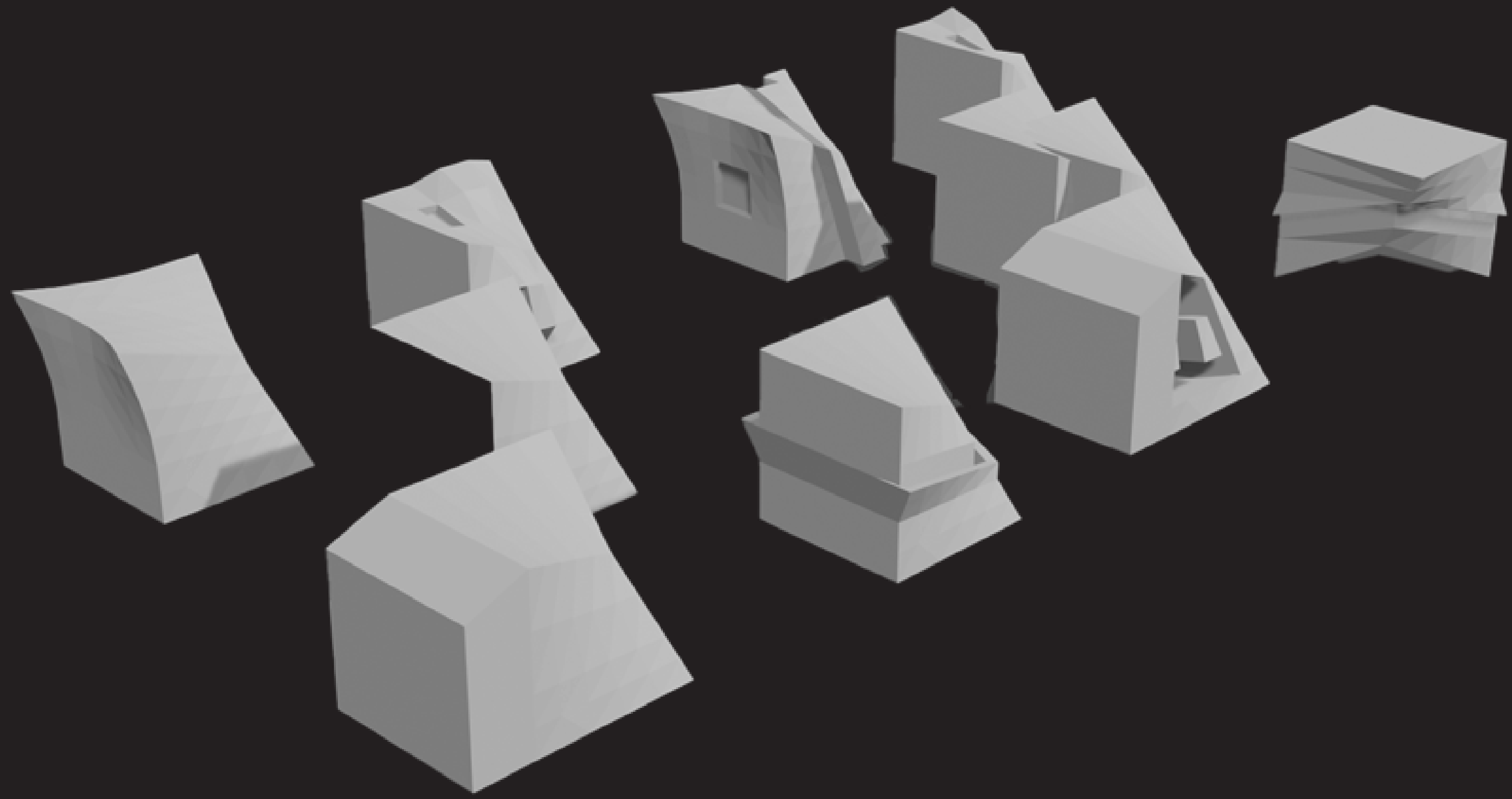
Calculated using PostGIS



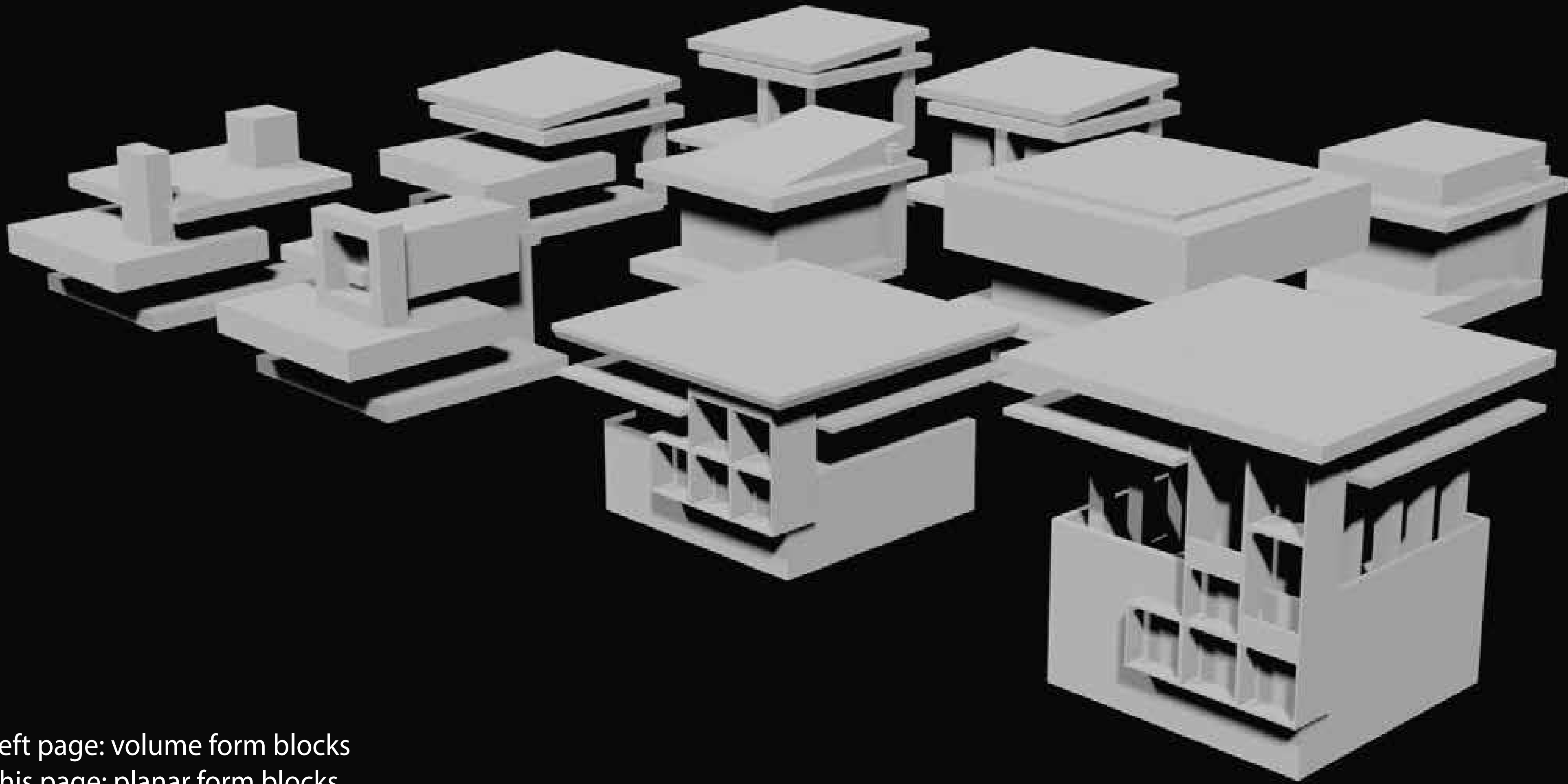
02 PointNet and Typology

Individual work: Oct 2022- Nov 2022
Data modelled using blender; classification done using PointNet

