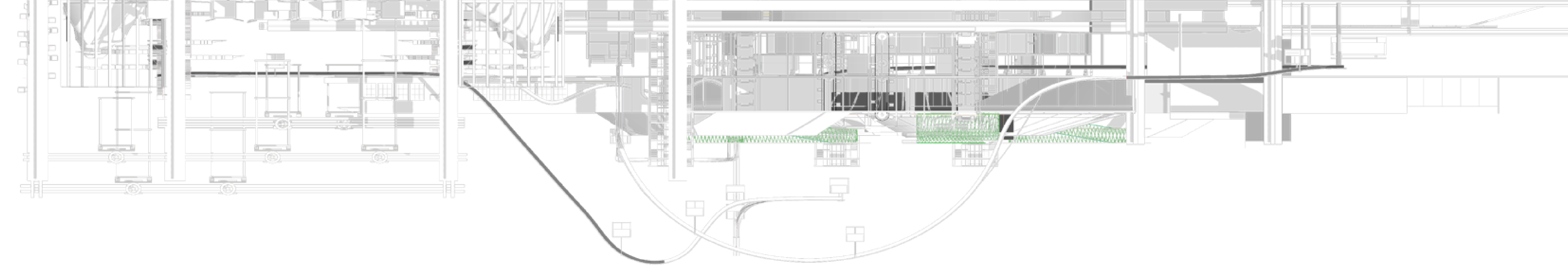
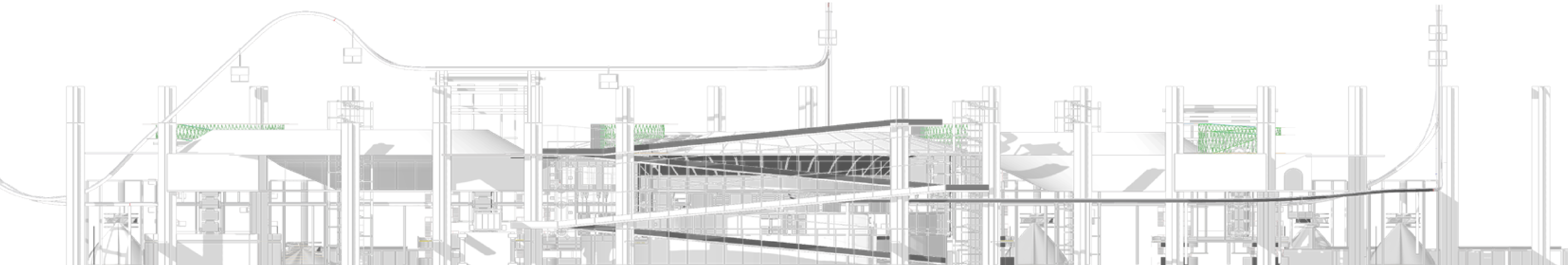


SOO HWA CHLOE HONG

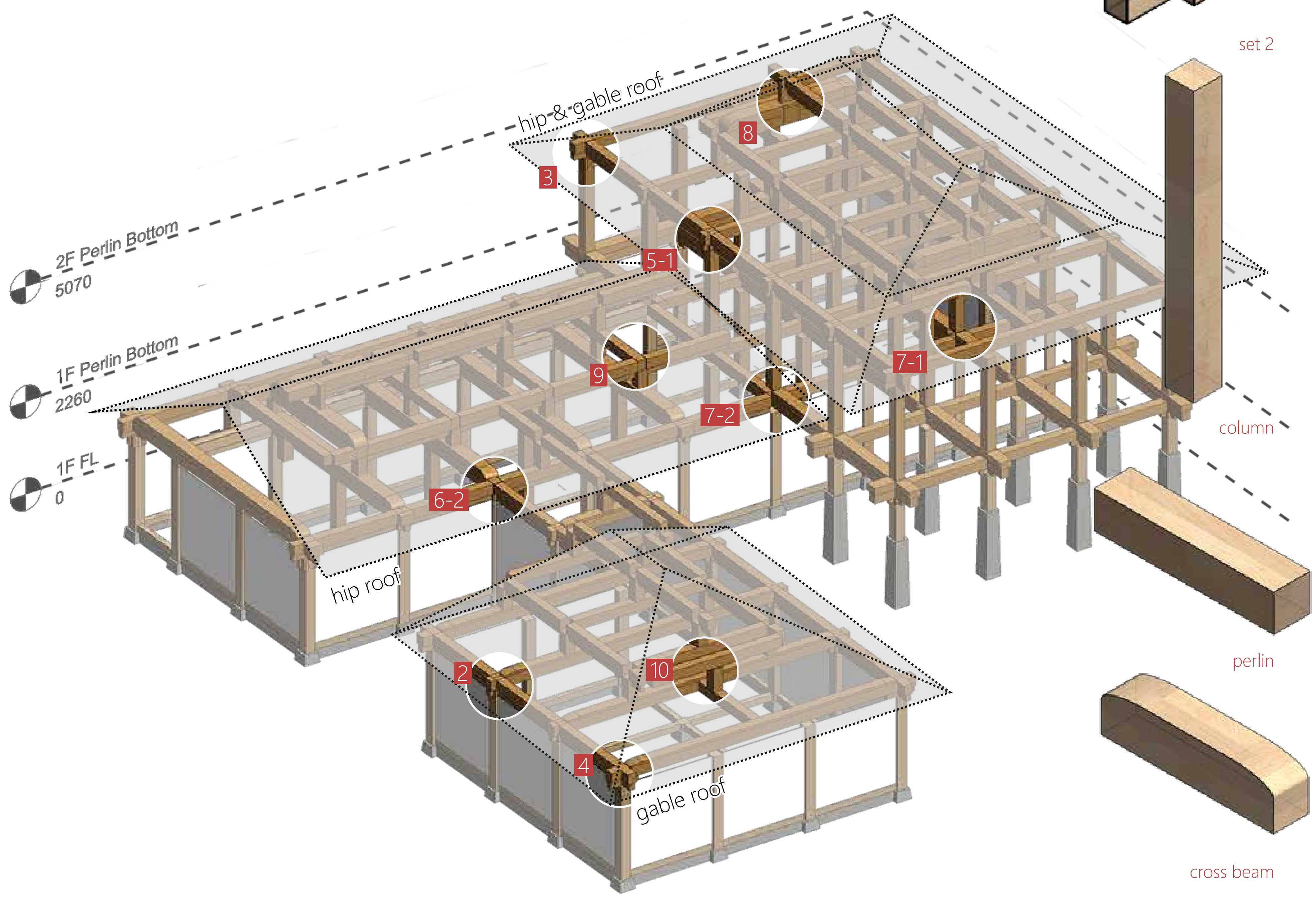
SELECTED WORKS - 2020

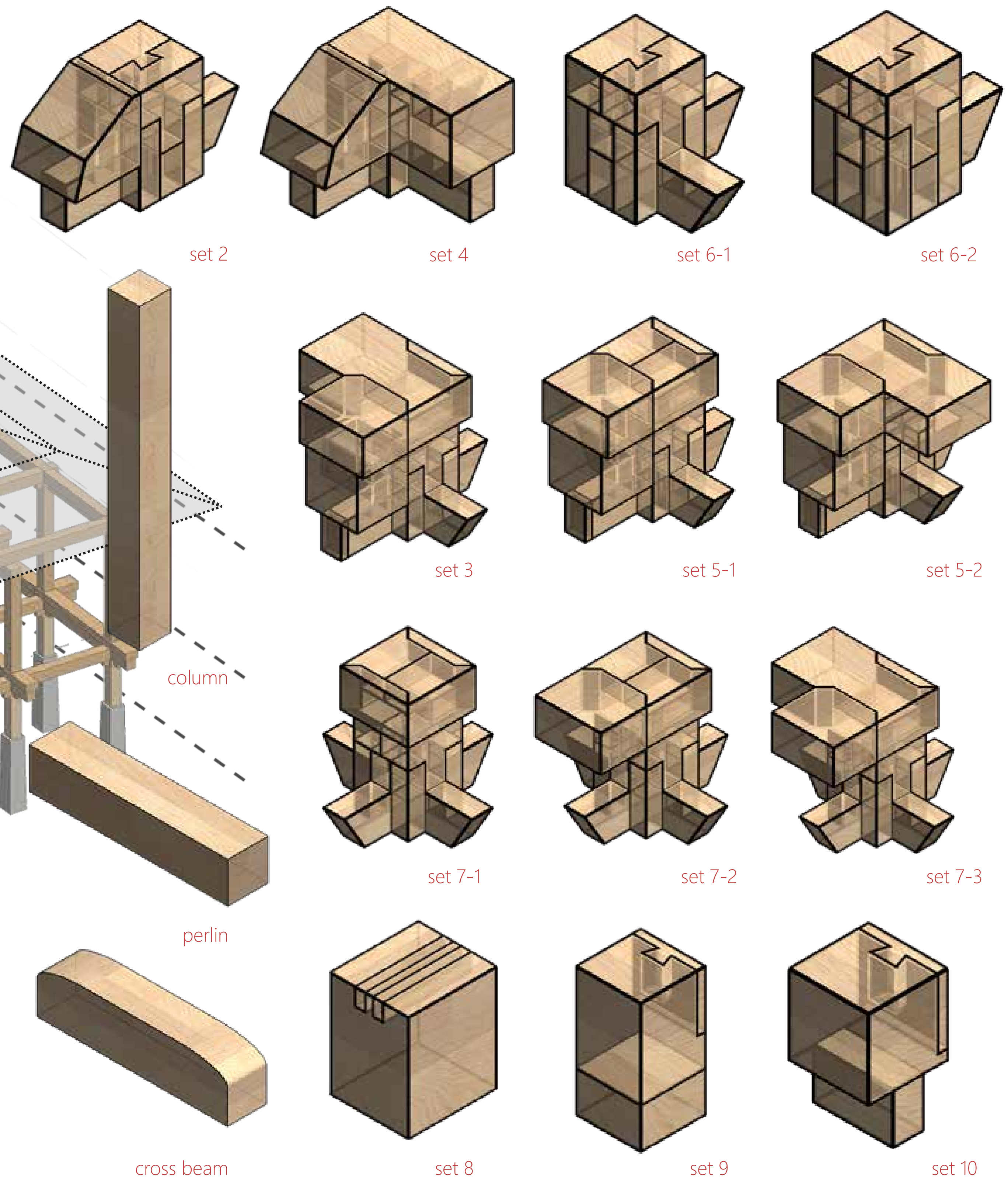


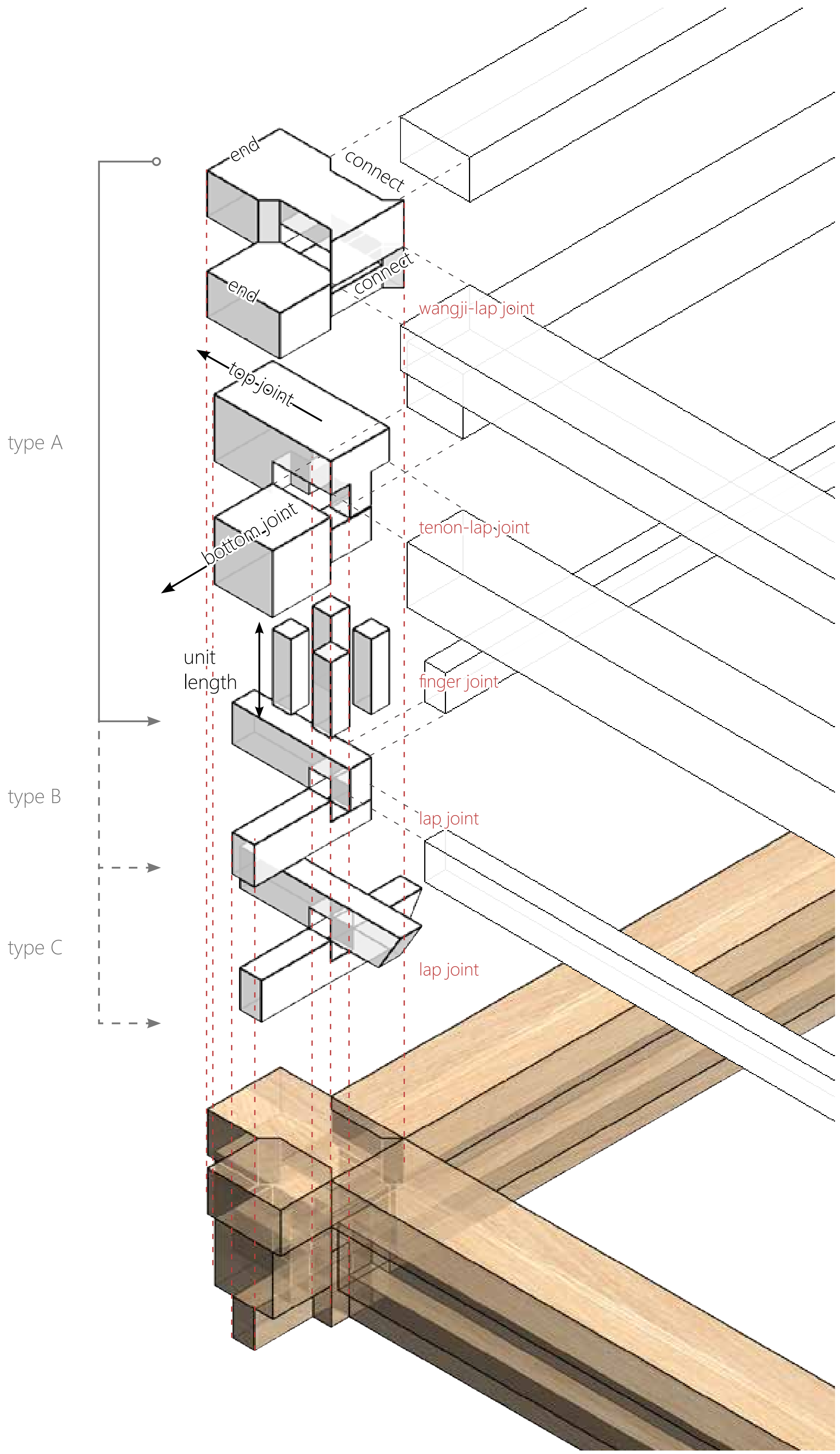
HANOK BIM LIBRARY

YEAR : 2020
TYPE : Professional
ADVISOR: Prof. Jeon, BongHee
(Architecture)
CREDITS : SNU Architectural History Lab
ROLE : program structuring and development

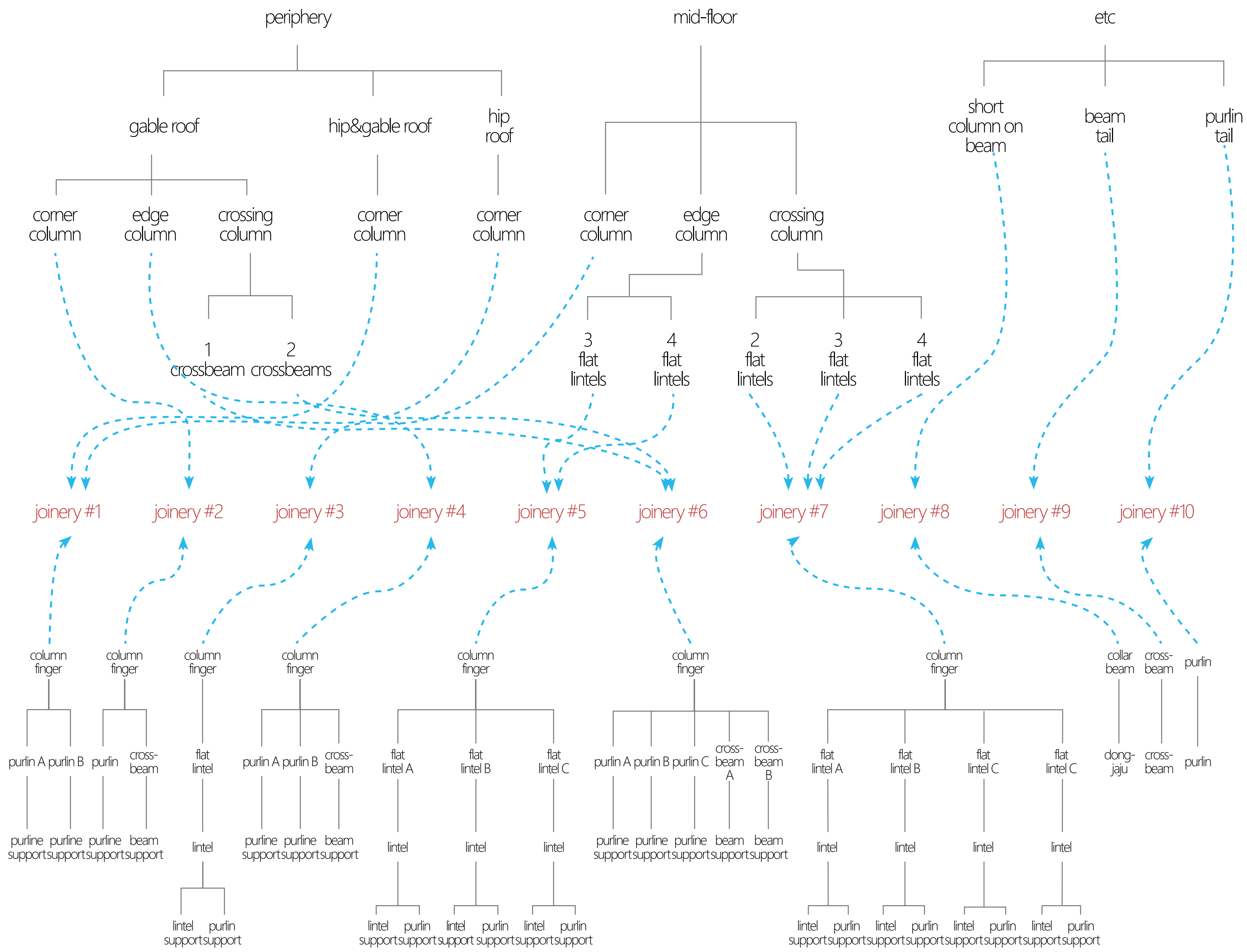
Hanok - the traditional residential typology of Korea, involves a comprehensive use of material, geometry, and carpentry. The interrelated composition of the Hanok is an elegant solution to the considerations of livability, structure, aesthetic, and traditional building codes.
In this project with SNU's Architectural History Lab, I develop a Revit BIM library for the Hanok design and building phase. The primary goal was to build a simple, user friendly system that is also comprehensive of the various components and complex composition of the Hanok. The essential task was to develop a parametric design tool that caters the interlocking of Hanok's structural components within various joineries. Analyzing historical documentations, I extracted a comprehensive alphabet of joineries and reconfigured the Revit program in an unconventional way that would allow the assembly of a Hanok with a simple parametric control interface.



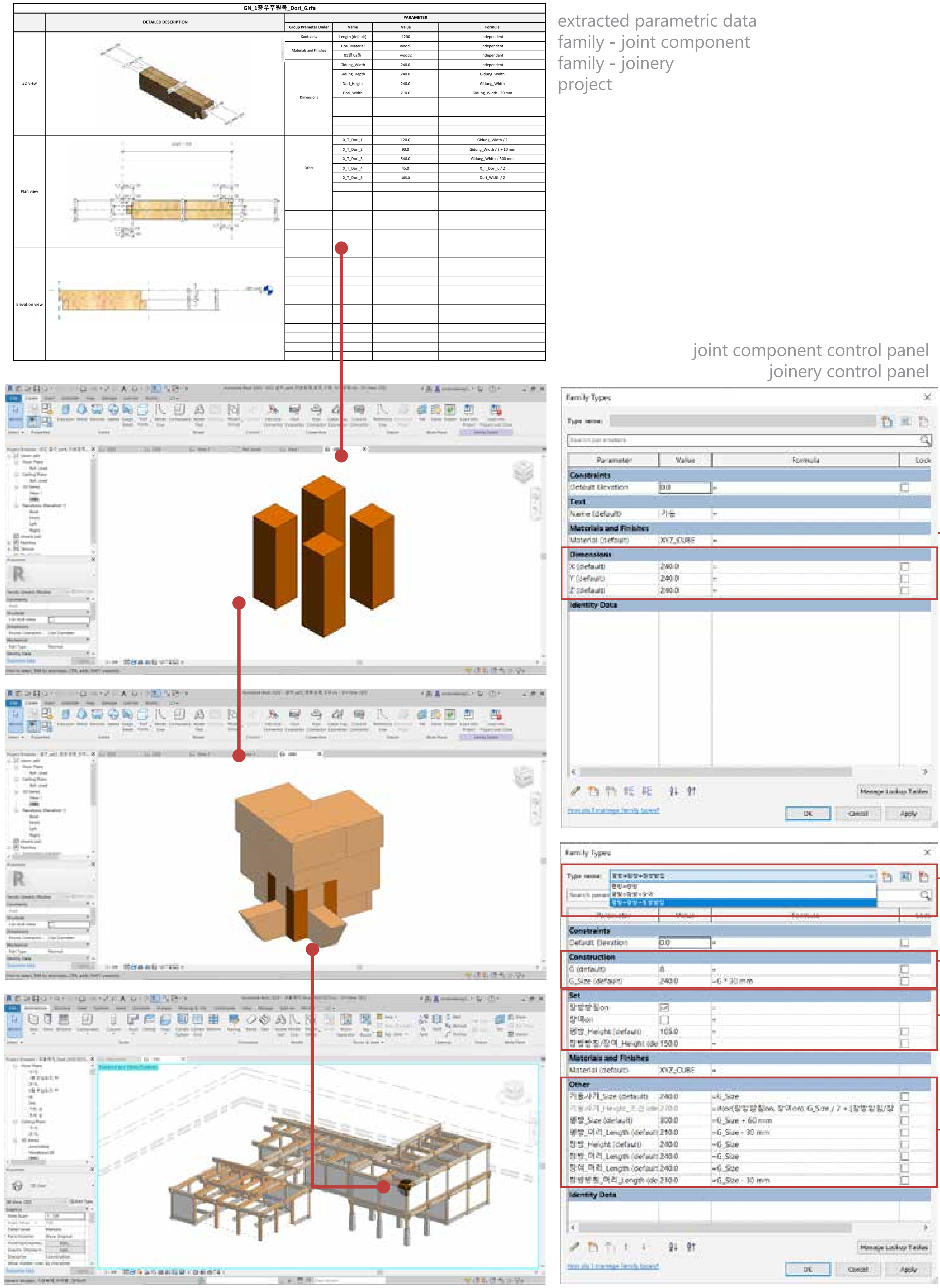


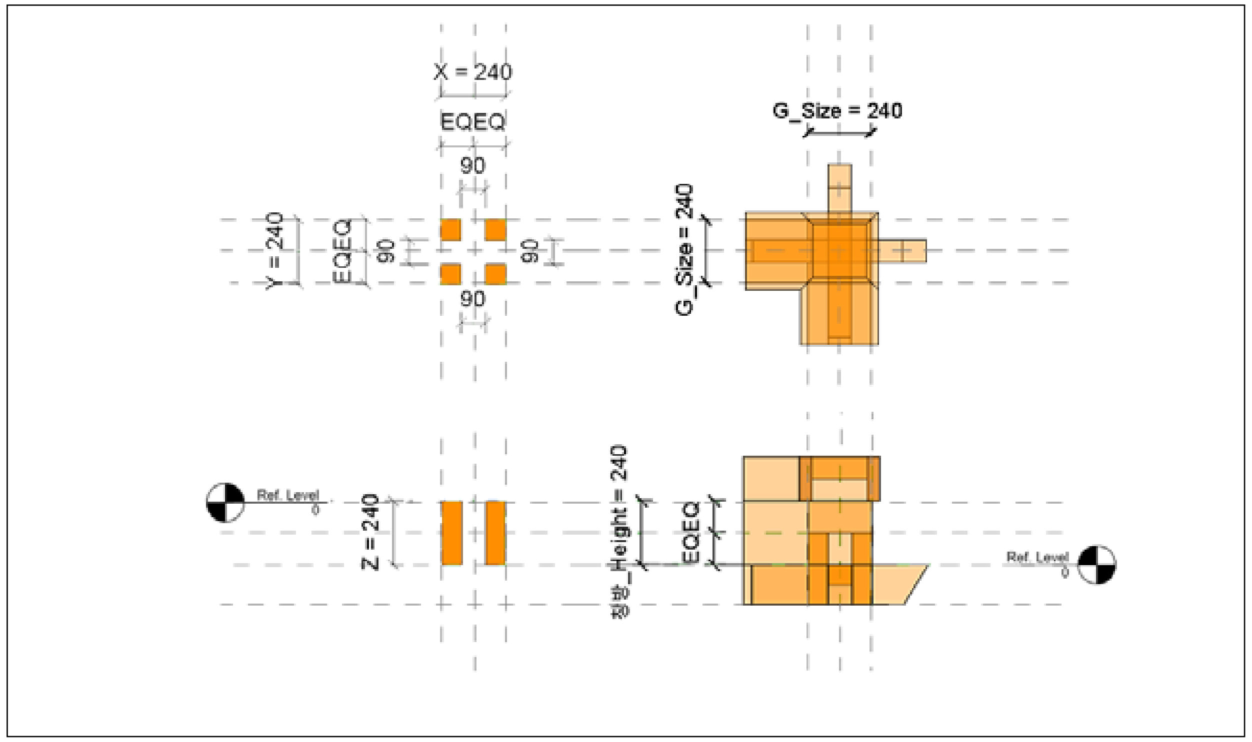


Interlocking of components in joinery set 3



Hanok componant & program structure





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평방+창방+장여
평방+창방+창방받침

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창방받침_머리_Length (de	210.0	=G_Size - 30 mm	☐

Family - Family - Project shell structure

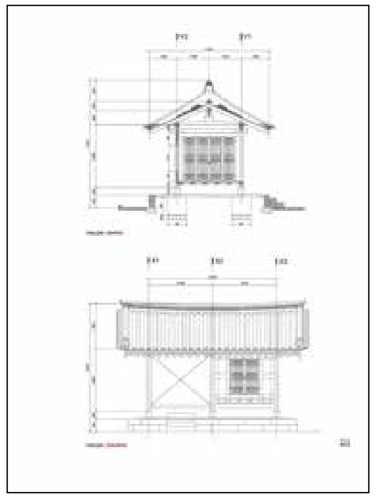
Interface

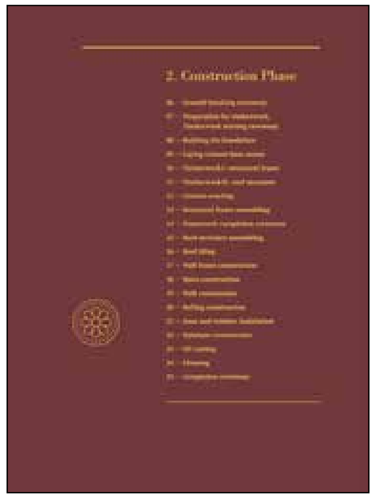
BUILDING HANOK

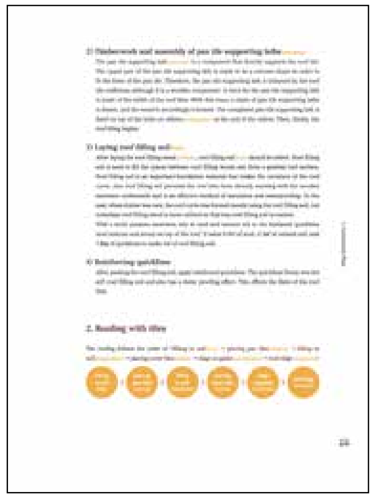
YEAR : 2016
TYPE : Professional
ADVISOR : Prof. Jeon, BongHee
(Architecture)
CREDITS : SNU Architectural History Lab
ROLE : text translation, building glossary

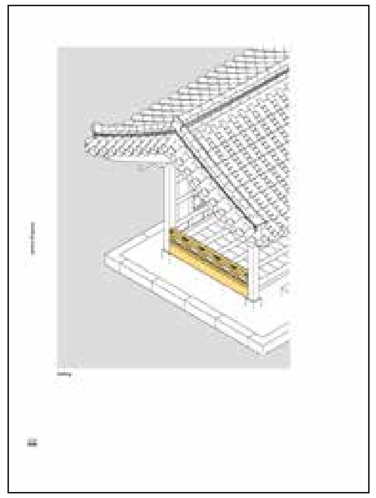
The demand for building Hanok - the traditional residential typology of Korea - has called for the documentation of a standardized Hanok construction procedure. We write an English Hanok building guideline while establishing a glossary of Hanok components and terms in the building process which involves cultural and historical aspects. The distinctive features of Korea's wooden structures require new vocabulary beyond the current English nomenclature which pertains to contemporary industrial wooden structures. The 200 page manuscript includes detailed descriptions partnered with illustrations to help understand the intricate building process of the Hanok.

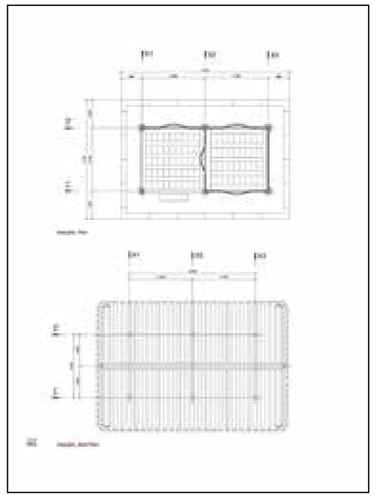
published work: *Bong Hee Jeon et al., Building Hanok Components & Techniques, Architecture & Urban Research Institute, 2017*

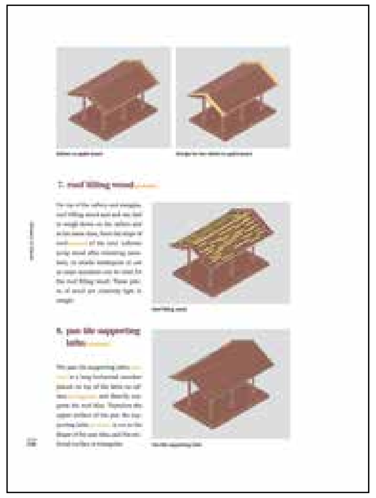


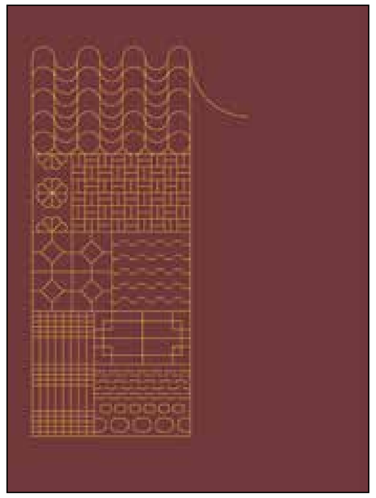


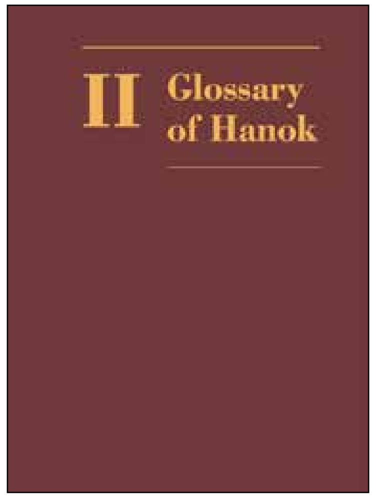


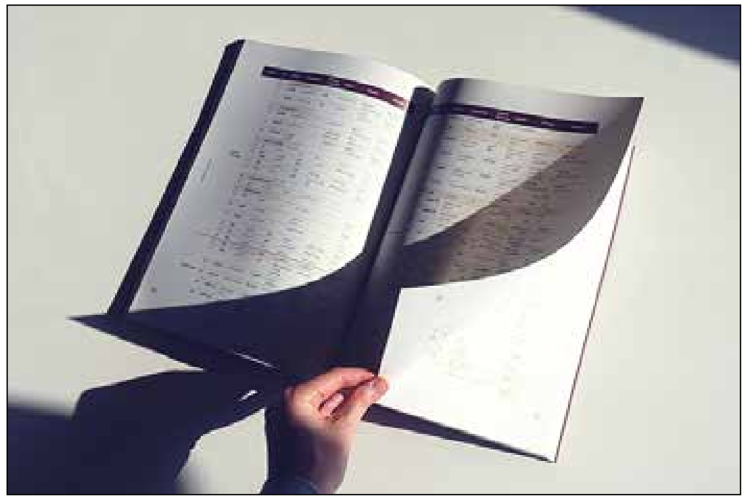


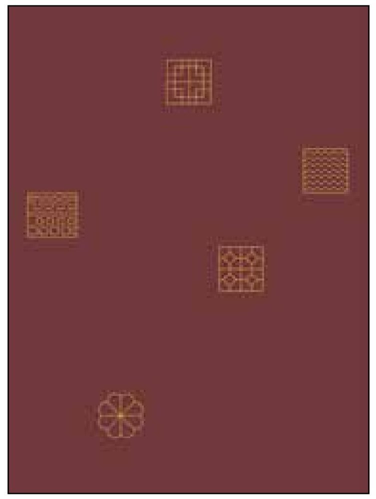








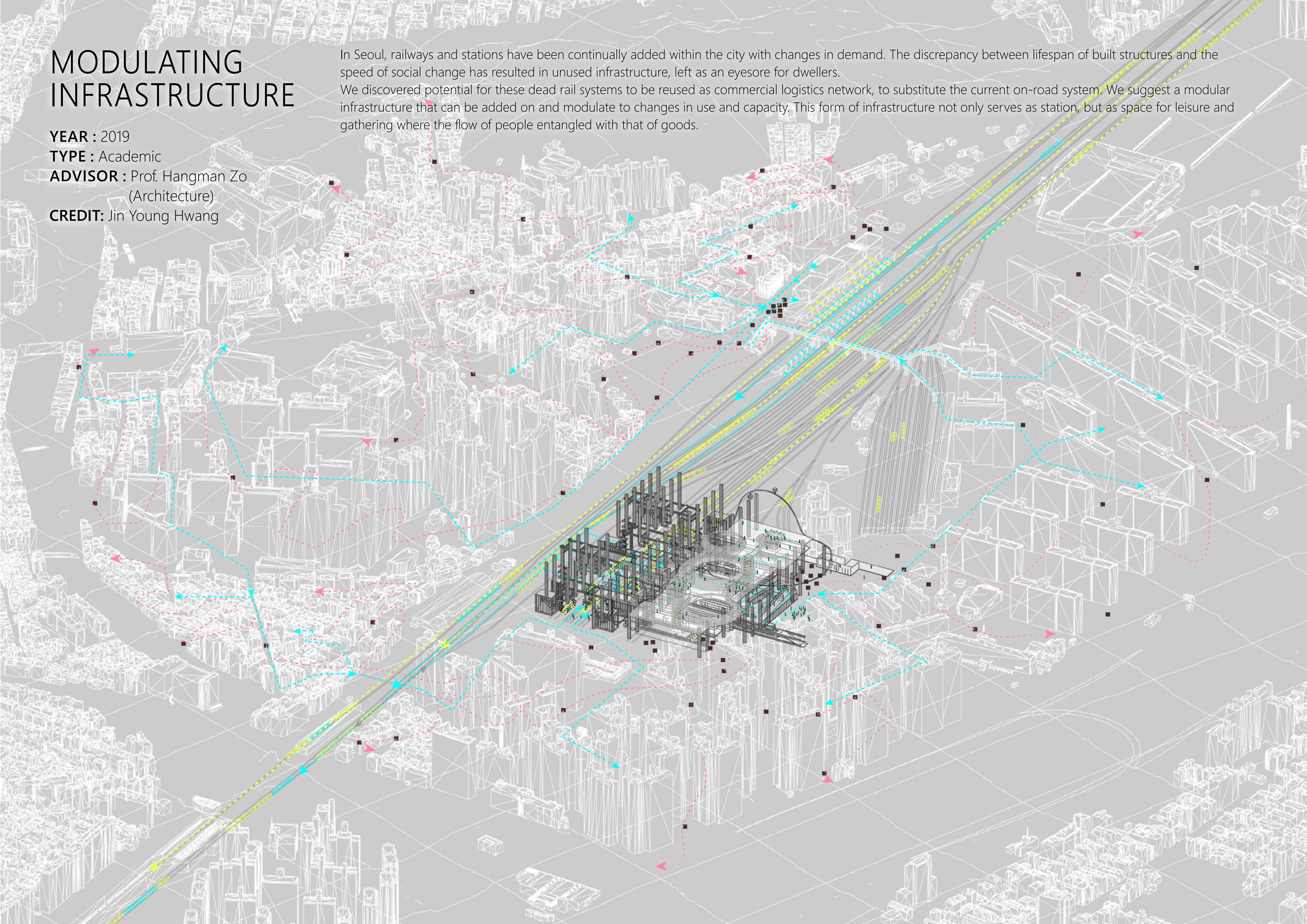


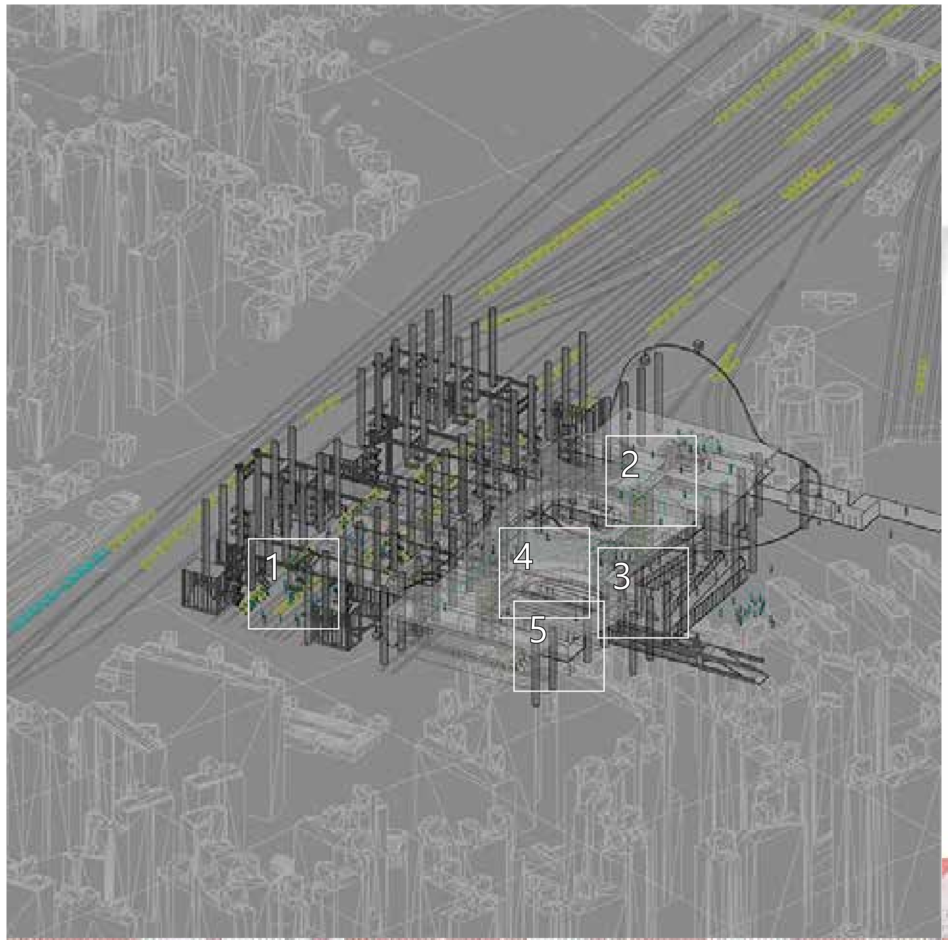


MODULATING INFRASTRUCTURE

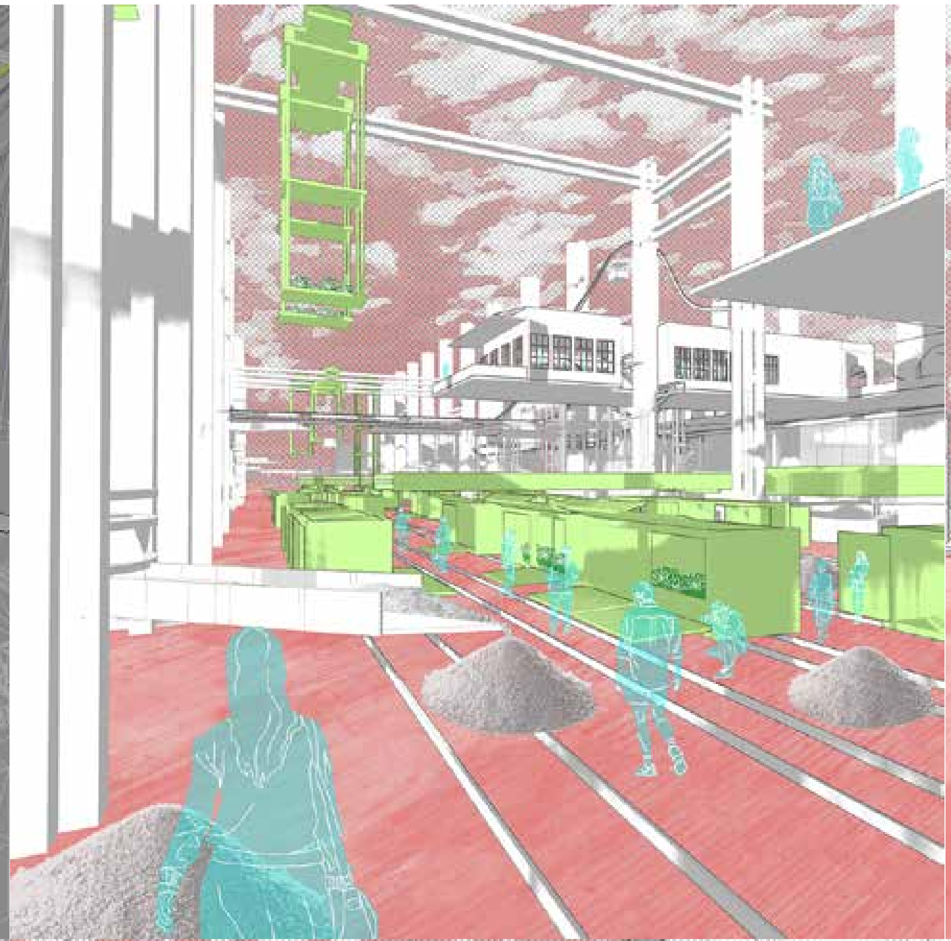
YEAR : 2019
TYPE : Academic
ADVISOR : Prof. Hangman Zo
(Architecture)
CREDIT: Jin Young Hwang

In Seoul, railways and stations have been continually added within the city with changes in demand. The discrepancy between lifespan of built structures and the speed of social change has resulted in unused infrastructure, left as an eyesore for dwellers.
We discovered potential for these dead rail systems to be reused as commercial logistics network, to substitute the current on-road system. We suggest a modular infrastructure that can be added on and modulate to changes in use and capacity. This form of infrastructure not only serves as station, but as space for leisure and gathering where the flow of people entangled with that of goods.

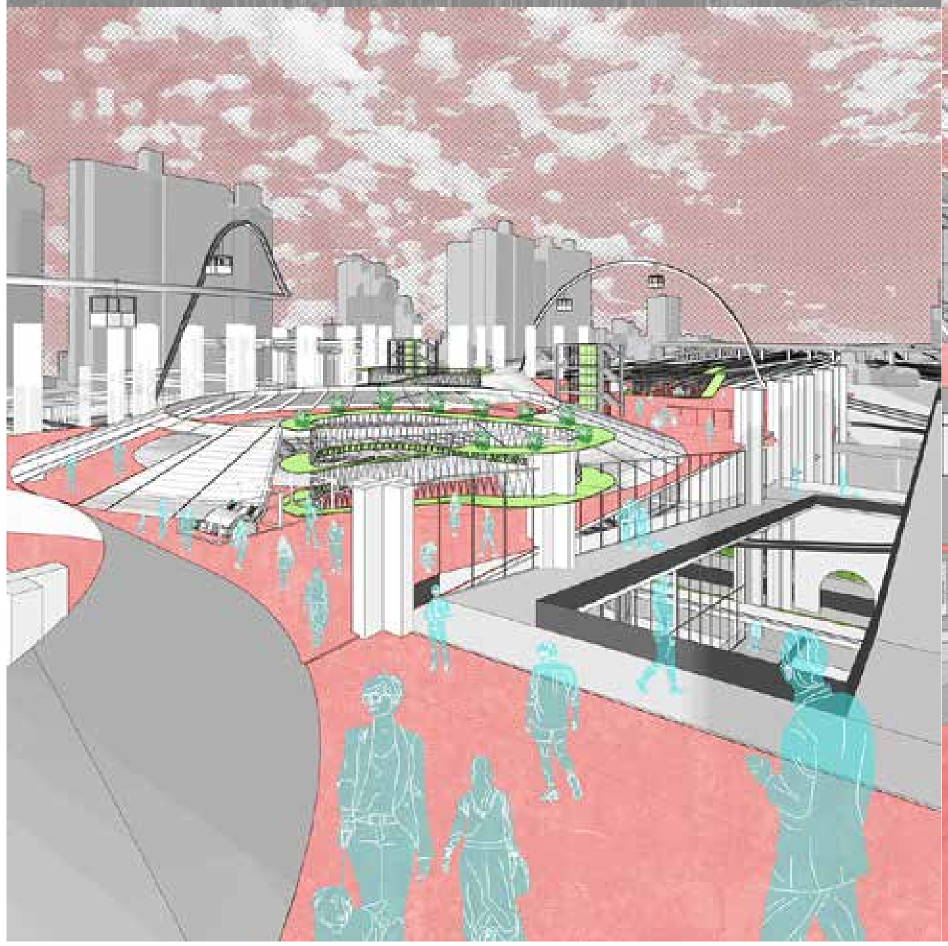




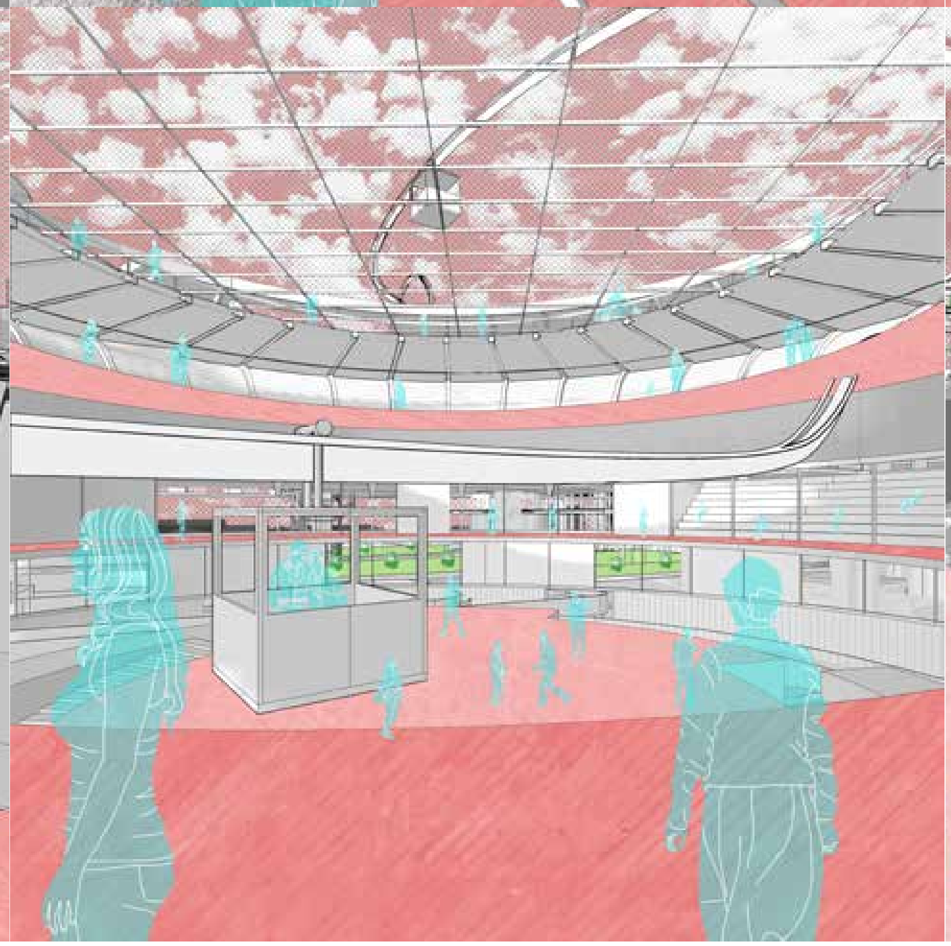
market in lifting area



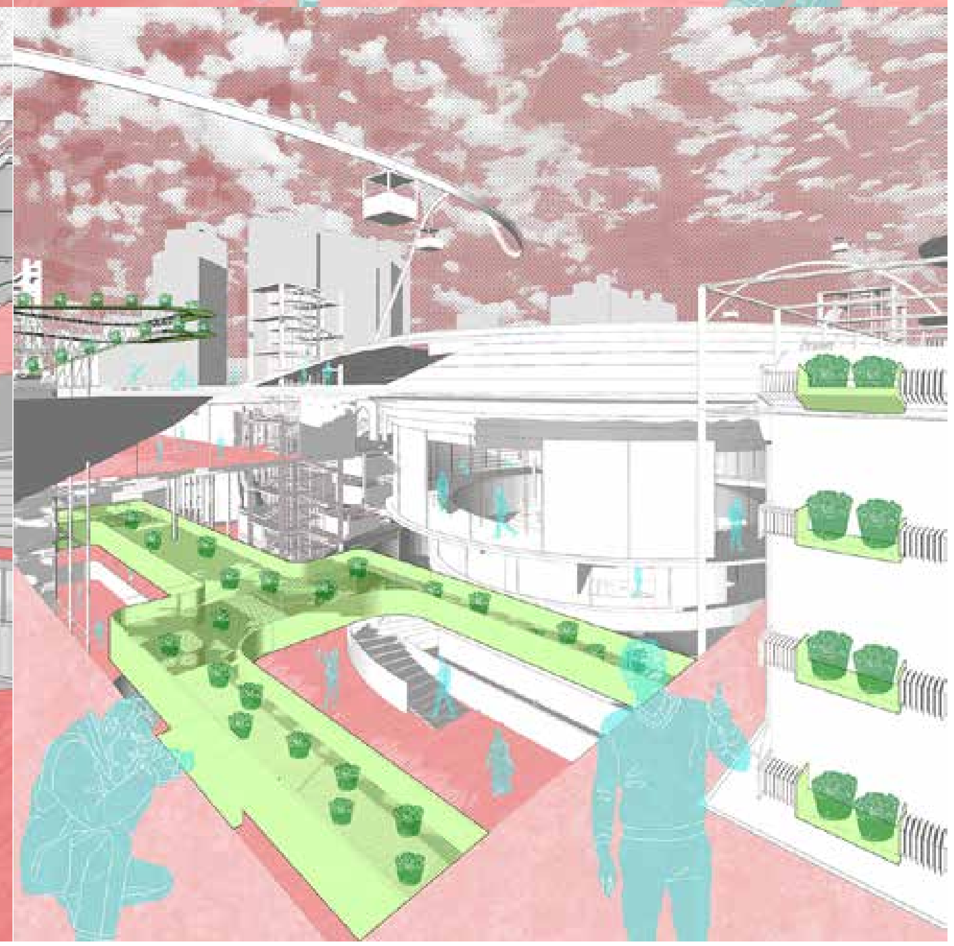
skate park + outdoor showroom on complex roof