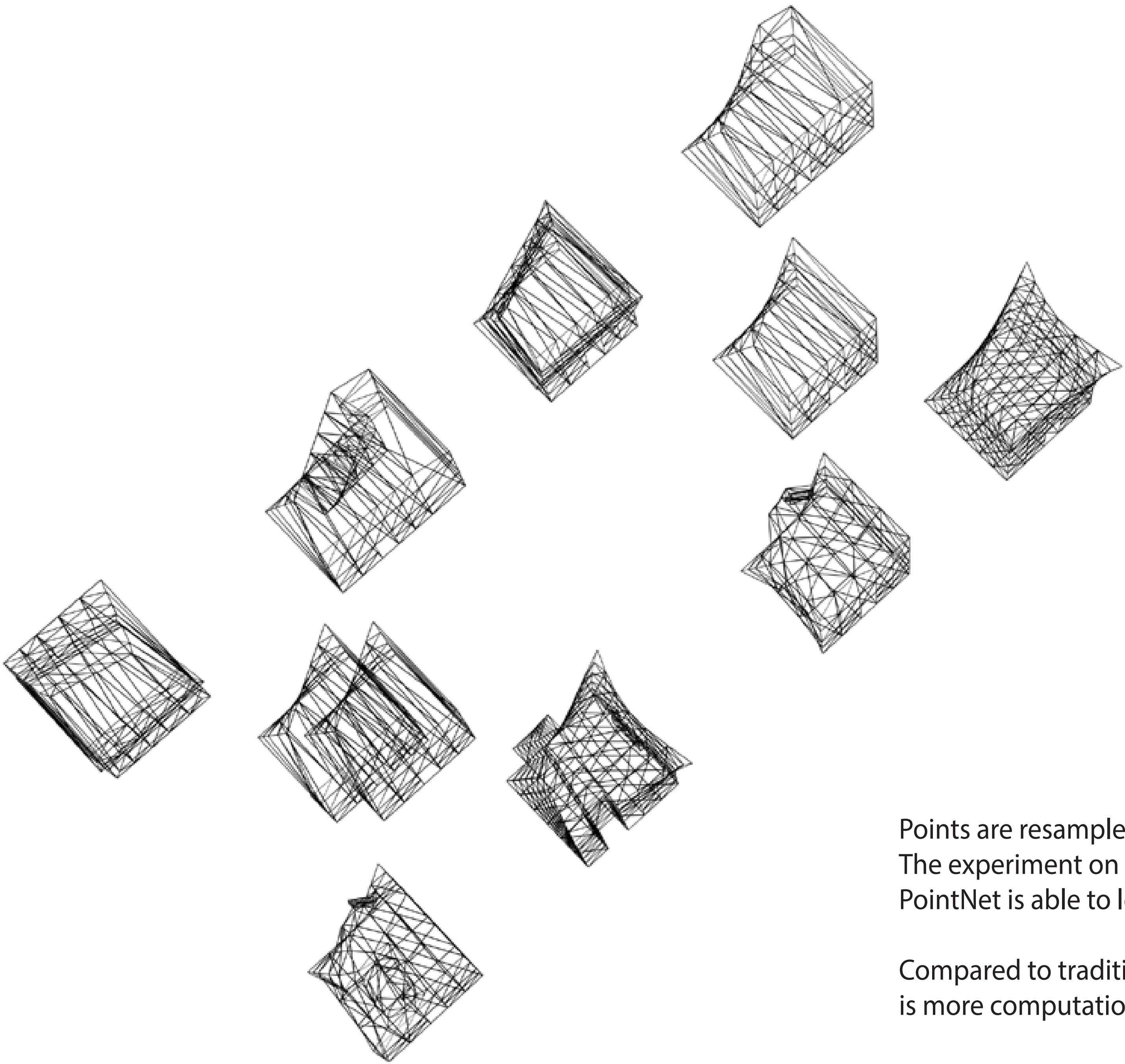
Typology is an crucial concept for both architecture and urban design. Therefore, in this research project, I propose an experiment to examine the potential of the point cloud deep learning model, PointNet in parsing buildings. Specifically, I propose an exploratory study: classify buildings based on their structural forms.



In this experienment, I generated two types of building blocks - volume-form buildings which morphed from a cube and planar-form buildings consisted of vertical and horizontal slabs. I use PointNet, an deep learning model that operates on point clouds to see if it is able to differenciate the two types.