pedestrial entry to complex roof

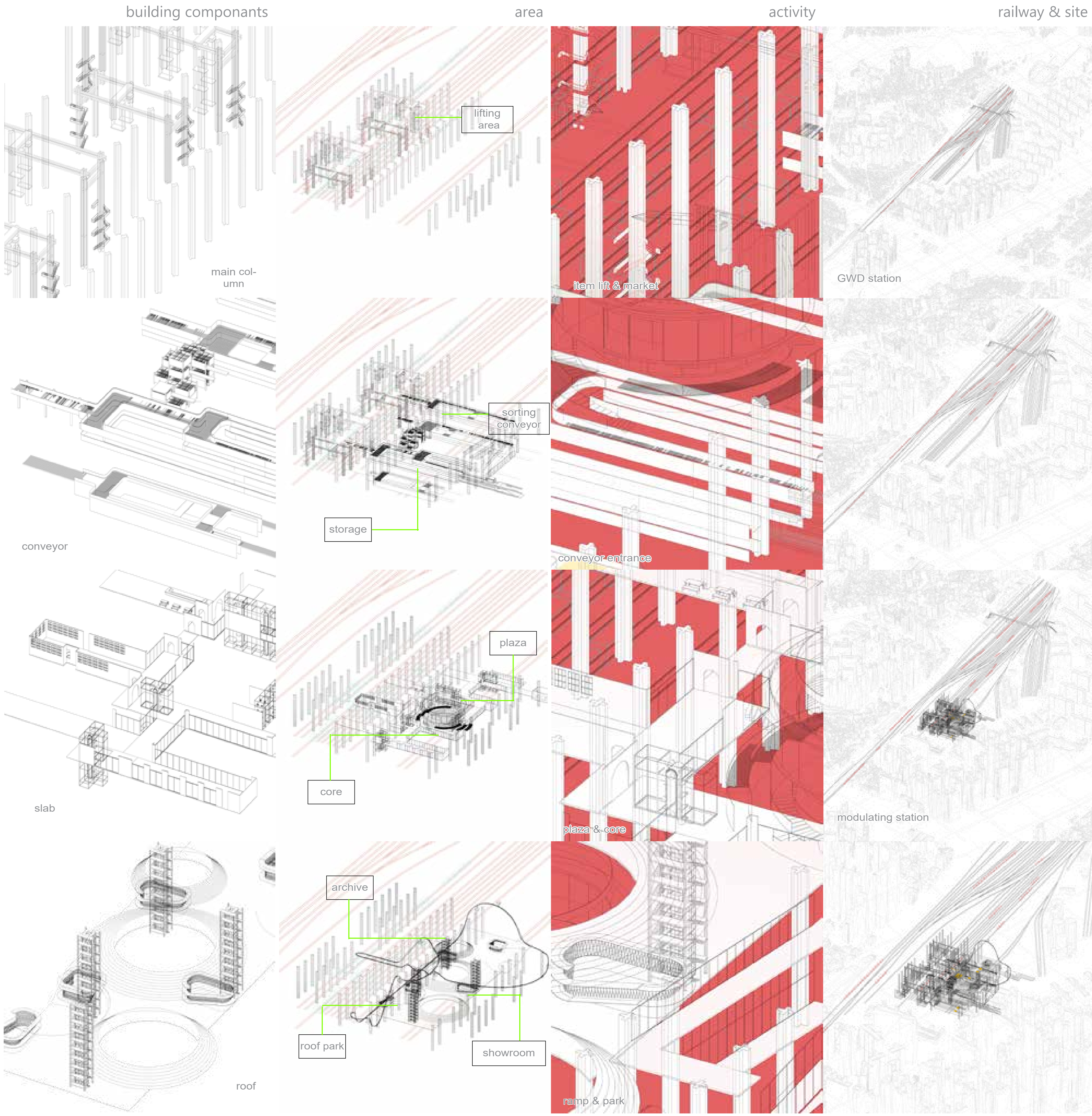


complex core attrium



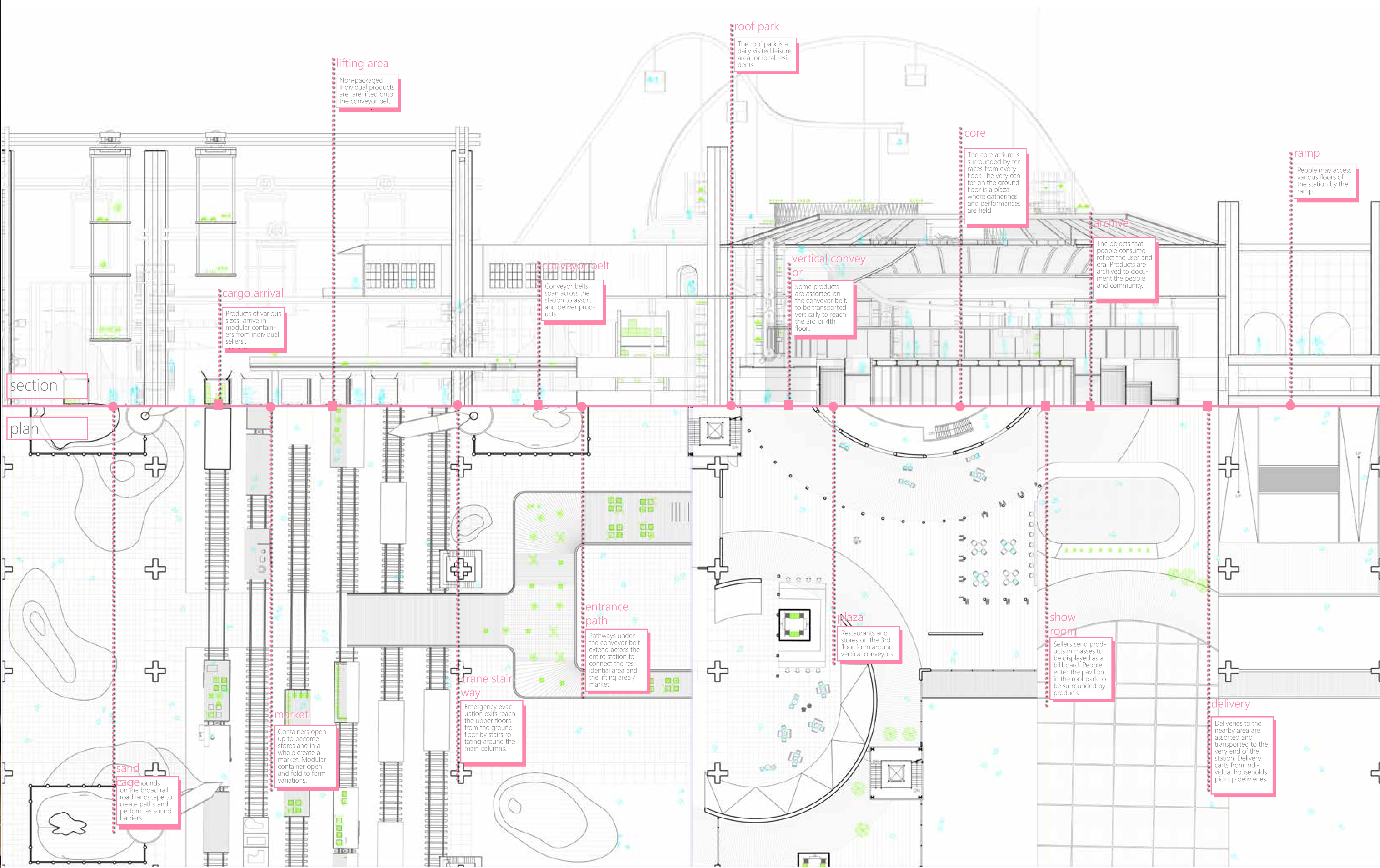
looking down from complex 2nd floor mall

Scenario



Composition

Mapping of site installation



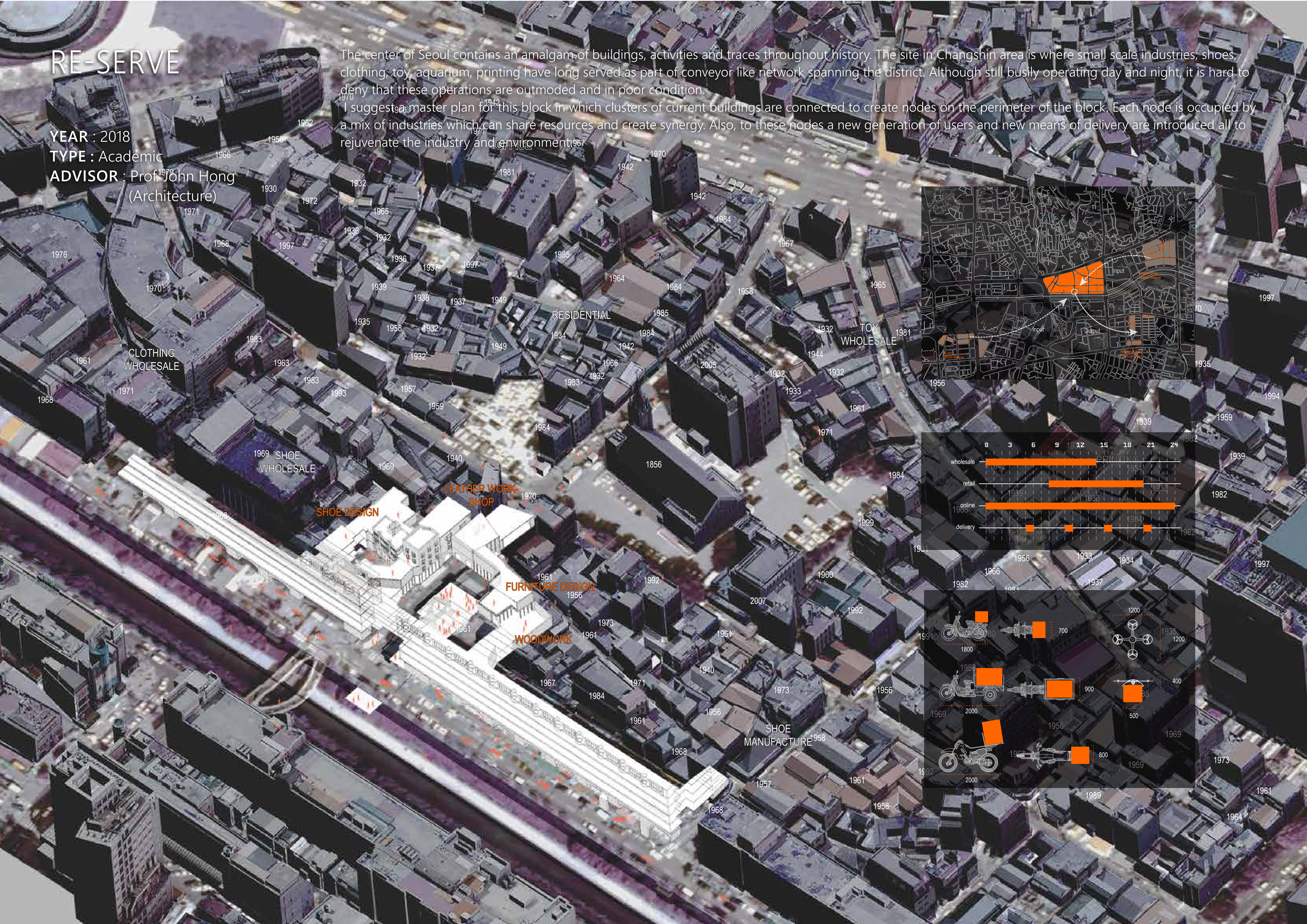
Flow of commodities and people

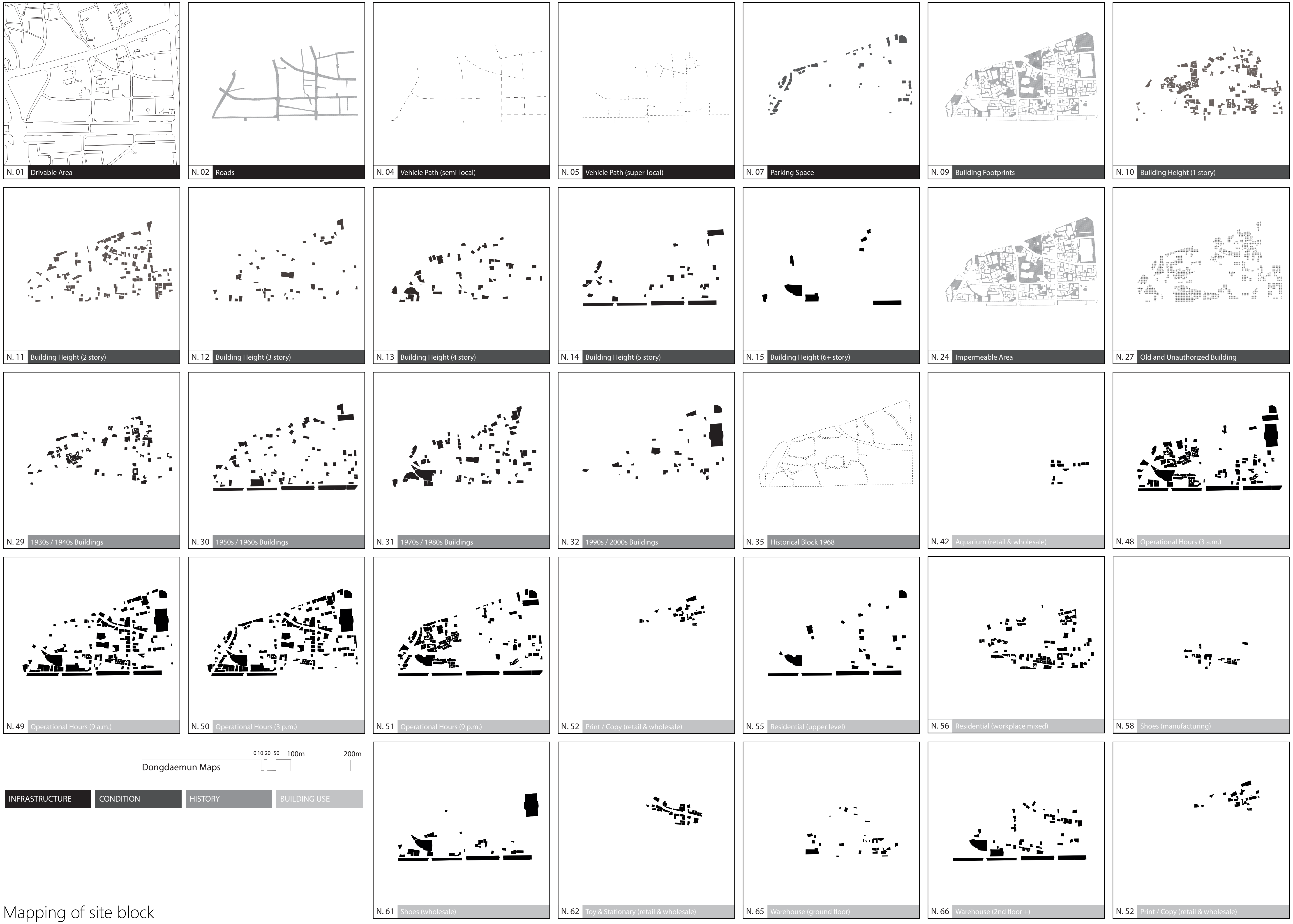
RE-SERVE

YEAR : 2018
TYPE : Academic
ADVISOR : Prof. John Hong (Architecture)

The center of Seoul contains an amalgam of buildings, activities and traces throughout history. The site in Changshin area is where small scale industries; shoes, clothing, toy, aquarium, printing have long served as part of conveyor like network spanning the district. Although still busily operating day and night, it is hard to deny that these operations are outmoded and in poor condition.

I suggest a master plan for this block in which clusters of current buildings are connected to create nodes on the perimeter of the block. Each node is occupied by a mix of industries which can share resources and create synergy. Also, to these nodes a new generation of users and new means of delivery are introduced all to rejuvenate the industry and environment.





Mapping of site block

e-commerce & delivery

buildings adequate for drone acceptance

existing multiple story warehouse

walkable loops

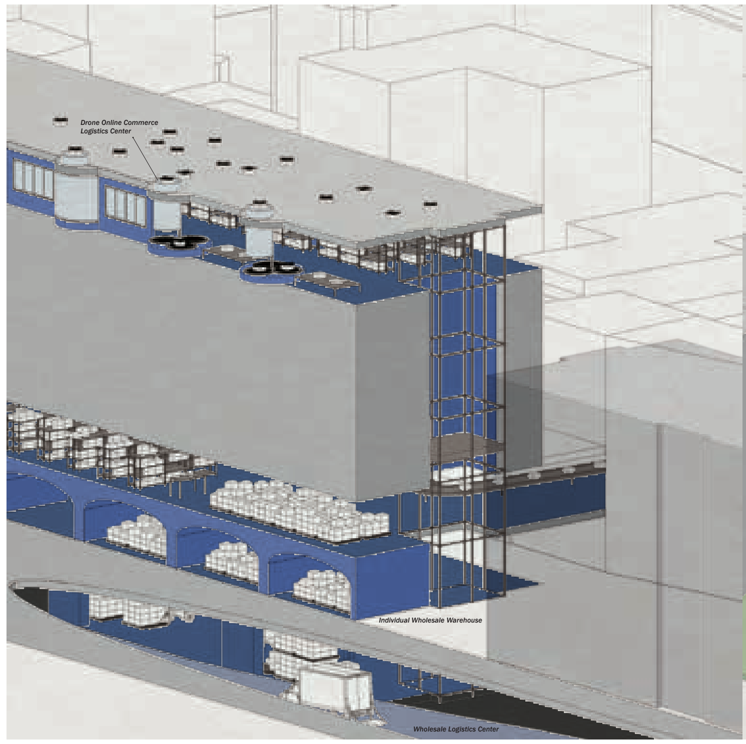
roads accessible by pedestrians & handcarts
industry clusters
warehouses
local paths

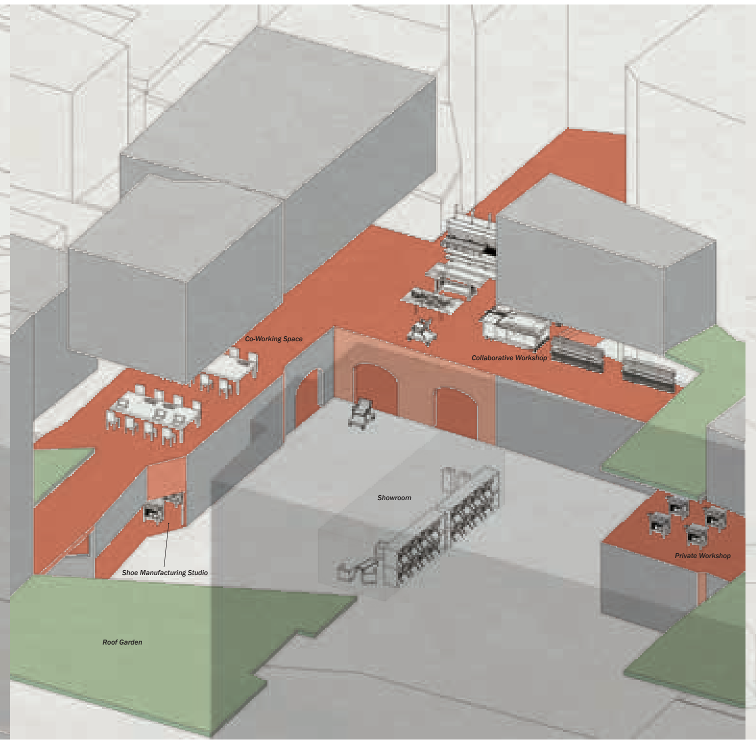
part-time residentials

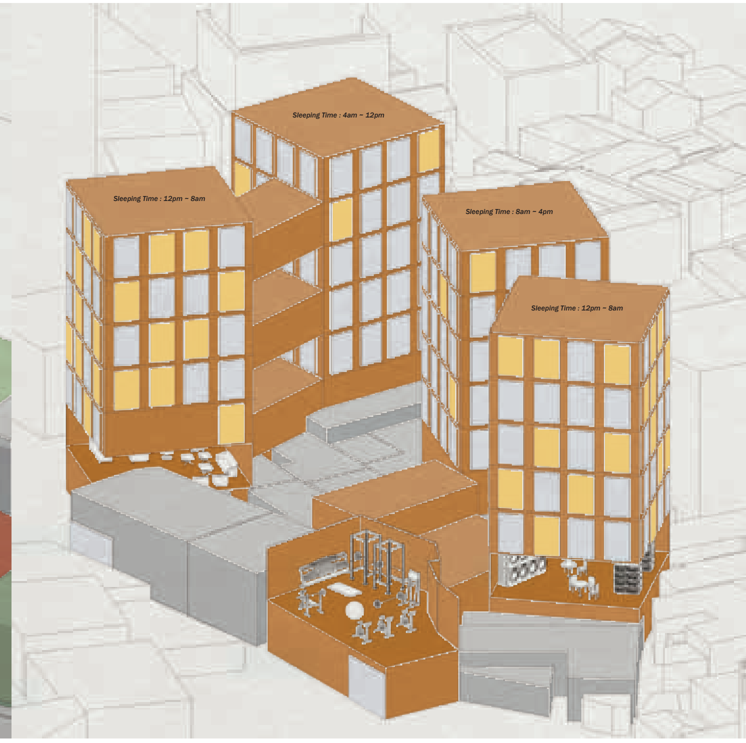
mixed use of industries & residential
residential use only
church

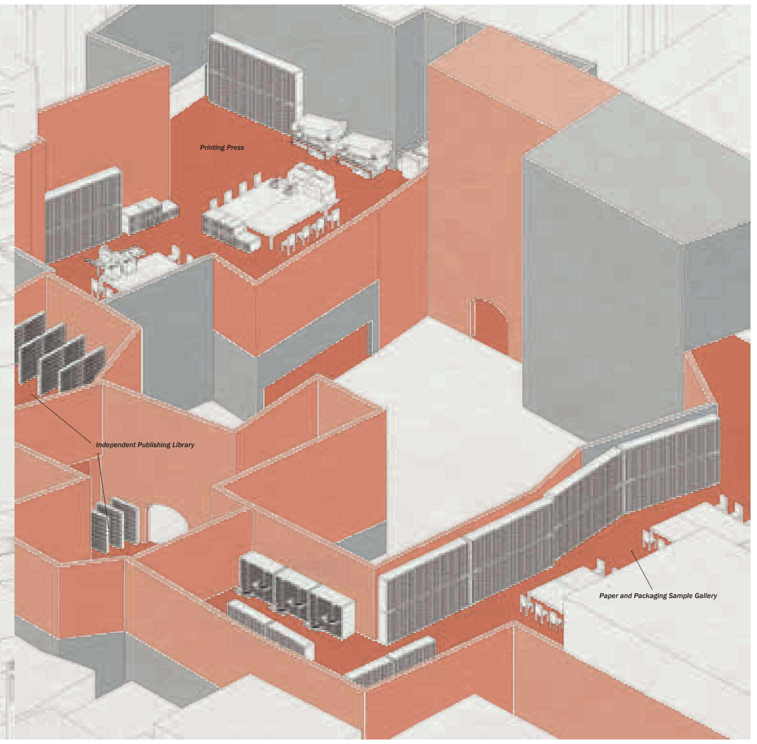
industrial nodes

old unauthorized buildings that need renovation
mixed use of industries & residential
vehicle accessible roads

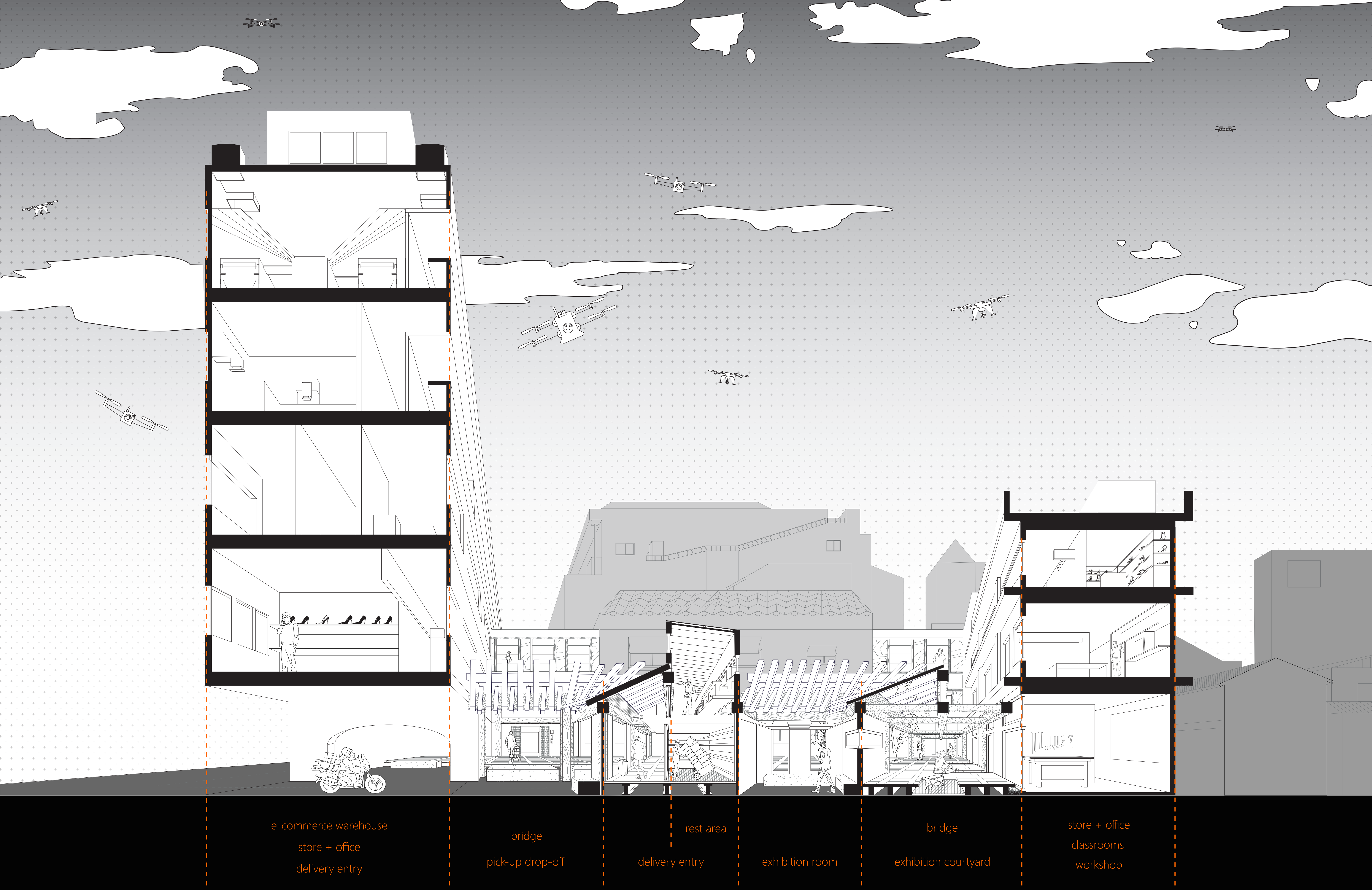








Palimpsest of maps translated to master plan

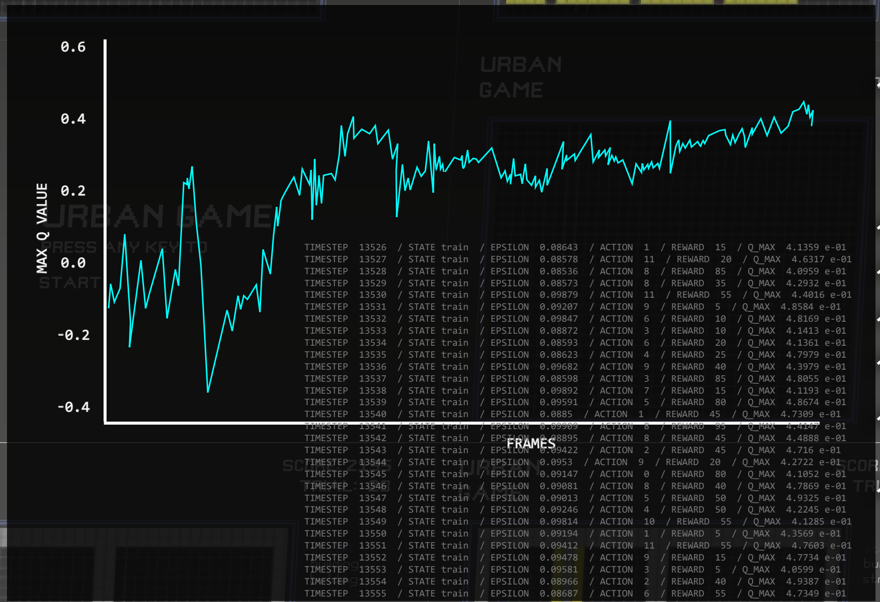


Node : shoes + furniture

URBAN GAME

YEAR : 2020
TYPE : Independent
(work in process)

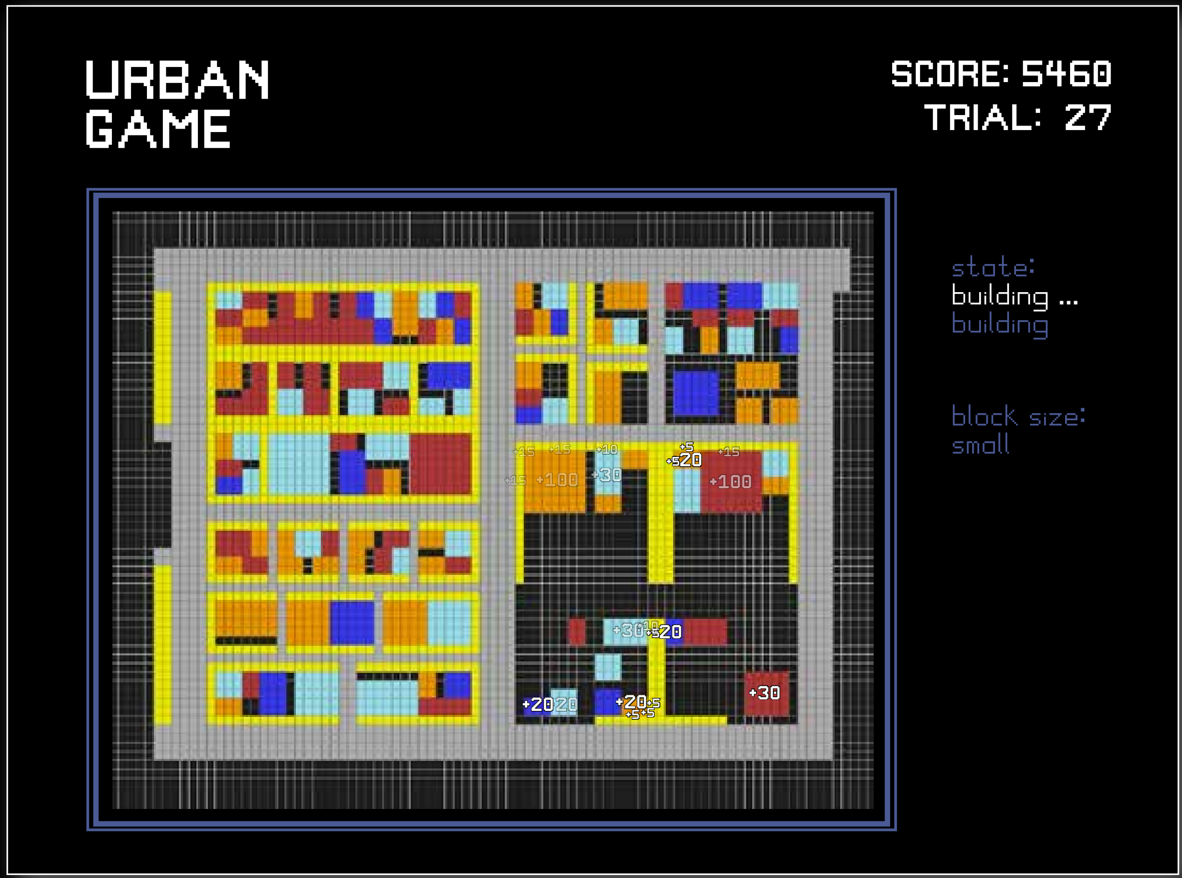
The common city block is composed of multitudinous entities entering and exiting, building and abolishing, forming clusters and competing. However, the uncontrolled ensemble they unconscious form act as the urban landscape and the environment for dwellers. With a grid based game I attempt to simulate the haphazard building activities of entities within an urban block setting and evaluate the resulting urban quality. I apply a reinforcement learning model that develops optimal control patterns for this game thus incorporating individual strategic behavior and at the same time find balance with the overall environment.
Experimenting with the game settings and game output, I seek to gain insight for the following questions:
1. How will enterprises act on the basis of individual advantage?
2. What policies can encourage or curb certain results?
3. How can urban quality measured quantitatively?
4. Does this combination of incentives and penalties result in a constant block plan type?

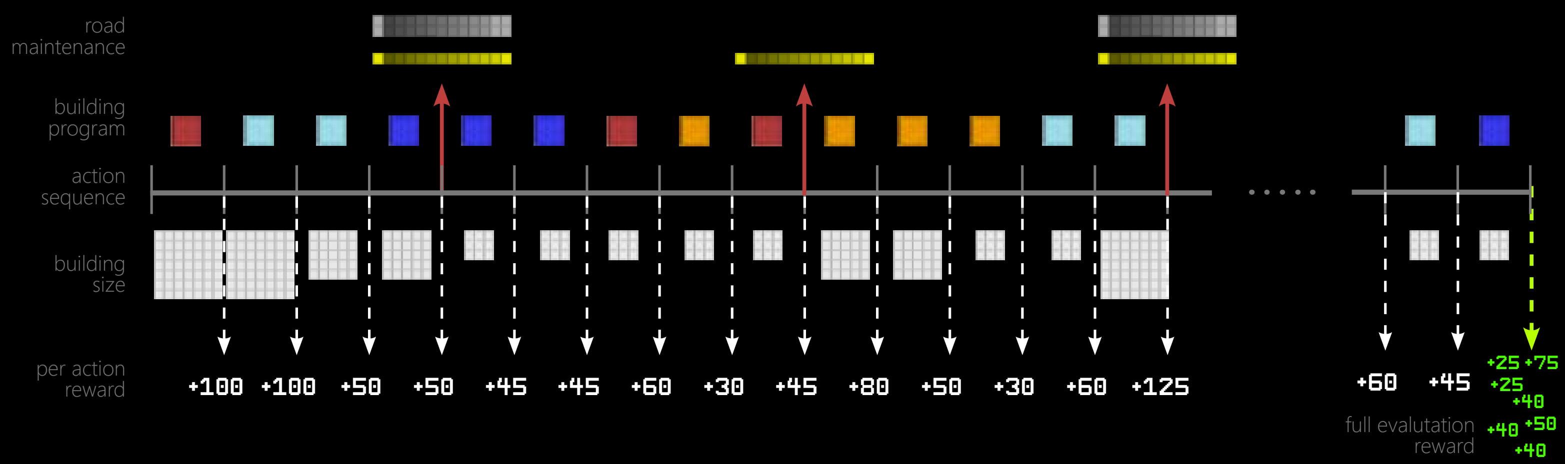


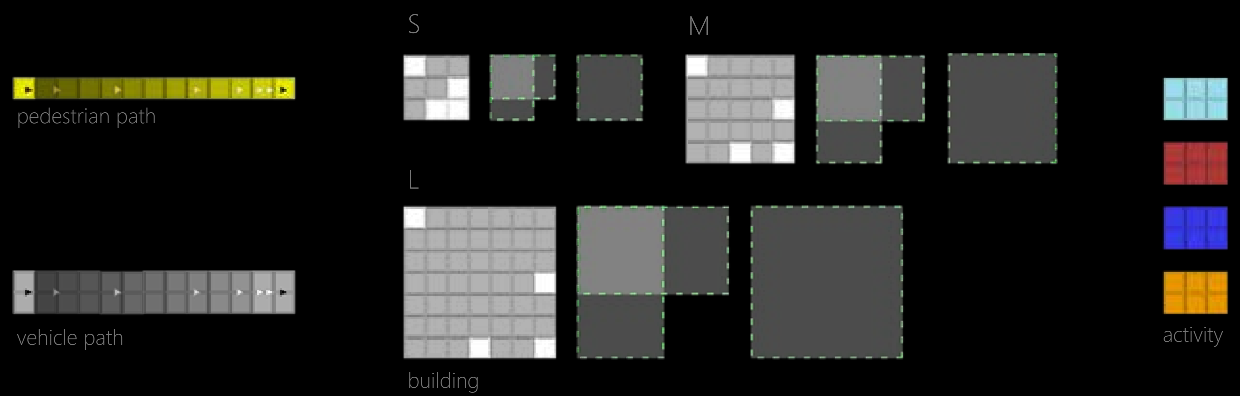

```
class  Setting:
    def __init__(self):
        self.BOARDWIDTH = 40
        self.BOARDHEIGHT = 30
        self.boardsizeseq = [s,s,s,s,s,s,s,m,m,l,l,v,s,s,v,p
,l, ...]
        self.boardcolorsz = [r,r,b,r,b,p,o,p,o,o,r,b,p,r,r,r,r
,r, ...]

class InstanceReward:
    def __init__(self):
        self.small = 20
        self.medium = 60
        self.large = 100
        self.adjpstreet = self.size / 4
        self.adjvstreet = self.size / 5

class Evaluation:
    def __init__(self):
        self.metricdiversity = ...
```

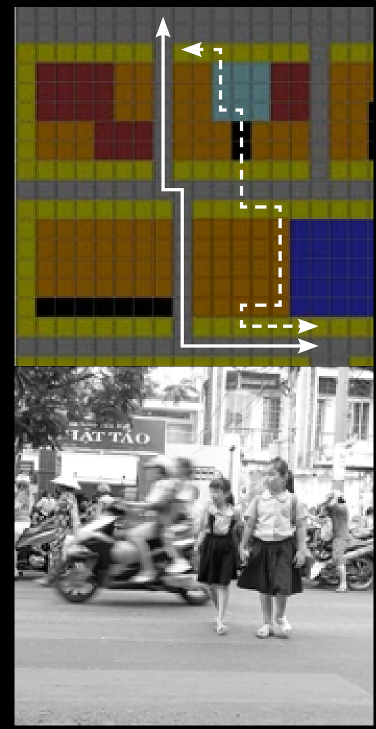






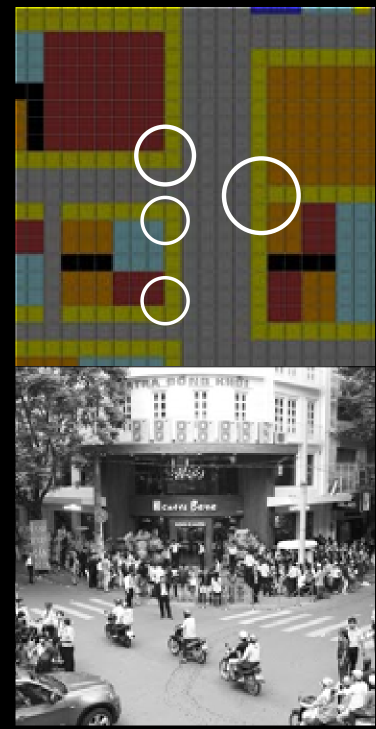
Game layout

vehicle pedestrian
permeability / accessibility



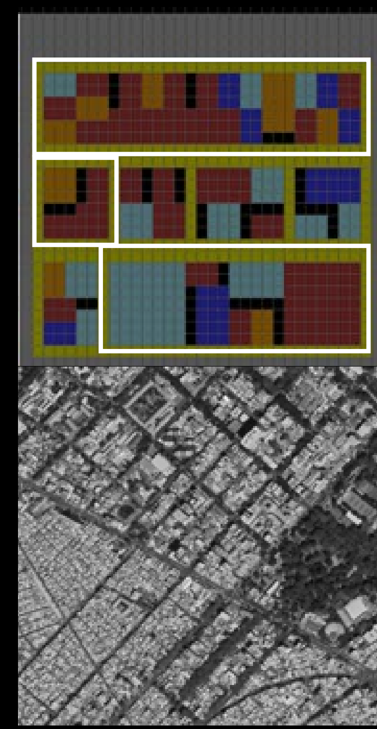
pedestrians and motorcycles entangled

corner



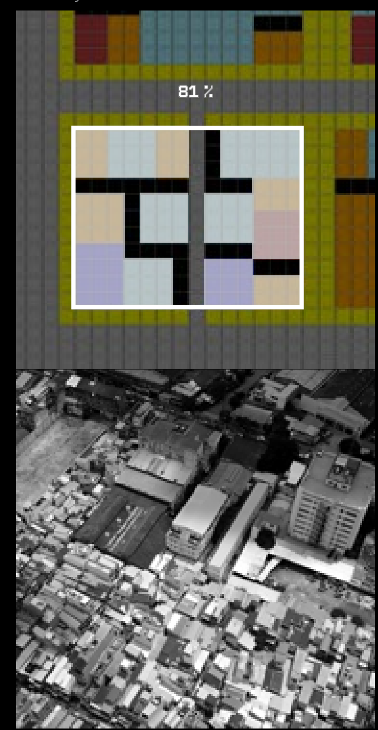
round corner serve as traffic buffer and attraction point

block shape / size



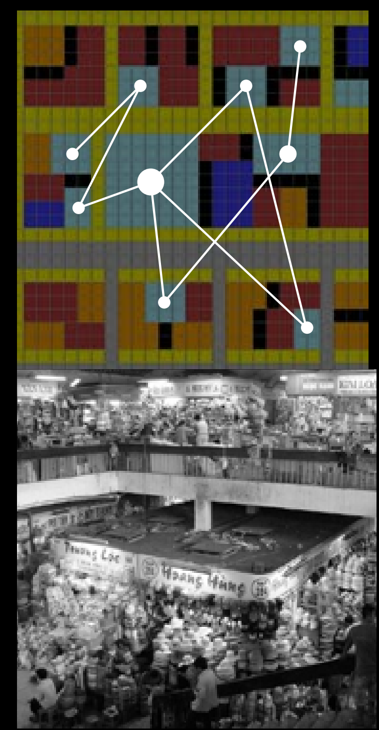
city grid of central HCMC

density



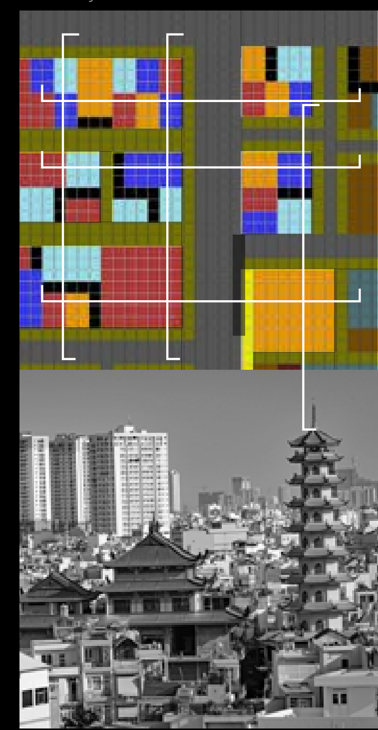
varying density of city block in HCMC

cluster effect



enterprises gaining the advantage of attraction but suffer from competition when they form clusters

diversity



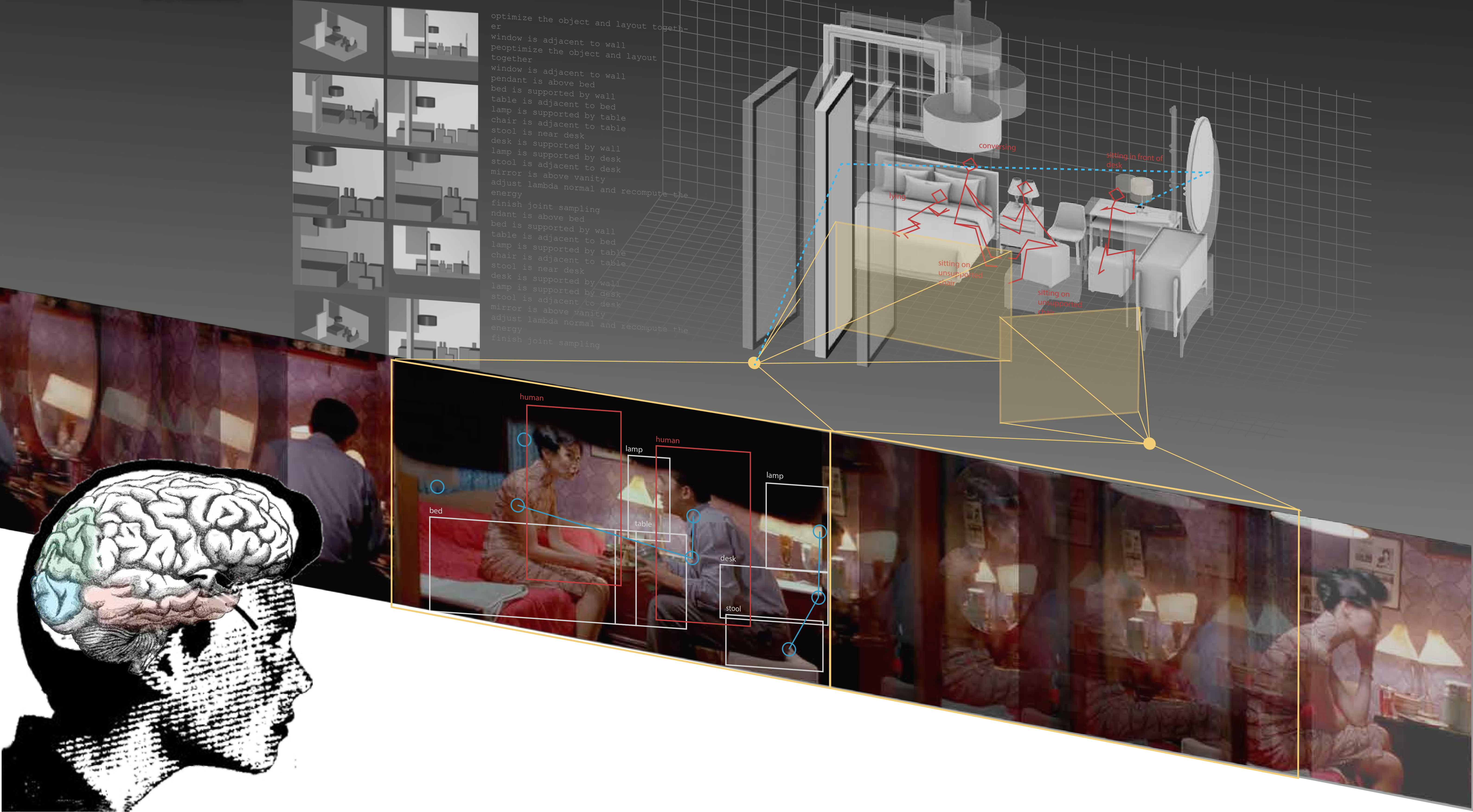
mix of residential, religious, commercial buildings