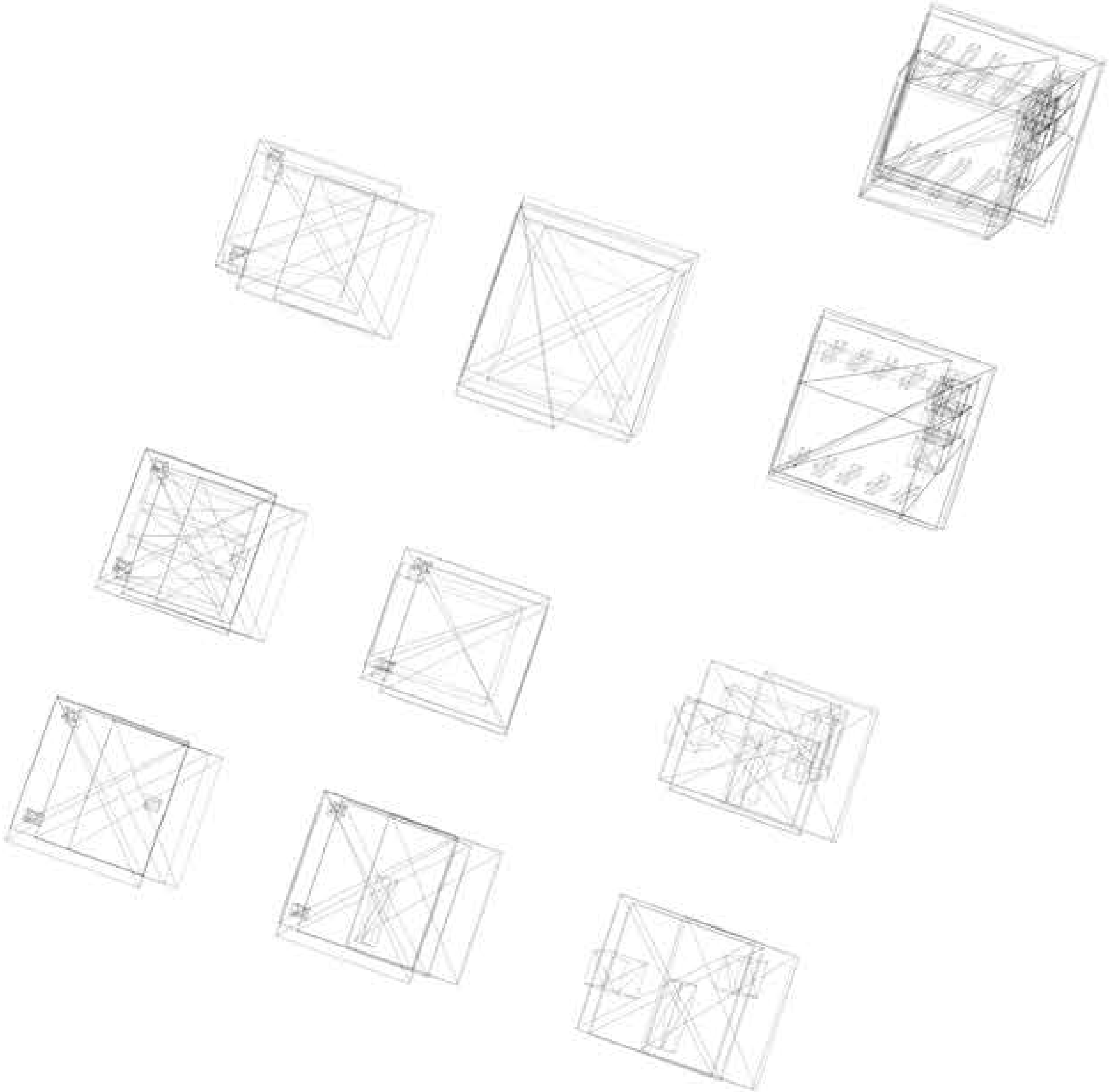
Left page: volume form blocks
This page: planar form blocks



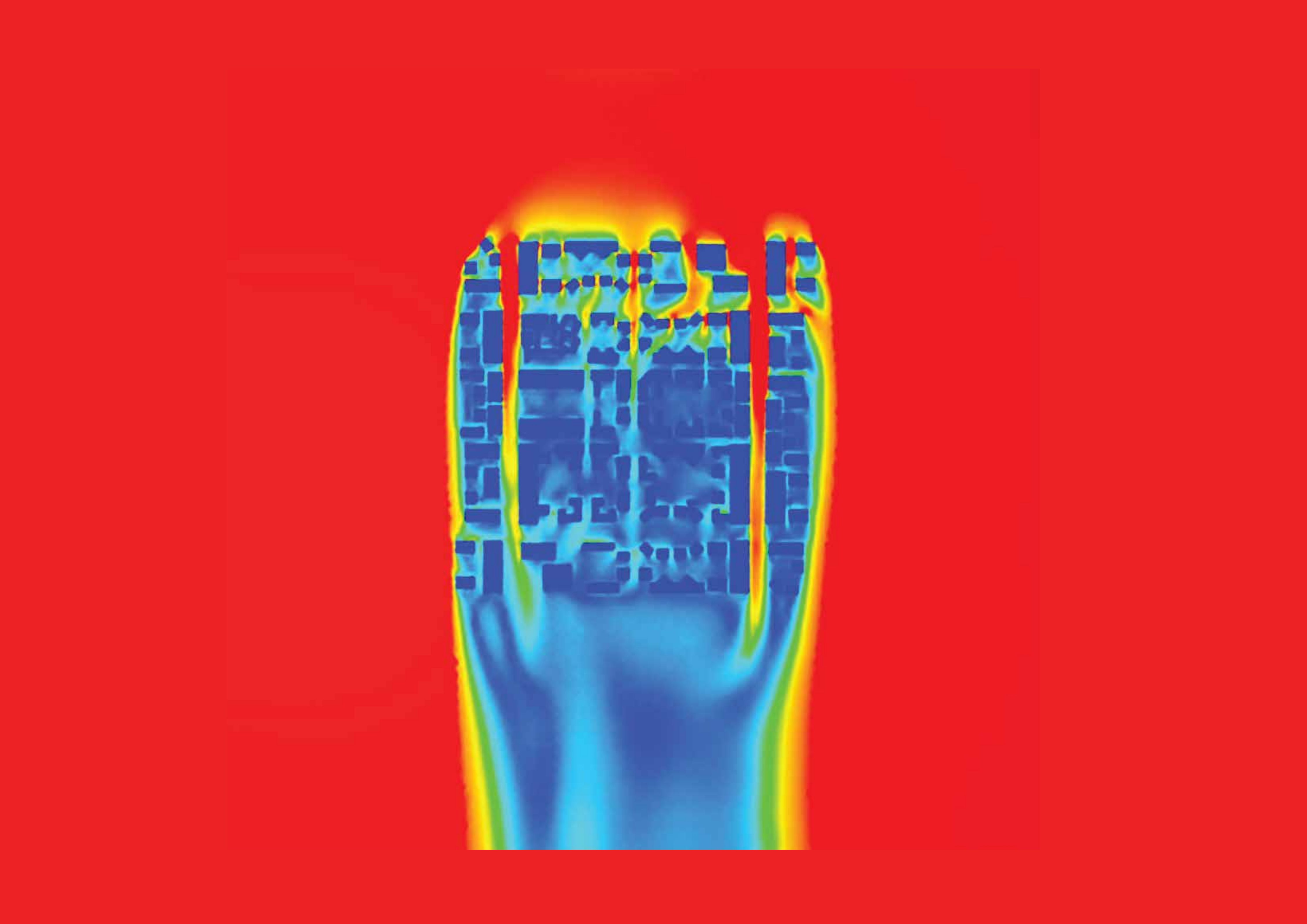
Points are resampled on block surfaces to produce the dataset.
The experiment on a small dataset demostrates that
PointNet is able to learn the differences of the two groups.