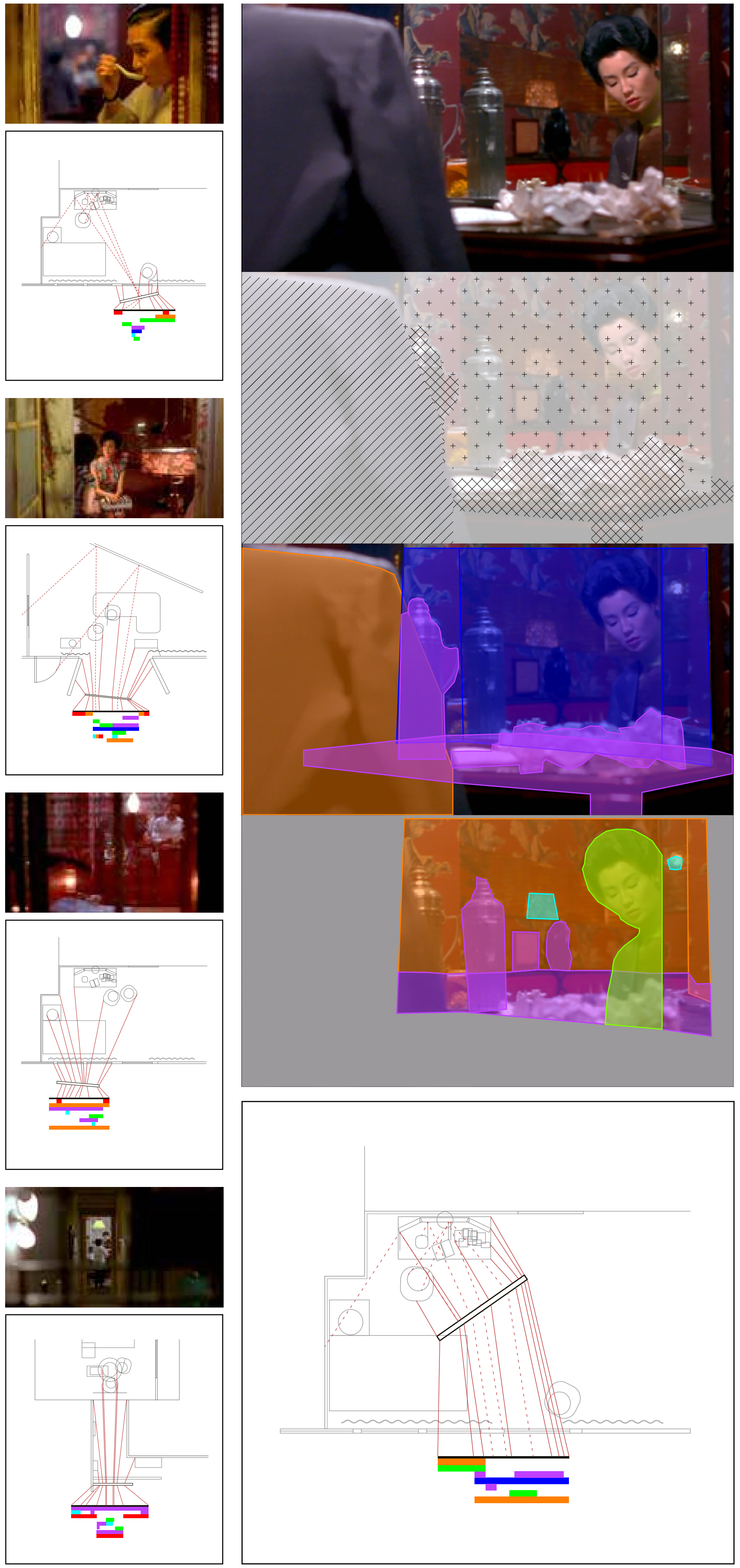
Scoring index

CINEMATIC DECOMPOSITION

YEAR : 2020
TYPE : Academic + Individual
ADVISOR : Prof. Choon Choi
(Architecture)

What defines “cinematic quality”? As with directors such as Wong Kar Wai (WKW) the “art of film making” incorporates designing and carefully manipulating physical setting; physical elements, camera, lighting etc, to configure the intended scene.
In this project I attempt to extract the arbitrarily defined elements of cinematic scene making through experiments of replicating this “style”. Starting from the 2D scene, I extract elements such as the scene layout, light, objects and camera placements to initiate a 3D setting. I reach a satisfactory result by manually iterating through a render and adjust process, and evaluating the similarity of the original movie scene with synthetic rendered image. In the next phase, with the elements of cinematic quality that I have extracted, I seek ways in which the machine can perform the same task.



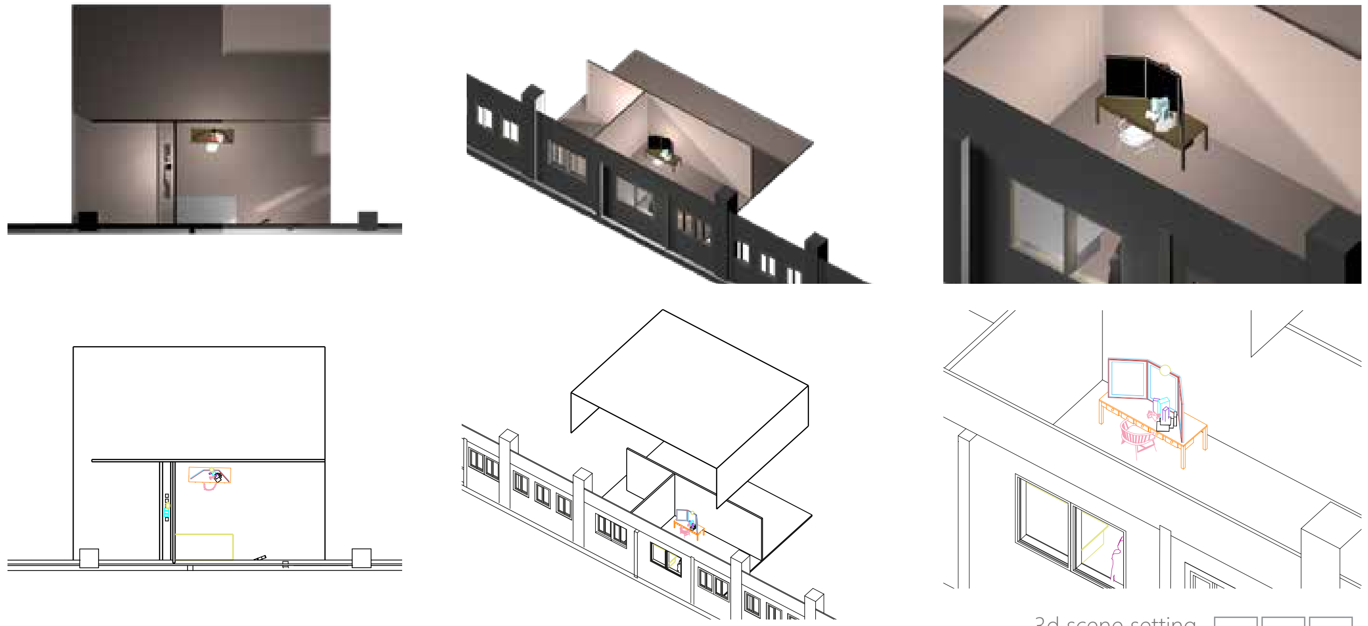


forground
midground
background
lighting
object
human
mirror
fabric
surface

0
1
2
3
S

0. original scene
1. depth
2. elements
3. reflected elements
S. space setting

2D scene analysis



3d scene setting
S1. (top)
S2. (perspective)
S3. (perspective close)

S1 S2 S3

https://www.
youtube.com/
watch?v=PTRfa-
BI7dSk

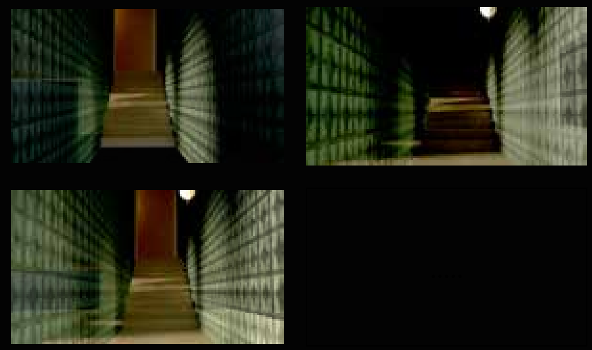
generated scene

G1
G2
G3

3D scene reproduction

2d multiple scenes perceive

3d model initiate



compare and adjust

"Walls are glossy so that lights in the background are presumable. Light of 100 lumens at about 500mm above floor level emited through glass tiles of 150mm size produces this kind of effect"
"The human is placed on the far left far side of the scene in contrast with the brightest light in the background where the source is unrevealed"

text based generation

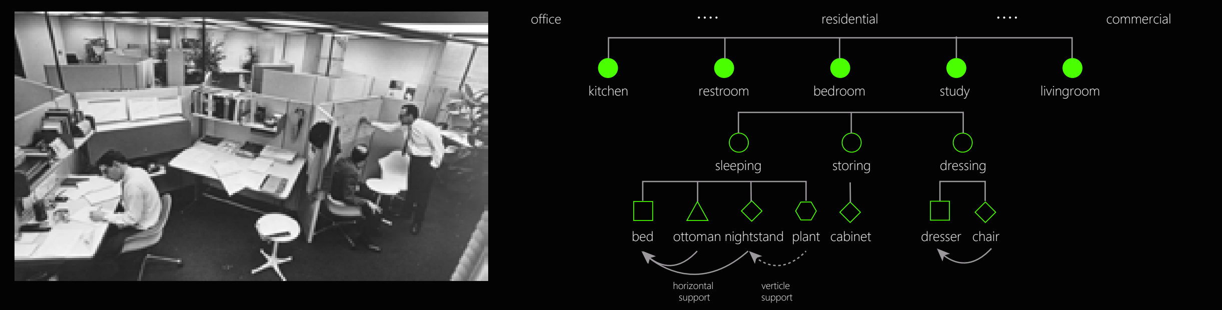
photo based generation

Human

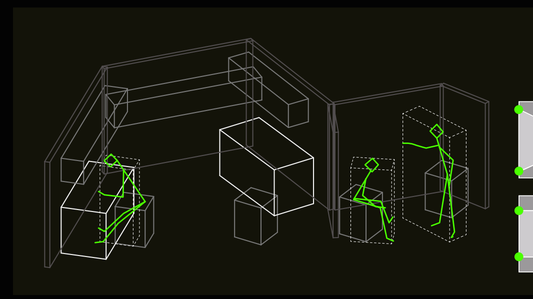
training

pattern recognition

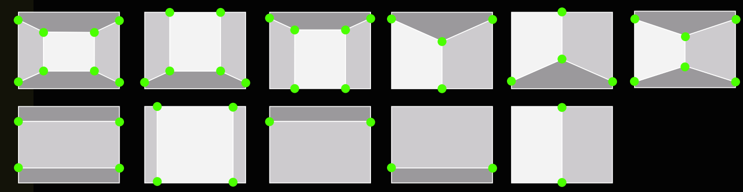
testing



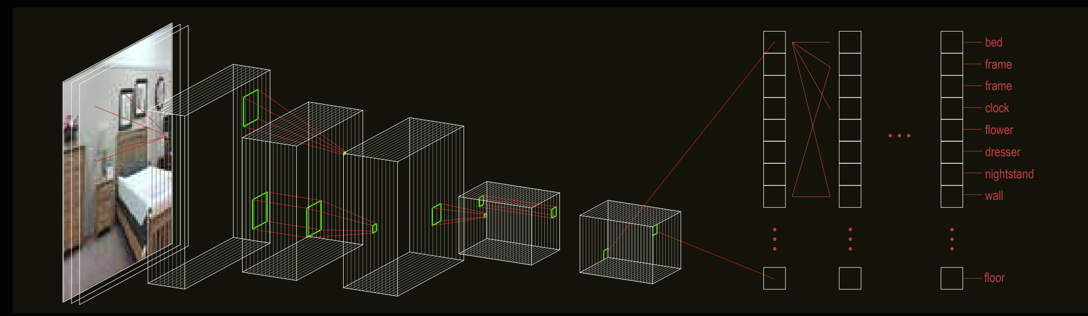
data 3. activity & object



data 1. human & object



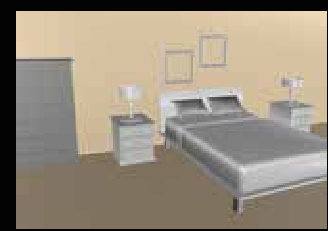
data 2. room layout



convolutional neural network

input photo

optimization process



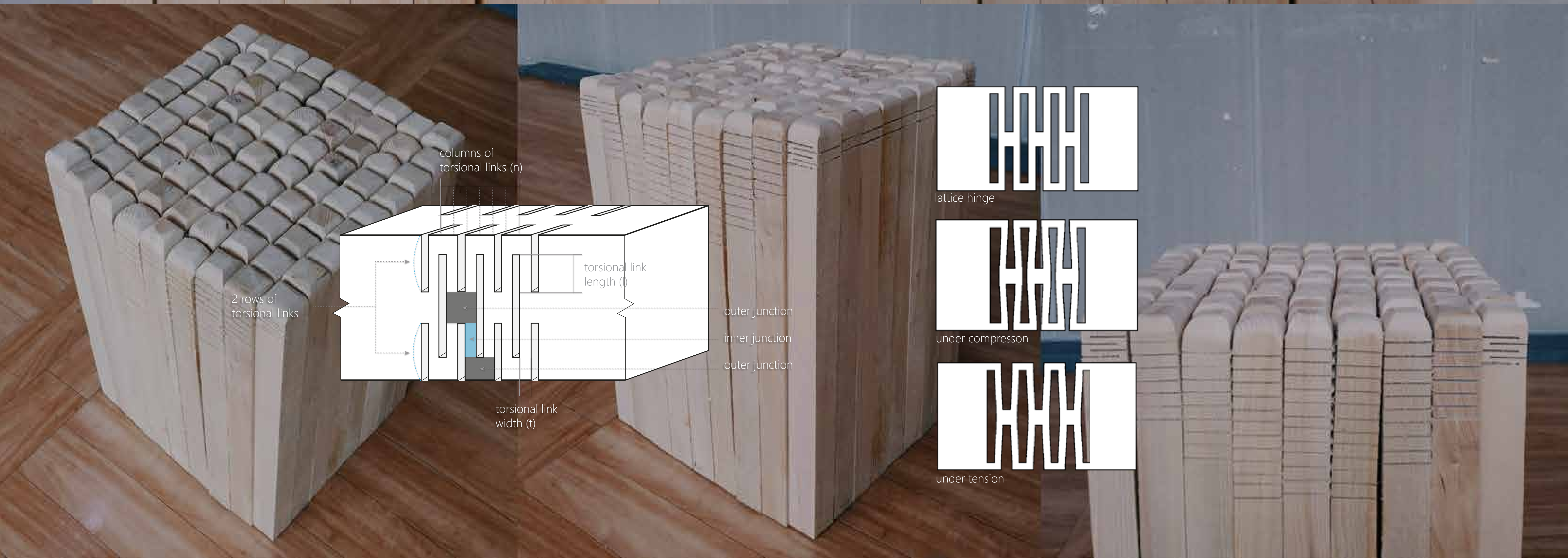
ouput scene

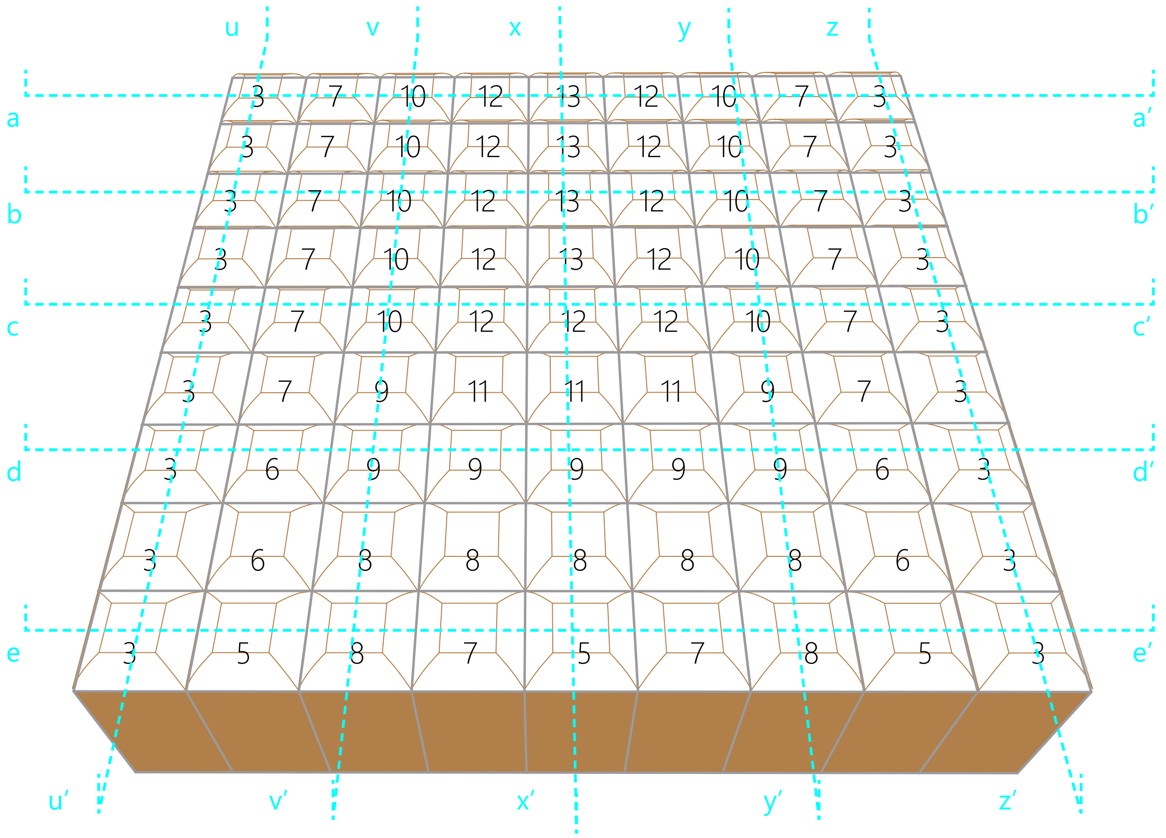
Machine

WOODEN CUSHION

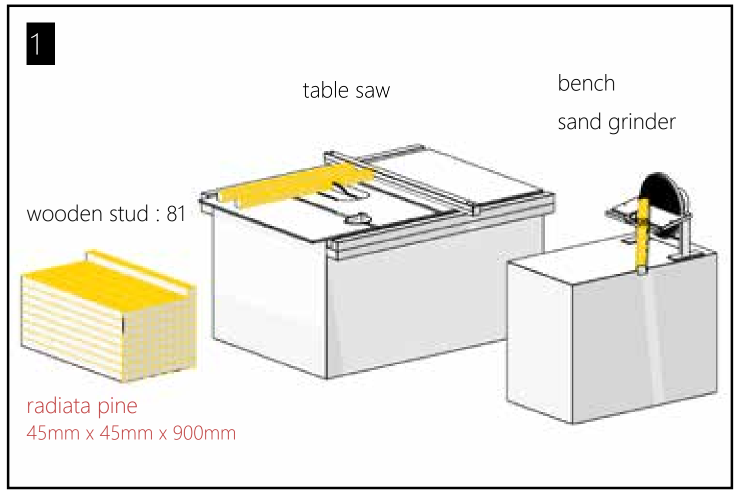
YEAR : 2017
TYPE : Academic
ADVISOR : Prof. Hangman Zo (Architecture)
CREDITS : Grace Moon

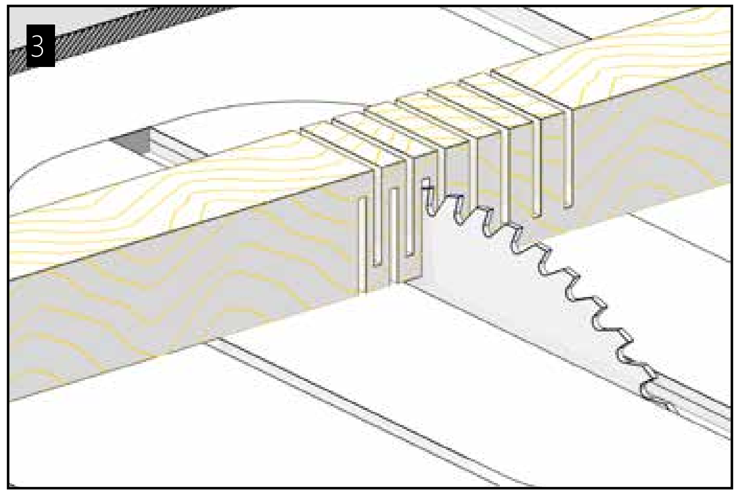
Wood is known for its hardness, stiffness, and unbending qualities which have determined the materials usage and ways of processing.
In this project, we seek to redefine wood beyond its known static features through alternative processing and simulating methods to embed a responsiveness to users. We employ parametric lattice cuts that endow wood flexibility while retaining its durability. The lattice hinge relies on torsion of the material to bend. The radius of the bend depends on the length of the cuts, the distance between them and the thickness of the material. Knowing the yield stress of the material, it is now possible to calculate the length and number of spring connections required to stay below the limit of non-permanent deformation. When processed in this manner, wood can yield and respond to the shape and weight placed on it.

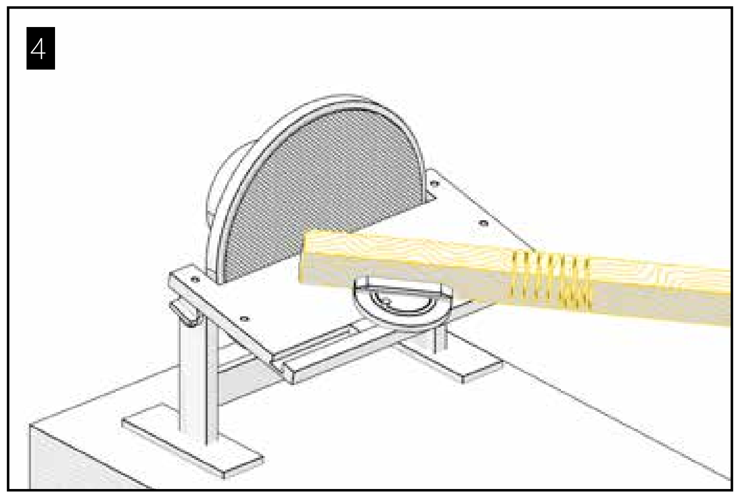


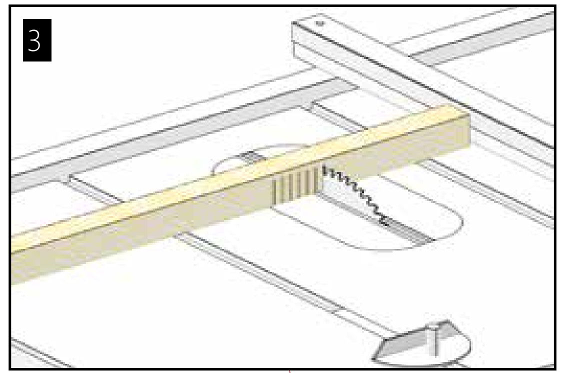


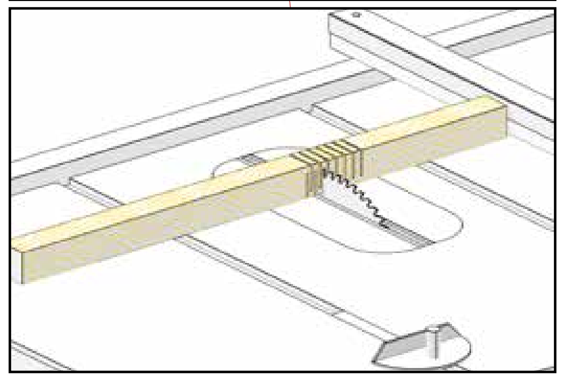
A sequence of cut numbers are assigned to the 9 X 9 stud grid to fit the curvature of the chair seat. One's bottom will sink in towards the rear and legs accordingly in the front. The frame is relatively rigid yet is squishier than the original wood material.