Compared to traditional neural networks like CNN, PointNet
is more computationally efficent.

Besides classification, PointNet can also be used for segmentation tasks too. It could potentially be used for purposes like the building restoration and the identification and analysis of historical architectures.



Wireframe visualization of the generated models.

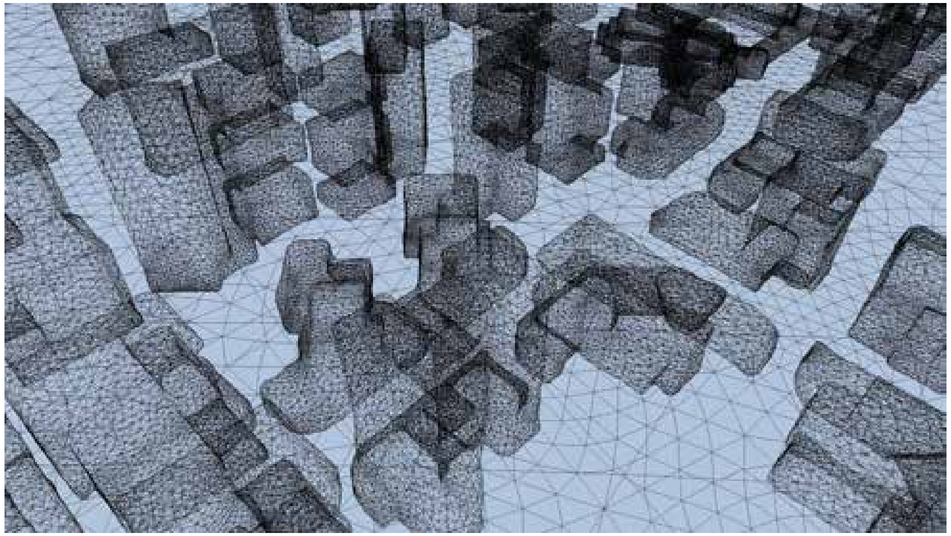


03 Fast Wind Prediction with deep learning

Final Year Project
Sep 2022- Now (Ongoing)
Supervisors: Prof Tung Kum Hoe Anthony & Prof Filip Biljecki
All images credit to NUS Centre for Sustainable Asian Cities