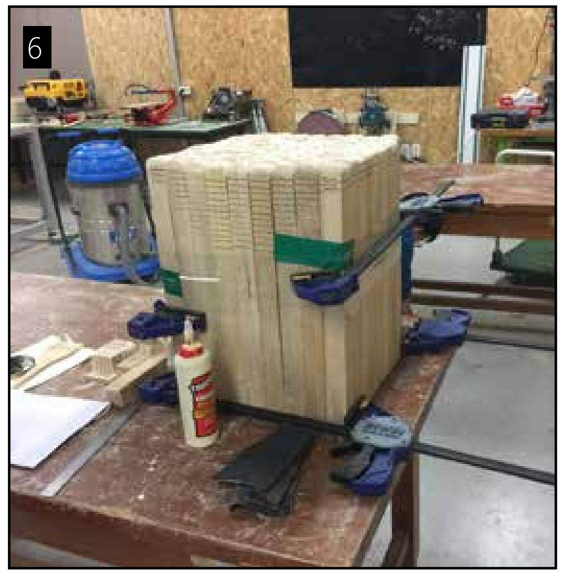










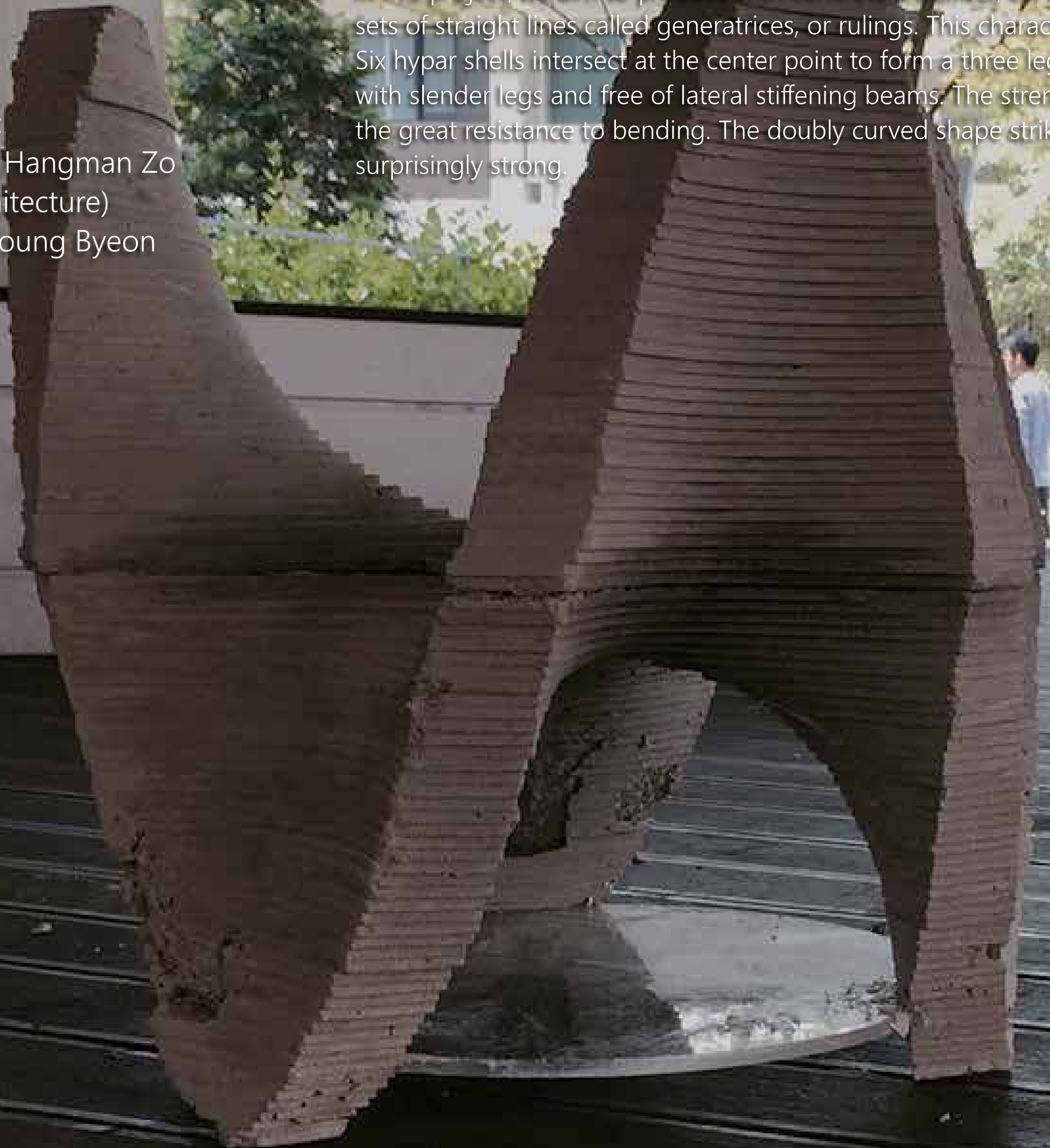


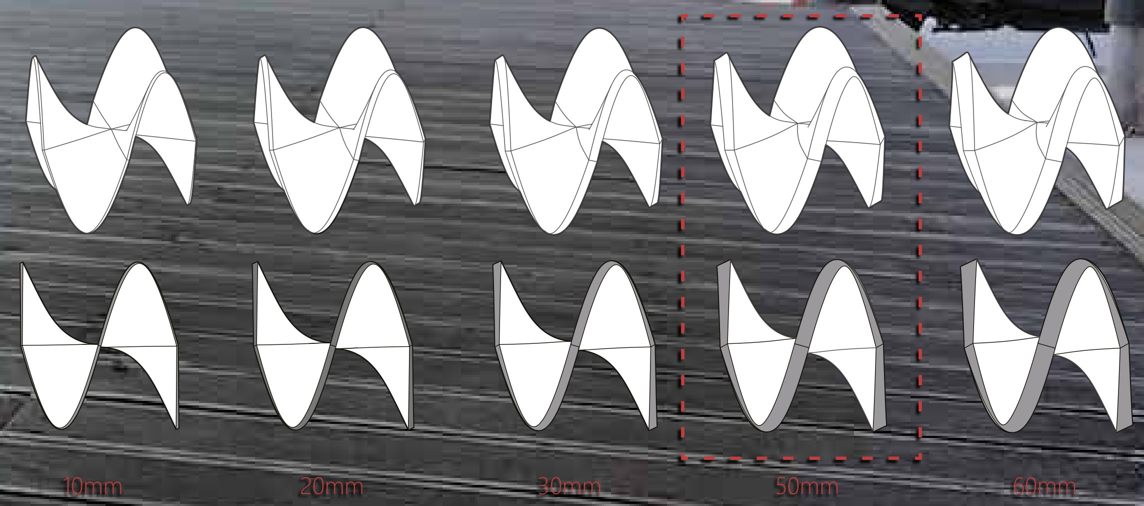
1. material & tools
2. arranging studs by number of cuts
3. cutting stud with table saw
4. rounding top corners
5. arranging studs to chair curve
6. assembly & binding

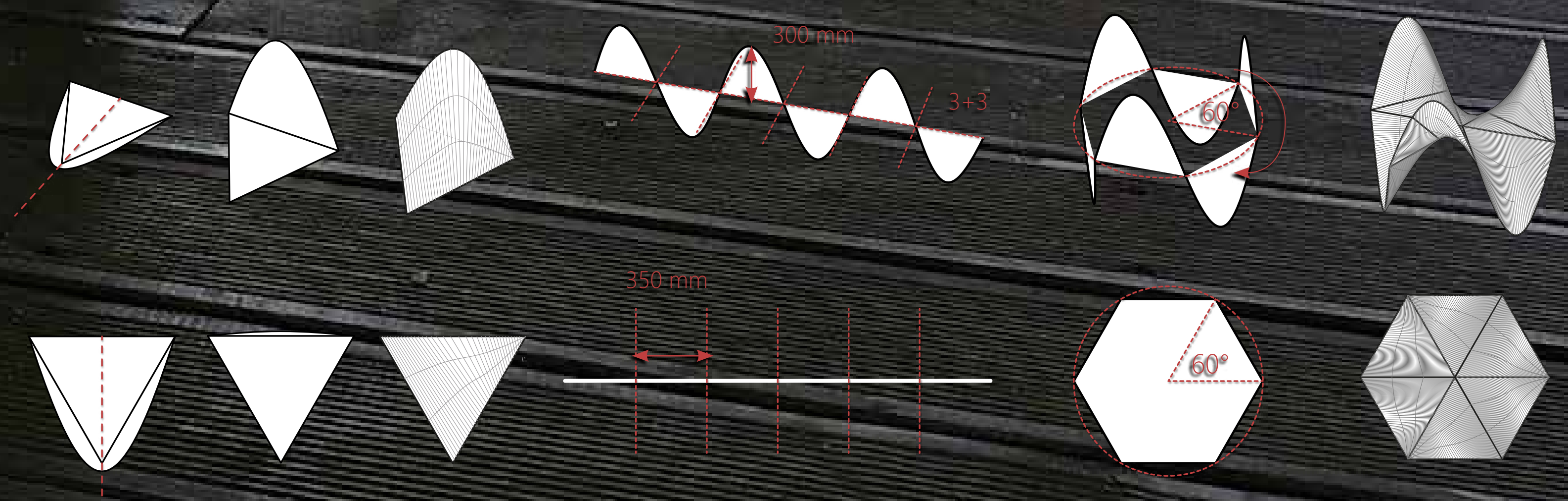
CONCRETE HELIX

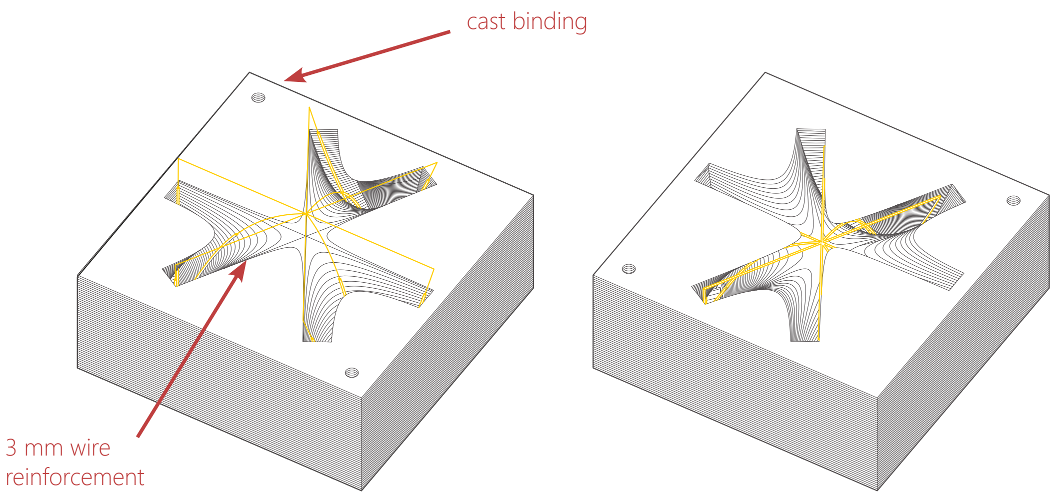
YEAR : 2017
TYPE : Academic
ADVISOR : Prof. Hangman Zo (Architecture)
CREDITS : Seo Young Byeon

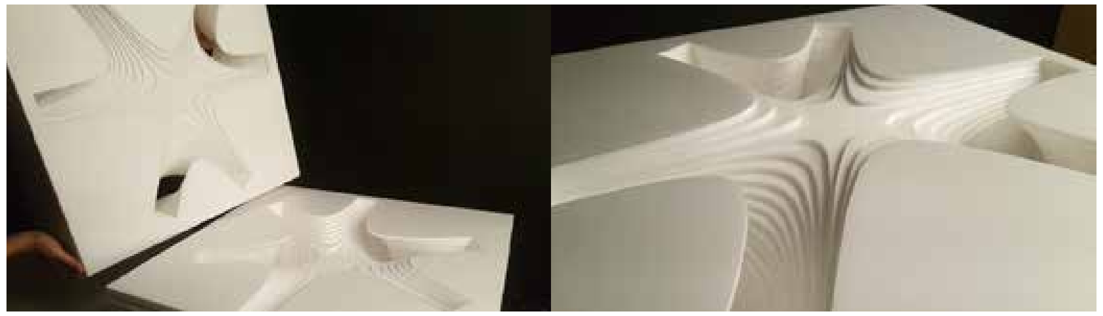
Concrete when wet is that it is responsive to its mold, but once hardened, retains its form and gains significant durability. However, because of its weight and hydration process, previous making with concrete has been limited to orthogonal and thick shapes.
In this project, we aim to produce with concrete a slender, curved profile with a parametrically carved and stacked cast. Hyperbolic paraboloid are formed by two sets of straight lines called generatrices, or rulings. This characteristic allows hypars to be joined together at their edges seamlessly, to make beautiful structures. Six hypar shells intersect at the center point to form a three legged standing structure. With such structure we are able to achieve long span areas supported only with slender legs and free of lateral stiffening beams. The strength comes from form, not mass. The strength from its double curvature that allows hypar structures the great resistance to bending. The doubly curved shape strikes a balance between tension and compression forces, allowing hypar structure to remain thin, yet surprisingly strong.

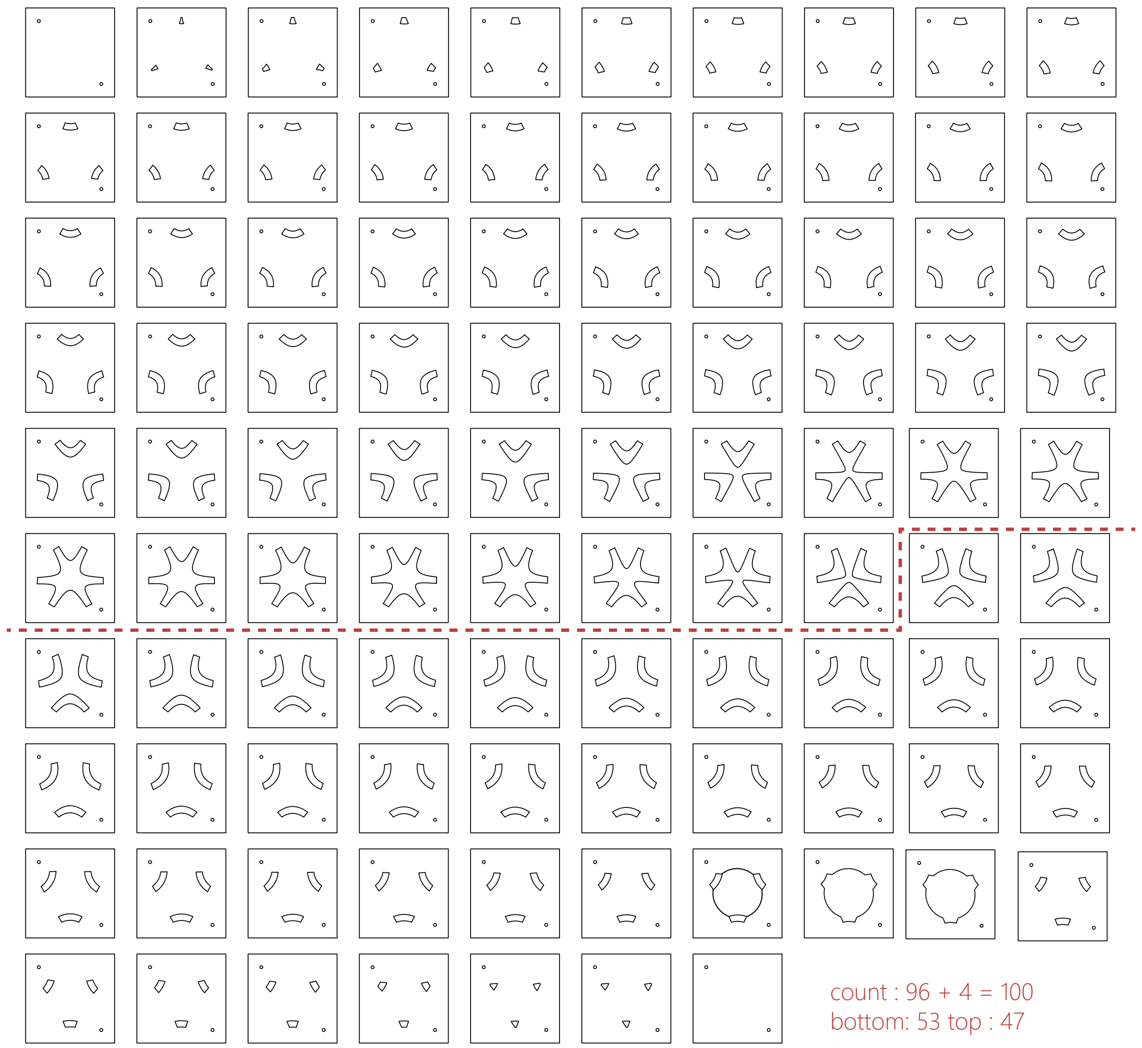






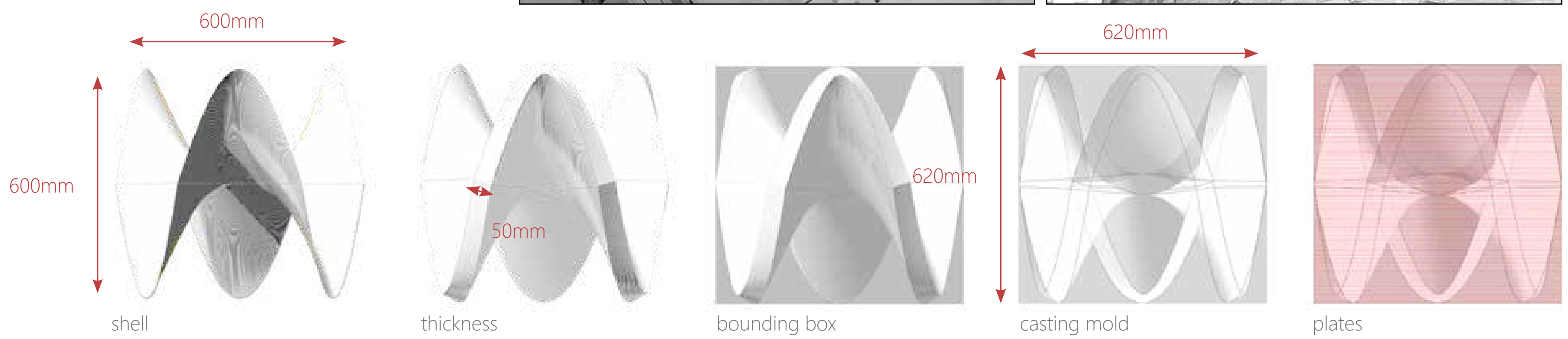


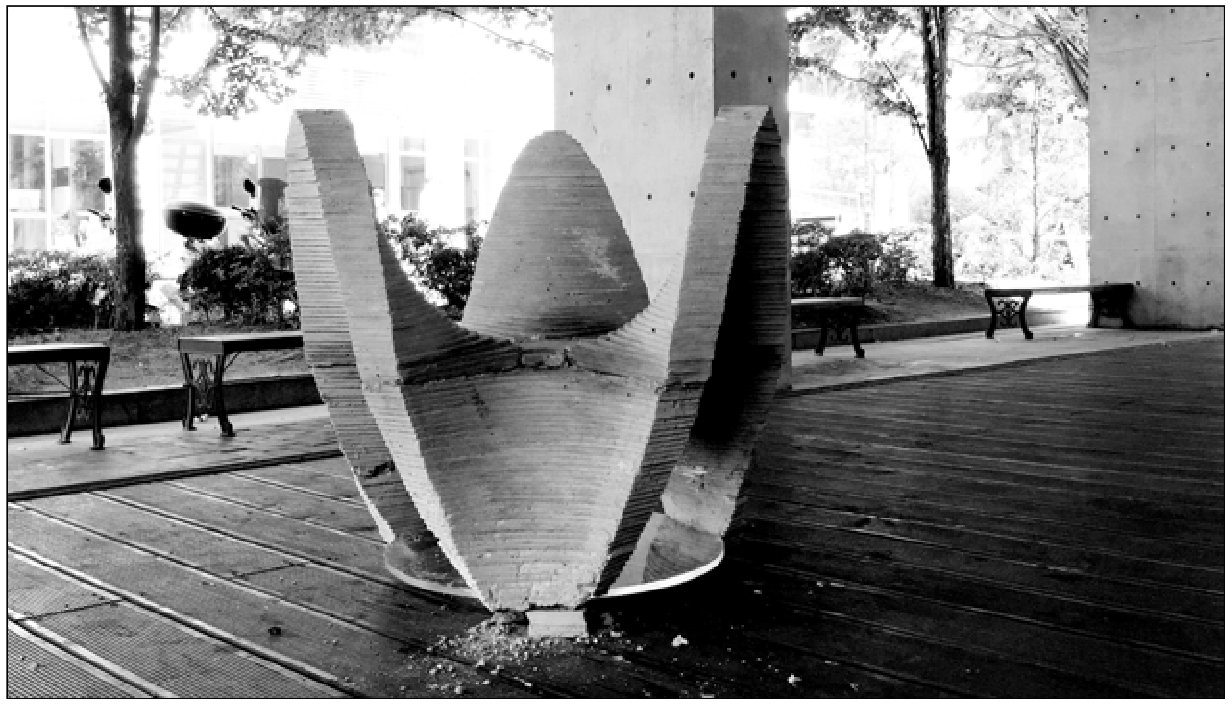




Cast plates

1. placing acrylic table top in cast
2. binding cast with wood brace
3. completed casts
4. pouring concrete mixture





Making process

LIGHT VIGIL

With candle light vigils, building signage, spotlights we are well aware that light is an effective means to gain attention and voice ones opinion. We design a tile module for the Gwanghwamoon plaza, a backdrop for various cultural and political activities in the center of Seoul. Opening and closing with the weight placed on top, polarized light is emitted either under-ground or over-ground with varying shapes dependent on the tile's curvature. The tiles endows people the right to light; to project light signaling and accentuating their activities.