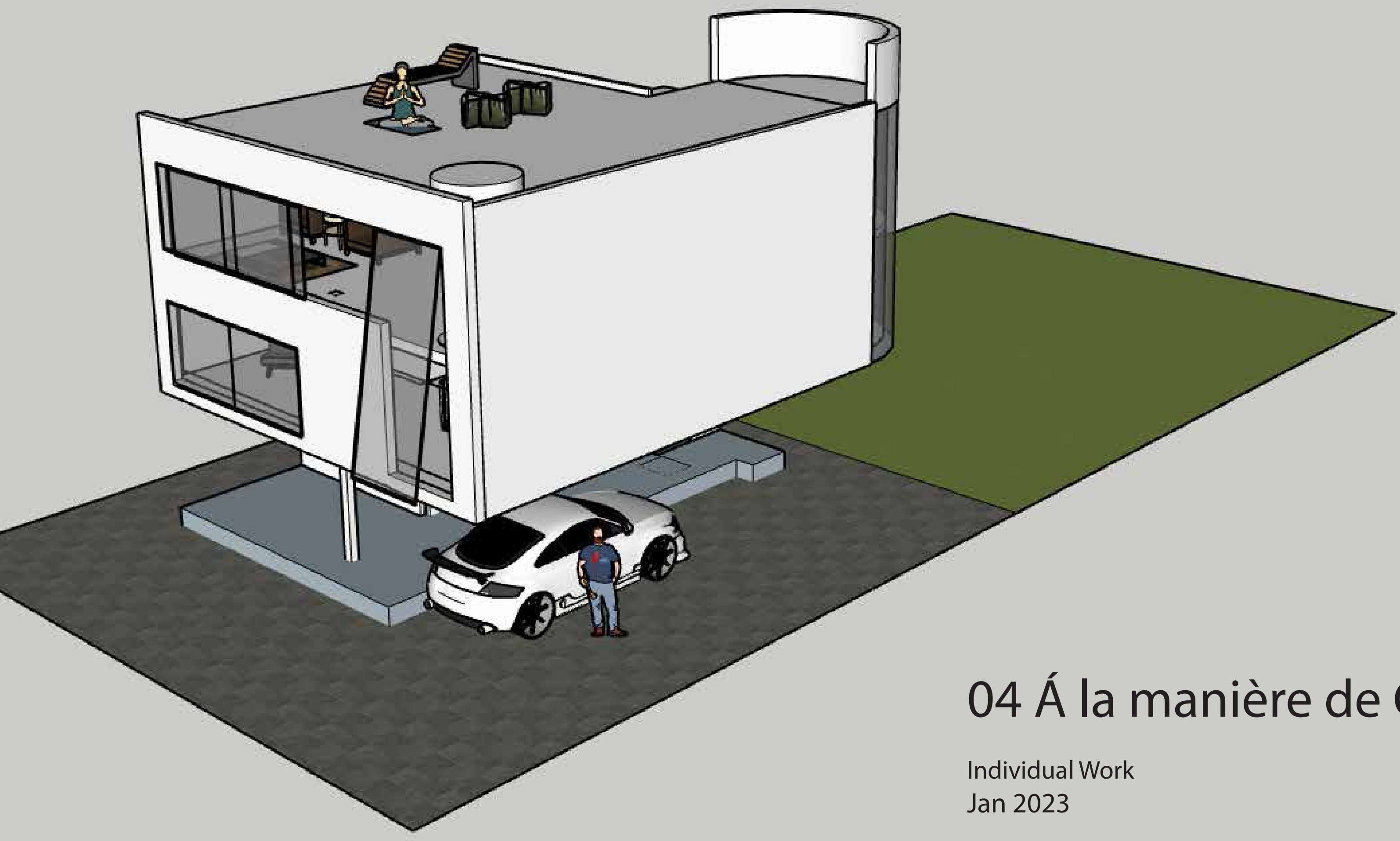
While wind speed performance is a crucial factor when design building mopholo-gy, traditional methods of wind speed estimation is frustratingly slow. In this project, I aim to improve existing machine learning methods on fast wind speed prediciton.

My contribution: Literature Review, ML model building and training.



Situated in a hot and humid island, increasing natural ventilization using architectural design has been a popular research topic in NUS.

As part of the ongoing project, the aim is to use machine learning techniques such as UNet and GANs to speed up the wind speed predition in order to aid the design process.



04 Á la manière de Corbu

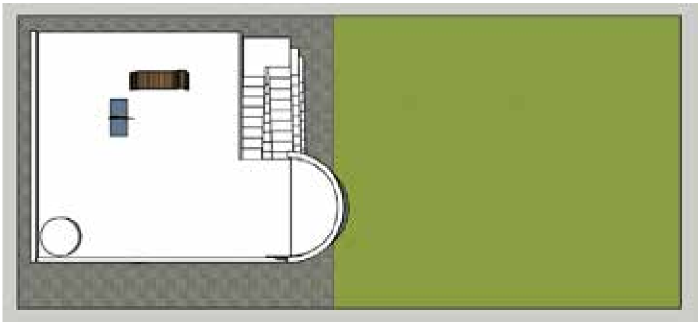
Individual Work
Jan 2023

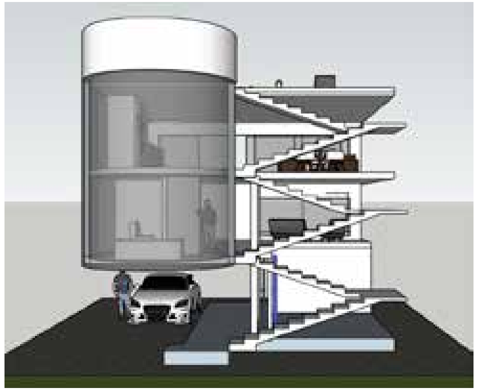
When I was doing the Edx module, the Architecural Imagination, I was tasked to design a small row house resempling the style of Le Corbusier.