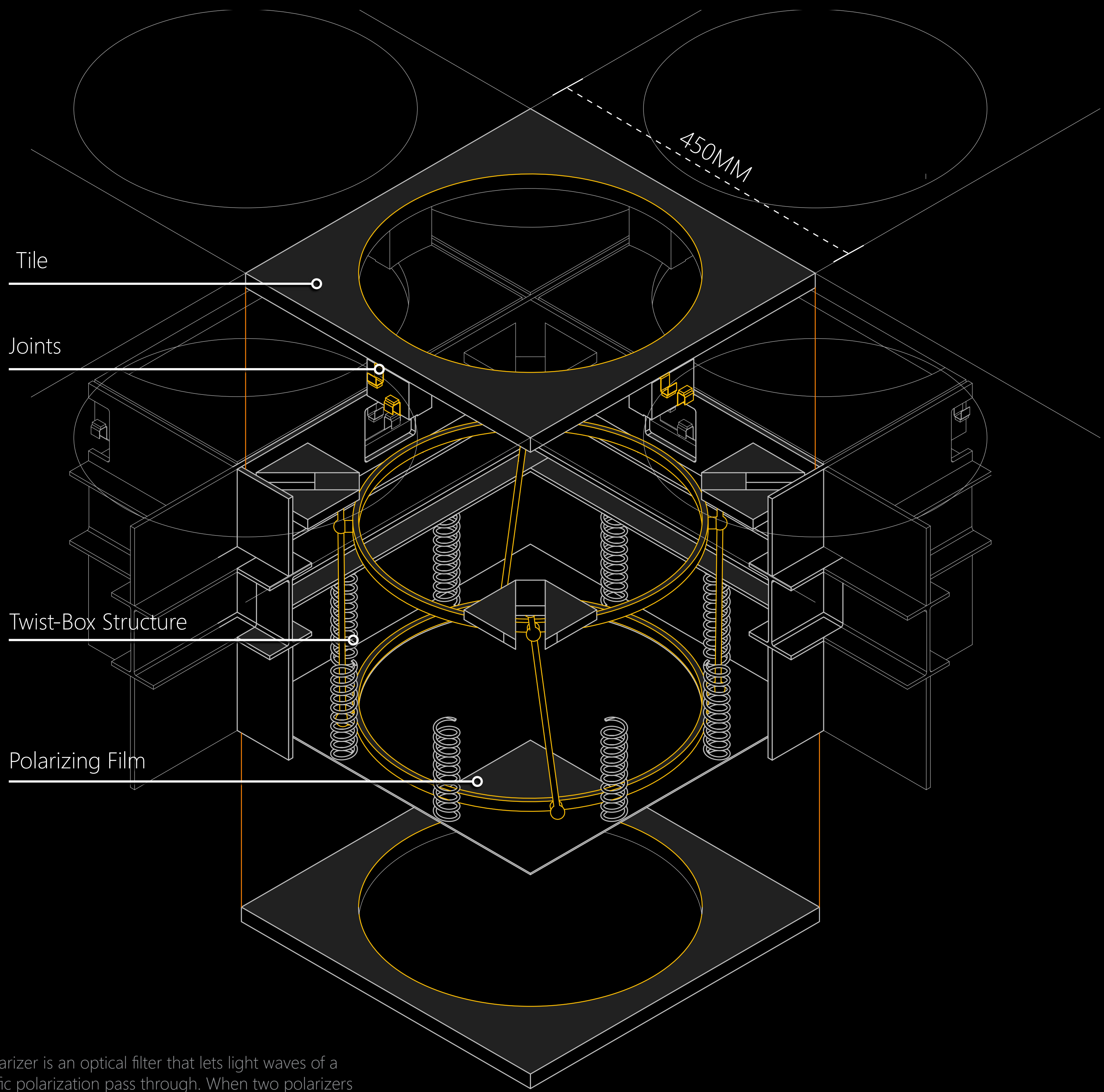
YEAR : 2020
TYPE : Independent
Competition for Velux
CREDITS : Chang Yong Kim, Ji Yong Jeon

Space Composition

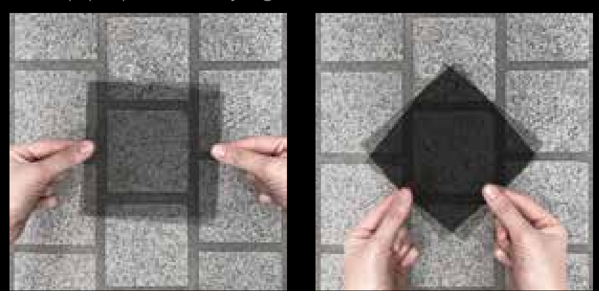
Undulating Surface
A rhythm of concave and convex surfaces accommodates various scales of protest/events.

Urban Context
Located in the milieu of Seoul's historic change, GHM plaza is considered the archetype of a protest-space in present-day Korea.

Underground
Underground areas preserve the nature of passageways yet hold open spaces with loose compartments parallel to the areas above.



A polarizer is an optical filter that lets light waves of a specific polarization pass through. When two polarizers overlap parallely, light passes though. If the polarizers overlap perpendicularly, light is not transmitted.


Polarized Light

This simple model changes vertical moverment into rotation, and rotation into vertical movement.

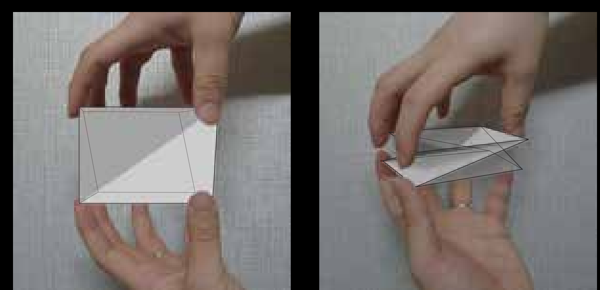
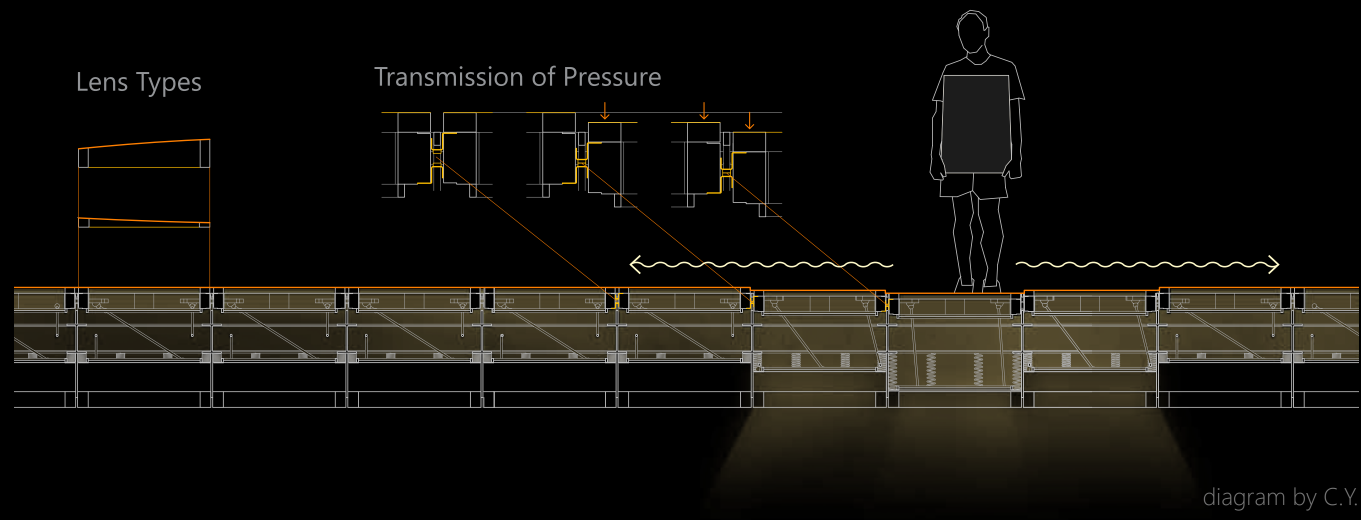
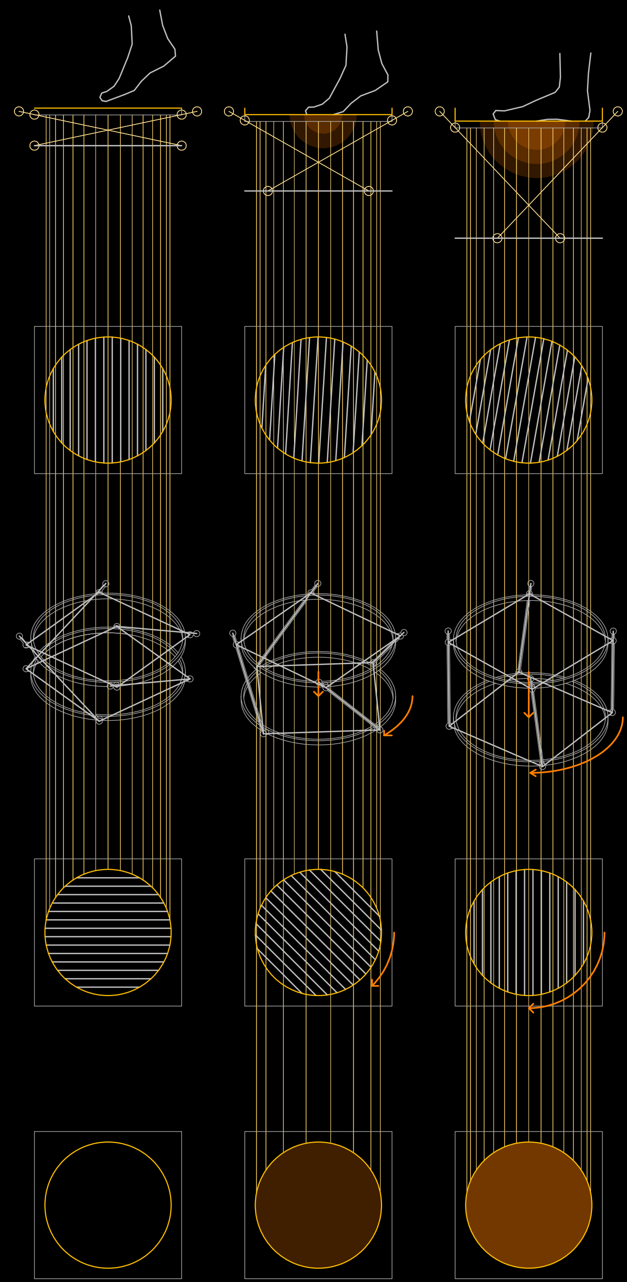

Twist Box

diagram by C.Y.



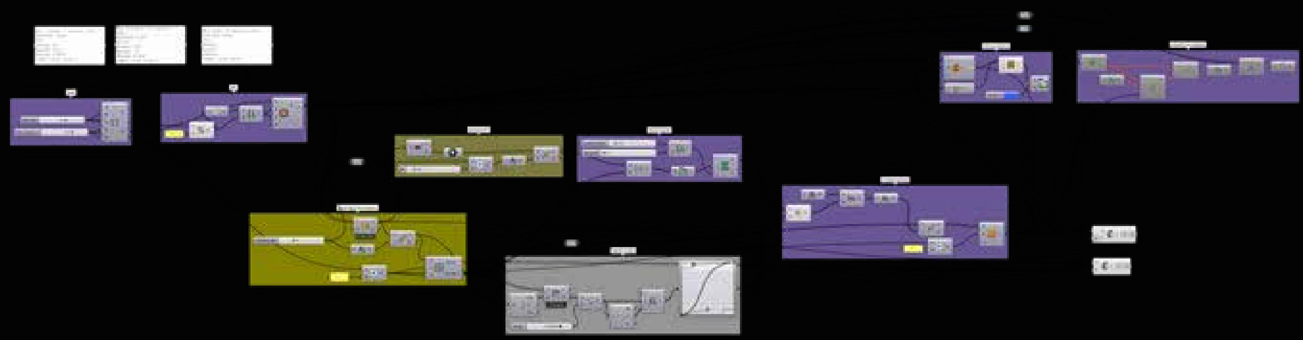


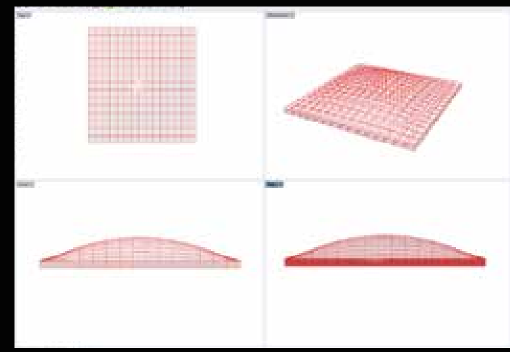
Tile module

Light transmitting mechanism

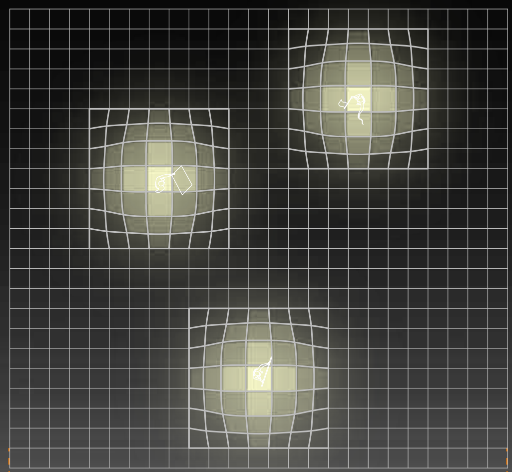
Geometry generation tool for tile curvature & light simulation

by S.H.



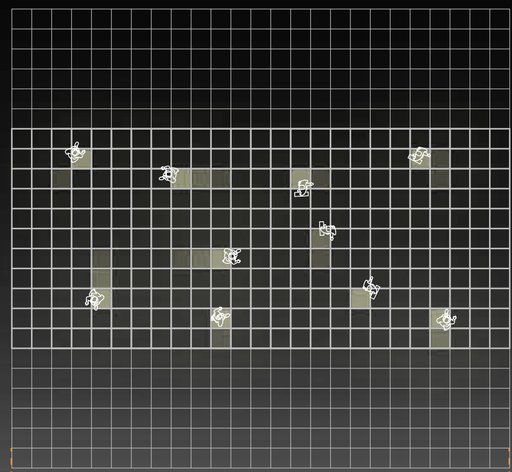


ABOVEGROUND



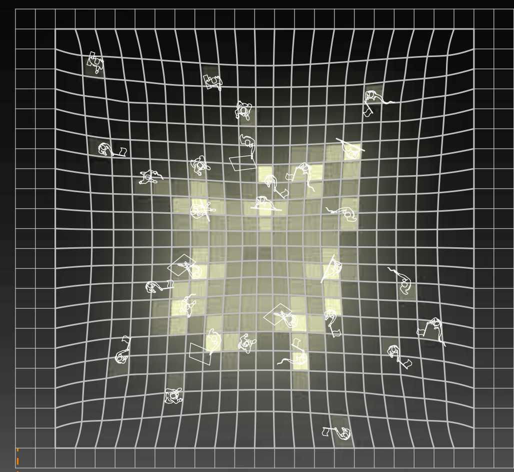
individual protestor

One-person protesters stand on podium-like mounds. Light area of one person is amplified.



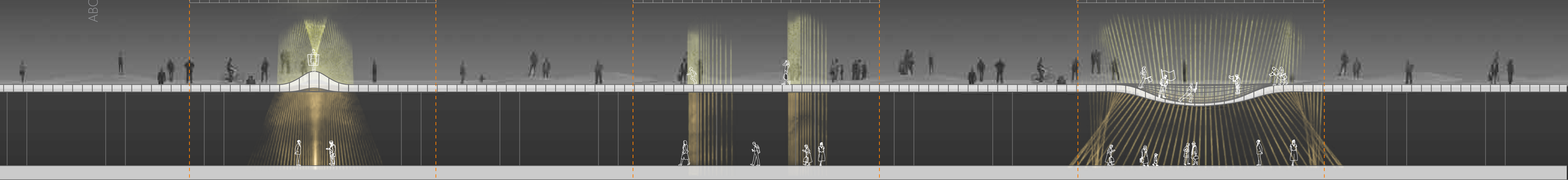
bypasser

Non-protesters relatively active compared to protestors walk around the plaza.



group protestors

Protest of 5~30 people join and face each other in a shallow concave crater. Light area of one person is normalized.



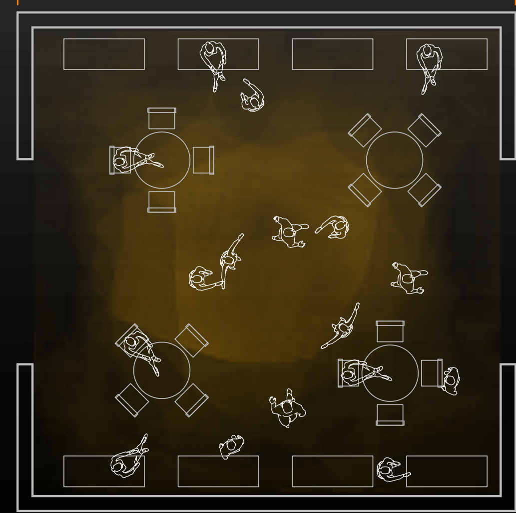
UNDERGROUND

spotlight

The convex shaped tile sends daylight to form a spotlight underground drawing attention to the location of the aboveground protester.

ray trace

Because of the tile's time lag, the tiles in the pedestrians trial are left open.



diffused light

The concave shaped tile sends diffused daylight to niches such as waiting areas.

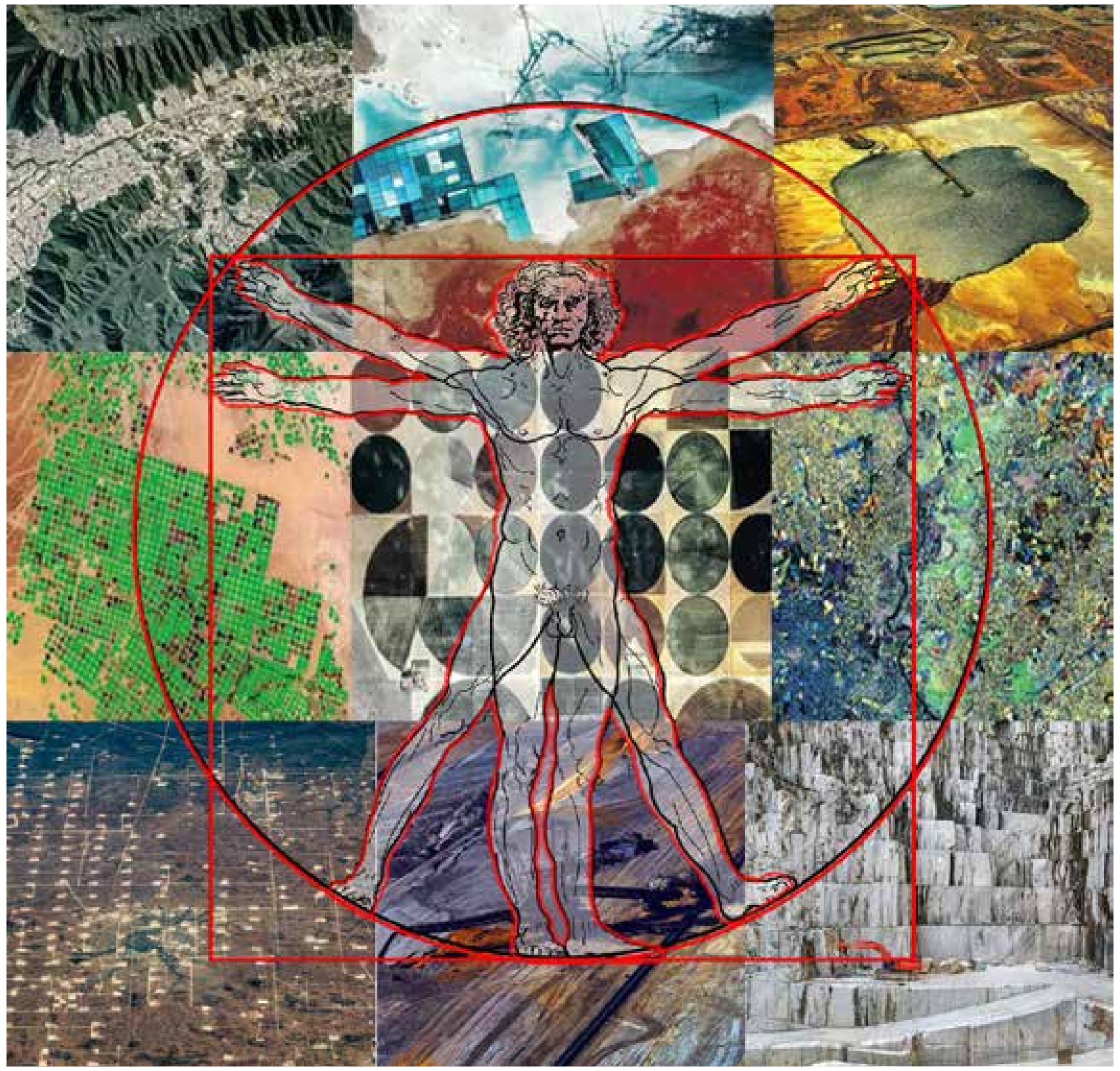
diagram by S.H.

Lightscape

INHUMANE DINING

YEAR : 2020
TYPE : Academic
ADVISOR : Prof. Sung Uk Hong
(History of Science)

The Anthropocene is a newly defined epoch that marks the shift that came with noticeable, global and geological impact of human activities. Efforts to retract this line of human activity have been proven futile and belated. This raises the question of more fundamental roots of the problem, which I find in the very idea of human. The contemporary human ontology and alternative modes of perceiving oneself and others has been a well discussed topic among anthropologists, philosophers, sociologists and scientists. Yet one is still perplexed about how to embody these innovative manners, when they are bred and stuck in the current ways of thinking.
With this project, I propose an exercise that reshapes one of the most common everyday activities of humans – eating. Having to adapt to a foreign course of action, participants are alarmed of their human-centric ways in everyday living and escape their ingrained sense of human.