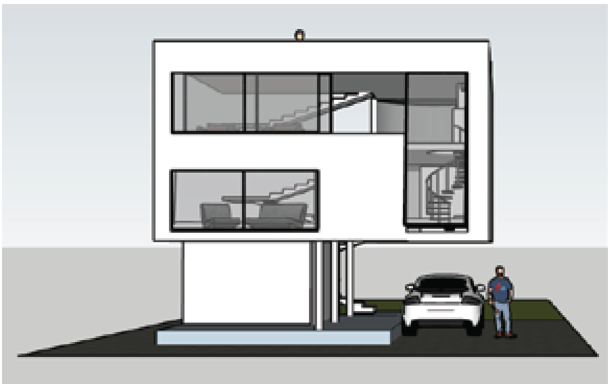
Do-mino, Le Corbusier

In his 1923 work Toward an Architecture, Le Corbusier proposed "the Five Points of the New Architecture" as a universally applicable language of the new architecture. They are:

- the pilotis,
- the roof garden,
- the free plan,
- the ribbon window, and
- the free facade.

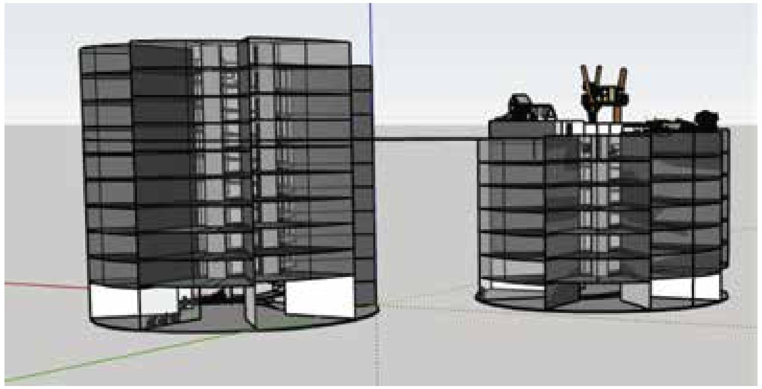


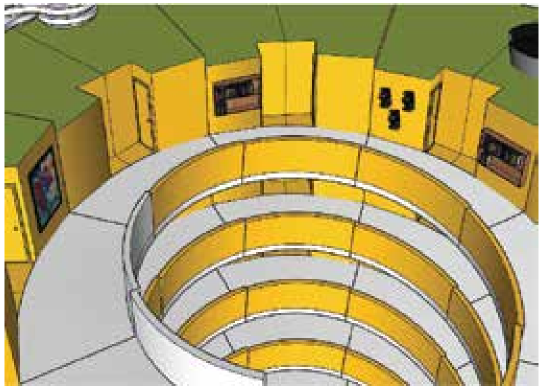


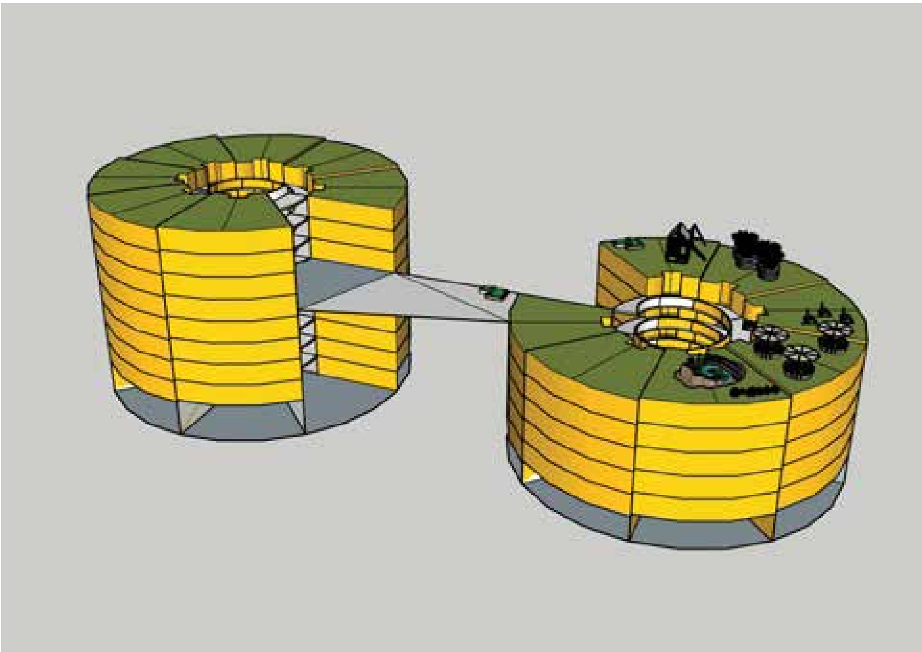


I designed this row house based on the do-mino model and the five points of new architecture. I was also trying to create “the architectural promenade” where the dwellers can experience different sceneries as they explore the space. I created two modes of the circulation. A stairway for more public usage and a spiral staircase which allows the resident to access the living room from the personal bedroom directly.

05 Other Works

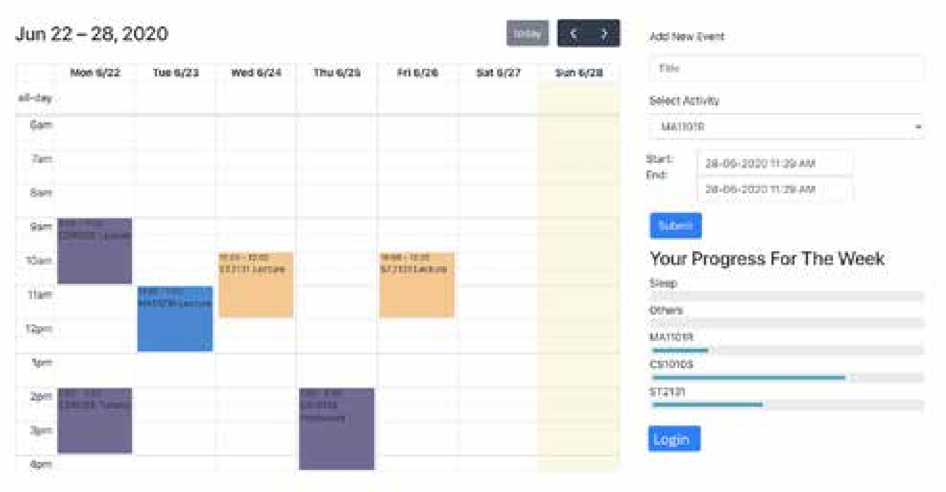






Jan, 2018 China Think Big Competition
Team Project with Wu Weiying, Zhang Huiwen, Long Zeling

CTB is an comeptition what encourage students to explore social issues. During this competition, we focused one common sentiments shared by youths living in big cities - loneliness. I created this design of a communal living space for the youth in the hope that with more public spaces - roof garden, void deck and a long shared circular ramp - there would be more interaction among the residents.

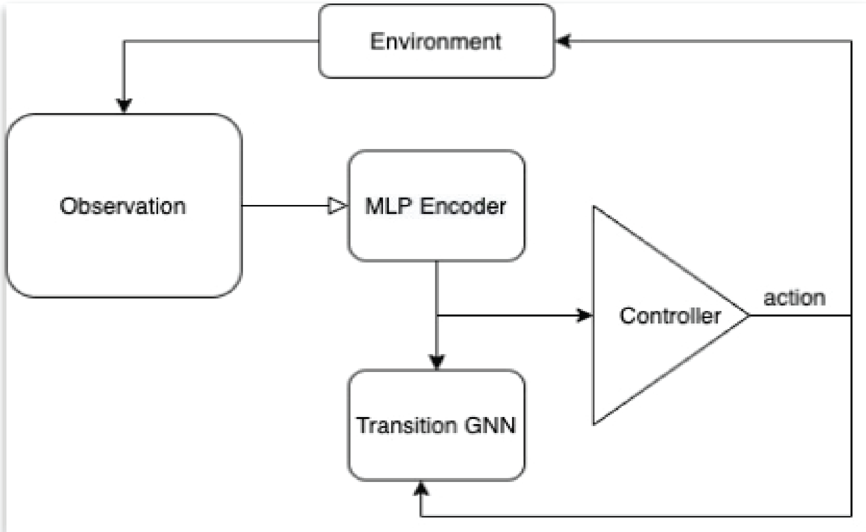


Web App Design - A time manegement app for Uni students

May - Aug, 2020
Team Project with Zou Runzhong

I coded this web app using React JS and rails. It is an website that monitor and tracks the time the users spent on various activities and the assignment deadlines.

My conrtribution is the software engineering and the UI/UX design.



SMAWM - Structured Multi-Agent World Models

Aug- Dec, 2021
Team Project with Jet New

As part of the module AI Planning and Decision Making, my team created this project where we proposed SMAWM for reinforcement learning, By encompassing other agents in a compositional structure, SMAWM better models each individual agent's properties, interactions and relationships between agents, and Interactions between agents and the environment.

Contribution: Literature review and experiment environment set up