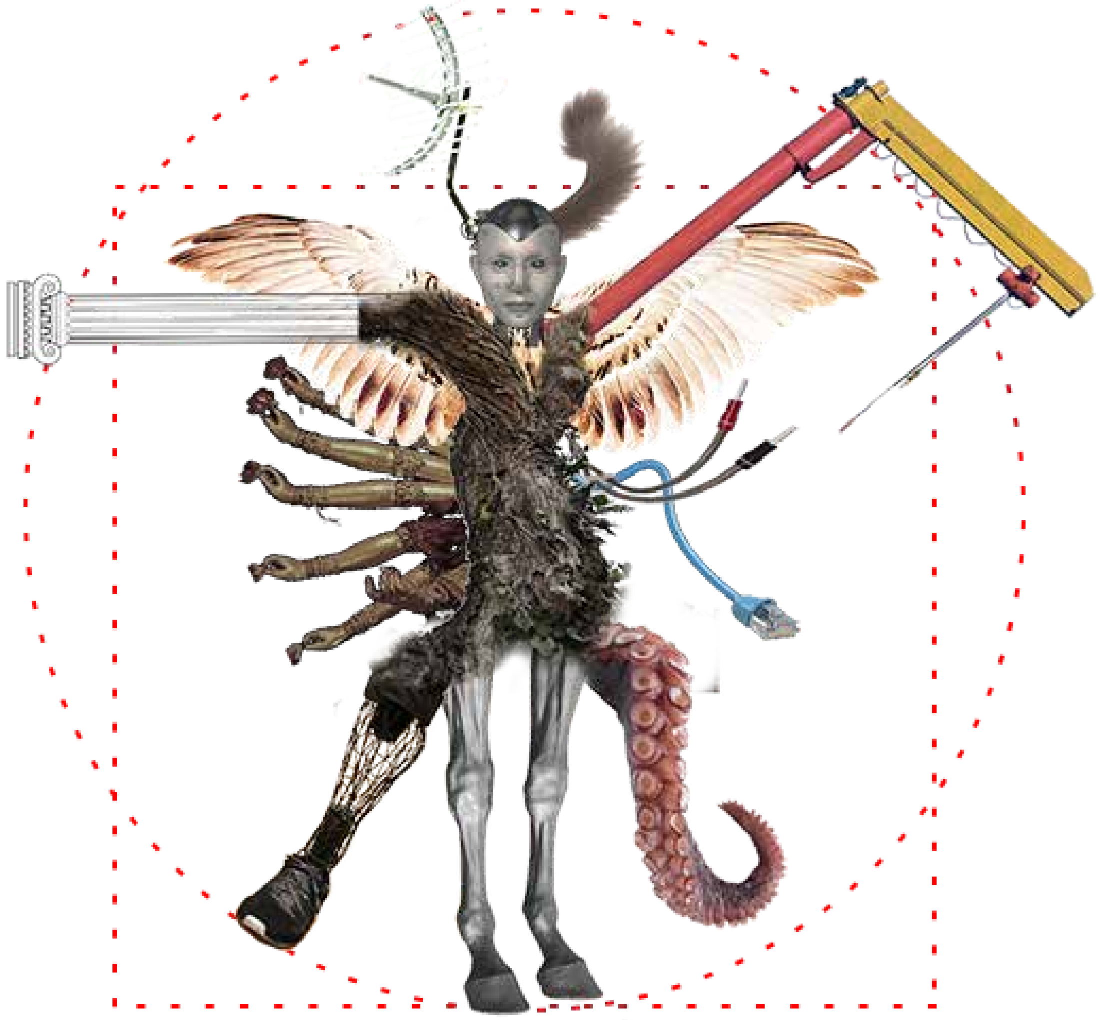


Human exceptionalism & Bounded individual ontology

“Anthropomorphism on steroids “
Bruno Latour (2011)

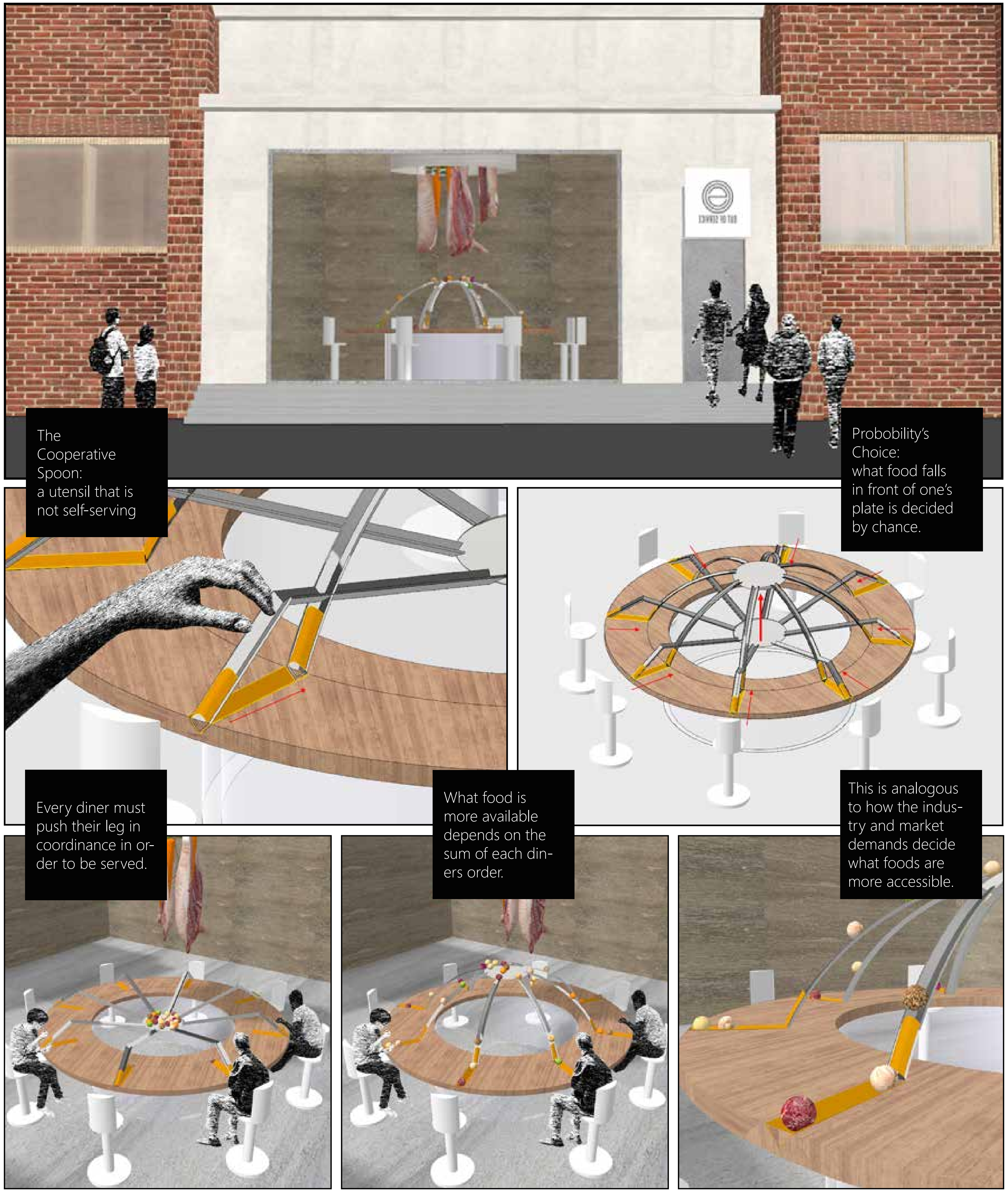
“...[We] need to break open the neurotic, post-Enlightenment tradition which compulsively separates subject and object, nature and culture, man and animal, matter and soul, individual and collective, as well as a whole host of other dualisms that lie at the root of most of the political, ecological, scientific, and aesthetic problems of our contemporary moment”
Félix Guattari (1980)

“We are humus, not Homo, not anthropos; we are compost, not posthuman.”
Donna Haraway (2015)



Non-human assemblage & Non-self ontology

Reinforcement of human-centric ontology in eating

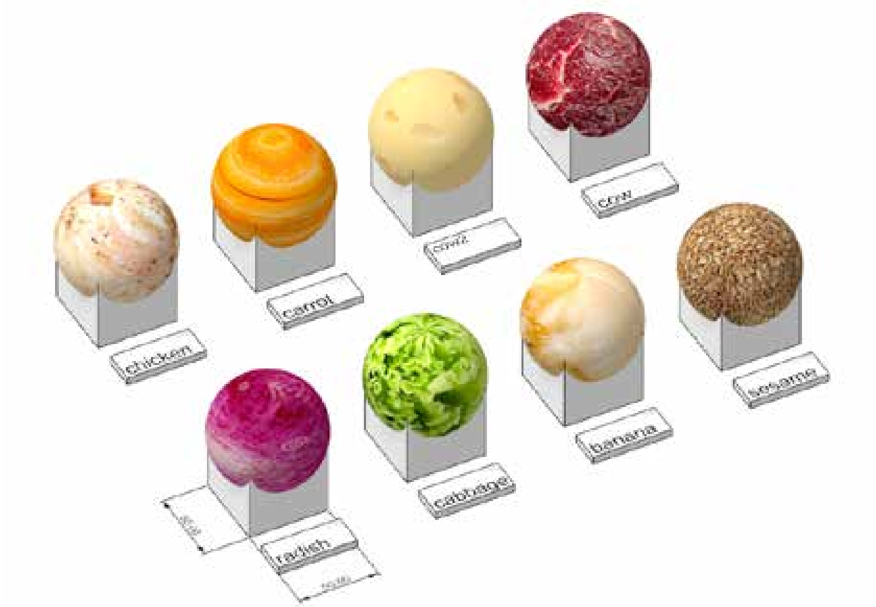


MENU

	RATING	Biology	Intelligence	Emotion
chicken		4	3	2
cow		2	2	1
pig		1	1	2
banana		3	4	3
carrot		5	5	3
cabbage		6	5	3
radish		7	5	3

What is edible?

On the menu, ratings 1of traits that are presumed "humanly" are presented. As apposed to deciding based on nutritional facts or taste, which strictly frame food as an intake source for humans, diners draw a line to which is acceptable to consume.



Refined dish

The hyper-refined form of food is drastically contrasted against the original names in the menu. All dishes are refined purees shaped in spherical molds. This is analogous to how foods are refined and shaped to reduce guilt and appear "edible".

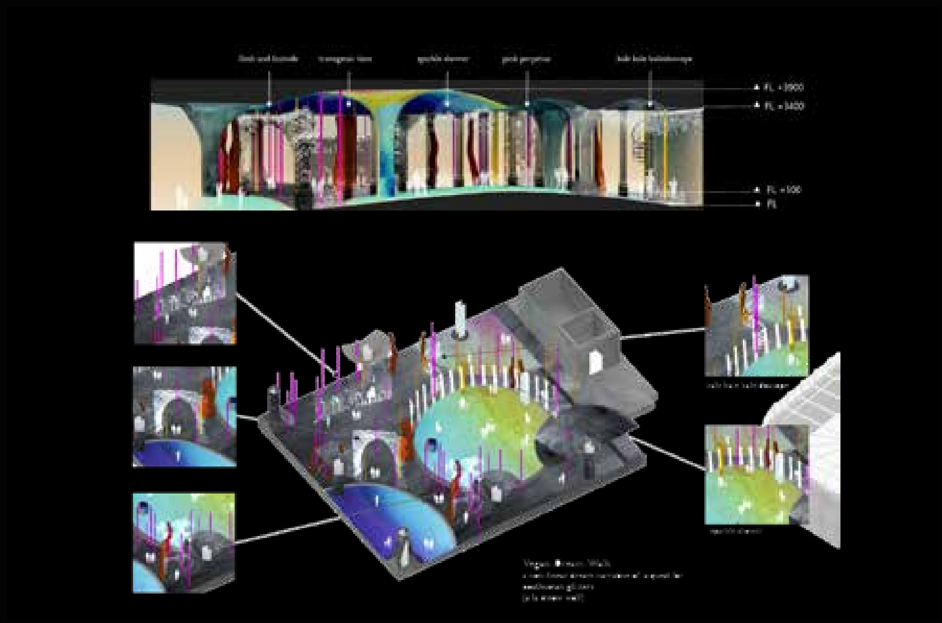
...hardly a domain of human life is not in large part infected with the production, distribution and consumption of food. ... [F]ood, as I have argued, offers the most intense and material reminder of the mutual dependence of living creatures across the globe.

153 Eating Anxiety Chad Lavin

An inhumane dining experience

PARTICIPATED WORKS

Continued in
Curriculum Vitae ...



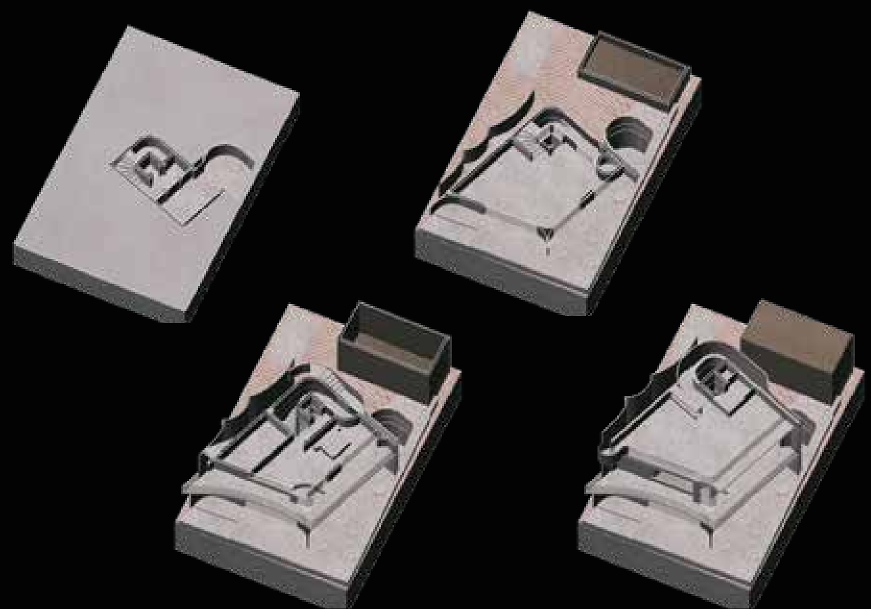
VENICE BIENNALE: AUTOPSY OF THE FUTURE
EXHIBITION
CHOON CHOI ARCHITECTURE
Dec 2017 - Mar 2018
research and archiving of Yeouido history for exhibition prelude,
3d modeling, physical model making

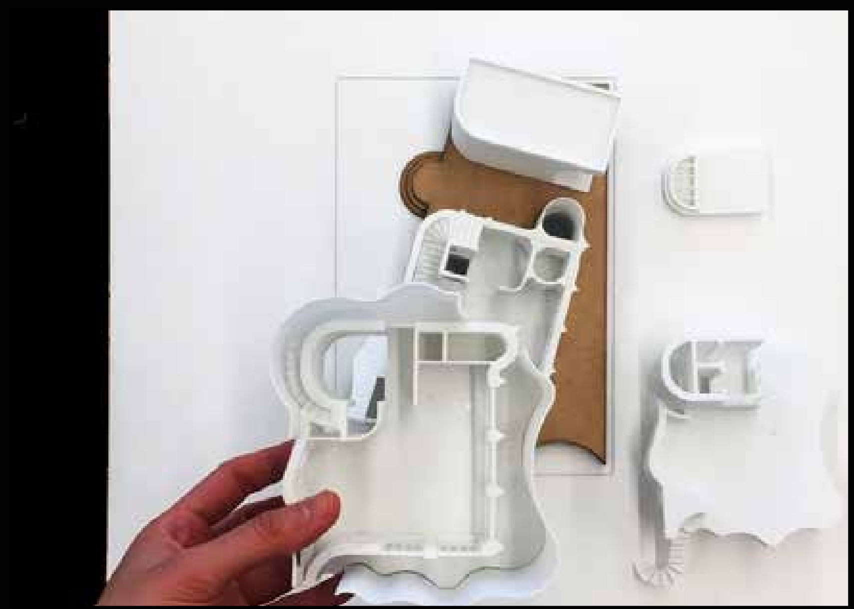
Hyundai Outlet Mall
COMMERCIAL
CHOON CHOI ARCHITECTURE
Feb 2019 - July 2019
concept design for post human green space

Seoul Public Art Project : Ellipse
PUBLIC ART
PYO VS PYO
Dec 2019 - Aug 2019
model making and public relations for contest

Private
RESIDENTIAL
CHOON CHOI ARCHITECTURE
Jan 2019 - Aug 2019
3d modeling, physical model making

Private
GALLERY
CHOON CHOI ARCHITECTURE
Mar 2019 - Aug 2019
facade design, mapping , 3d modeling, physical model making





CHLOE (SOO HWA) HONG

PREVIOUS WORKS

Design Science

Three Decades of Machine Learning with Neural Networks in Computational Design (1990-2021)

Jinmo Rhee[1], Pedro Veloso[2], Chloe Hong[1], and Ramesh Krishnamurti[1]

[1] *School of Architecture, Carnegie Mellon University, Pittsburgh, PA, USA*
[2] *School of Architecture, University of Arkansas, Fayetteville, AR, USA*

Abstract

Over the past years, computational methods based on deep learning—i.e., machine learning with multi-layered neural networks—became the state-of-the-art in main research areas in computational design. To understand the current trends of computational design with deep learning, to situate them in a broader historical context, and to identify future research challenges, this article presents a systematic literature review of publications that apply neural networks on computational design problems. Research papers employing neural networks were collected from CuminCad, a main repository of the computational design community and categorized into different types of research problems. After analyzing the distribution of the papers in these categories, the composition of research subjects, data types, and neural network models, this article suggests and discusses several historical and technical trends. Besides, it identifies a crucial aspect of machine learning research that is typically absent in the reviewed publications: reproducibility. The article points out the importance of sharing training experiments and data, and of describing the dataset, dataset parameters, dataset samples, model, learning parameters, and learning results. It proposes a guideline that aims at increasing the quality and availability of computational design research with machine learning.

Introduction

Problem solving in computational design based on deep neural networks and deep learning has become increasingly prevalent As et al. (2018). Deep learning represents the new wave in artificial intelligence (AI) and machine learning (ML). Hierarchical network models and learning are supported by increasingly more efficient algorithms and models, with access to larger data sets and greater compute power and access to machine learning libraries and frameworks.

Developments in deep learning rely on a history of advances in AI and related fields of which some have been explored in computational design Zhang, H. (2019); Rhee, J., Veloso, P. (2021). In this respect, recent conferences on computational design have established thematic sections based on AI and ML CAADRIA et al. (2021); CAAD Futures et al. (2021). Online communities, such as Digital Futures, have organized diverse workshops and public discussions based on deep learning Digital FUTURES (2020). There are emerging groups in academia and industry with a focus on combining creativity, architecture, and deep learning, as evidenced by their scholarly production and practical activities Newton, D. (2018); Del Campo, M. (2019); CRAIDL (2020)

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Des. Sci.
journals.cambridge.org/dsj
DOI

Figure 1. Pipeline for establishing a neural network-related research database from CumInCAD

common neural network architecture used by deep learning models to learn visual patterns from images or other structured representations.

Starting from Zwierzycki's original motivation we have narrowed the scope to machine learning with neural networks in computational design research. Investigation of research trends with this refined scope increases the accuracy in detecting trends and causal analysis.

Data Collecting

Scraping the literature

The first step in analyzing trends and characteristics of research in computational design that uses machine learning with neural networks is collecting data on research publications. The source for our data is CumInCAD (Cumulative Index about publications in Computer Aided Architectural Design), a digital archiving platform supported by several conferences and journals in the computational design research community. A site-specific crawler was developed to collect information on publications.

Prior to the crawling process, a list of keywords was established, which specify whether or not a particular research publication belongs to the field of deep learning: [”deep learning”, , ”deep neural network”, ”artificial neural network”, ”neural network”, ”gan”, ”generative adversarial network”, ”vgg”, ”cnn”, ”imagenet”, ”unet”]. The keywords were established by using a minimal matching algorithm where, for example, terms like ‘deep learning’, ‘deep-learning’ and ‘deep-learning-based’ would all be equivalently matched. Note that terms relating to not only ‘deep learning’ but also to ‘neural network’ are included in the list, since even simple neural networks require training and optimization. Data collection was restricted to publications between 1990 and 2021.

The crawler accessed all 16,182 publications in CumInCAD and extracted research information such as research id, title, year, authors, source, abstract, references, etc. It then checked whether the information had at least one of the keywords. If the publication information included a keyword, the full-text pdf file and its respective repository information as a csv file were saved. A total of

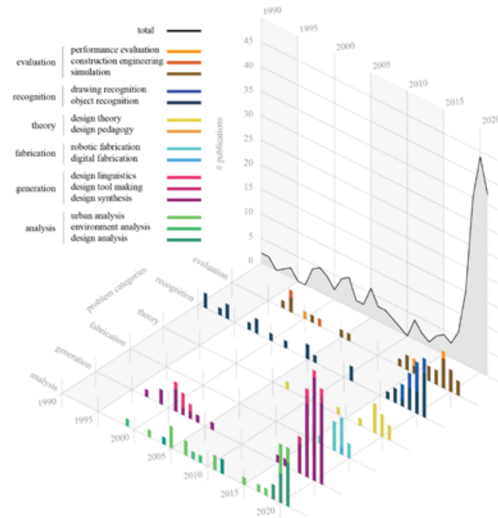

Figure 2. Number of neural network-related research in computational design by time and research problem

A notable inference that can be drawn from Figure 2 is that machine learning research has been present in each 5-yearly interval. Integrating neural networks in computational design research is not wholly new. From the early 1990s to 2015, the number of papers on neural network-related research in computational design has been relatively steady with small fluctuations year by year. Because of the archiving limitations, there is no clear indication of machine learning in design prior to 1990 in CumInCAD. However, Figure 2 shows that efforts to employ neural networks in design research were not an emerging but extensions of earlier research initiatives within the computational design realm. Specifically, as Figure 4 shows neural networks have been consistently used.

Another notable indication from Figure 2 is that there are two distinct periods when neural network-related design research was active: 1995 to 2005, and 2015 to 2021. The first period follows the second AI winter. This period had a small number of, but continuing, attempts to implement neural networks in computational design. However, by 2005, research using machine learning declined until 2015. During this period, shallow neural networks were still

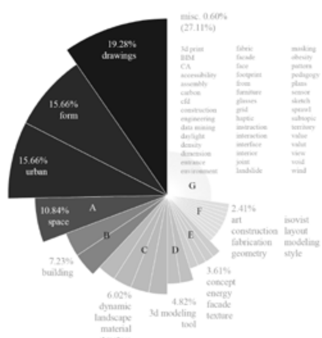

Figure 3. The composition of the subjects of neural network-implemented research in computational design

Design analysis is another emerging problem type with the shortest recession in 2005-2015. Despite being in recession, design analysis problems with implementations of deep learning techniques have been steadily studied. Design analysis did not disappear during the recession; post-recession, it has experienced an increase in the past five years like the other problem types.

Another notable pattern in the research trend is on fabrication and theory. Both have recently emerged and have experienced neither a recession nor boom in the past three decades. Specifically, neural network-implemented robotic fabrication shows rapid growth when it appeared after 2015, and research on design theory using deep learning techniques also re-emerged in this period.

Research Subject

Figure 3 presents through a pie chart the composition of the subjects in neural network-implemented research in computational design. The area of the pies is proportional to the number of publications. The darker shades also indicate more publications. The chart shows that there are various subjects in neural network-implemented research and a distinctive trend of dominance in subjects. The sum of the top four subject slices (drawings 19.28%, form 15.66%, urban 15.66%, space 10.84%) makes up about 60% of the total. The sixty-six other topics make up the other 40%. Standard deviation is 5.01. That is, drawings, forms, and urban topics are the dominant subjects in neural network-implemented computational design research.

Drawing and space are respectively the top observed research subjects. Group A, B, C, D, E, and F are clusters of subjects with respectively 6, 5, 4, 3, 2, and 1 publication(s). Subjects in group A and B (shape, form, structure, 3d modeling,

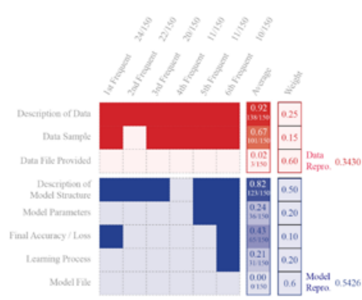

Figure 6. Reproducibility of neural network-related publications in computational design

in computational design research and CAAD publications neural network-implemented research may not be fully technical or scientific, nor presented in a proper structure or format, deep learning implementations are technical and thus should be properly presented within a scientific frame. In our analysis we did not take into consideration the availability of repositories such as Github, which was released in 2008, and results from earlier publications would not have been so readily reproducible.

Three data tags and five model tags were used to investigate how neural network-implemented research publications address reproducibility. Figure 6 illustrates four matrices to represent reproducibility in publications: an accessibility matrix to the data and model of the five most frequent combinations, a matrix with ideal accessibility to data and models, and a mean matrix of the accessibility matrix, and a weight matrix of the accessibility matrix. Each matrix is a concatenated matrix of data (red-colored) and model (blue-colored) matrices. Reproducibility can be defined as the inner product of average and weight matrices.

Most publications include data description, data sample, and model structure. However, they do not include data files, learning process, final accuracy, and model (hyper)parameters. Data and model reproducibility of machine learning implementations in the publications are respectively 0.3430 and 0.5426. Fully reproducible data and model has 1.0 for their reproducibility. The minimum value for reproducibility is set at 0.6 which is the weighted value of accessibility to data and model file. For most publications, the experiments were impossible to reproduce in terms of data and model.

Thesis Title

Enhanced Early 3d Design Exploration with an Interactive 3d Modeling Framework

Extended Abstract

Early exploration in 3d design is an iterative and evaluative process to reach a final design of a targeted object. Exploration is essential in the 3d designing process as it effectively reduces the large search space with criteria that are multifaceted, ambiguous, and bound to change. Current computer-aided design (CAD), specifically 3d modeling tools, are deemed unfit for early exploration stages of design. Recent generative design tools involving algorithmic modeling and machine learning methods enable the exploration of 3d designs by means of adjustable parameters to provide a large array of alternatives. However, these methods still require the designer to create a system specific to the design task with explicit logic and a set of constraints. With this thesis, I explore possibilities for computer-aided design methods to support and enhance the early exploration of 3d designs. My hypotheses are 1. Early exploration of 3d designs can be supported with interactive modes of computer-aided modeling and 2. Early exploration of 3d designs can be further enhanced with learning-based computational modelers. I propose an interactive mode of 3d modeling where the human designer and learning-based computational modeler take turns in deforming a geometry. The objective of the system is to provide the user with invigorating midway 3d geometry in the exploration process that still aligns with their intentions. The system borrows the basic structure of interactive machine learning frameworks where multiple agents benefit the training of agents by testing each other or adding nuanced useful information. I conduct experiments to design and train a computational modeler with various learning-based algorithms and a proxy objective. The interactive framework and learning-based computational modeler are evaluated by being placed in comparison to other modeling systems on diversity and alignment metrics. Further variations to the interface, operations, and training methods for the computational modeler can suggest further ways to facilitate exploration within this framework.

Committee

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3d Sketch with Evolving Learning Model

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ABSTRACT

The early exploration stage in 3d design open-ended, incomplete and is dependent on the user's knowledge base. Existing computational tools for 3d modeling facilitate the user to express complete 3d geometry and is useful for analysis and evaluation. However because these frameworks require precise specifications for each step, they are considered inappropriate to use in the early exploration stages of 3d design and deemed to restrict the user's creativity. Recent advances in deep learning, and its application in 3d geometry have introduced new ways that computation can assist users in 3d modeling. However applying these methods to design brings forth a set of new questions. Can a learning model help the user to be creative? How should we represent 3d shapes and its features to fit for open-ended tasks in design? How can the user interact with the learning model? With this thesis, I would like to propose that a learning model can assist the users' creativity in 3d modeling. As a proof of concept I would like to develop an interactive 3d modeling framework in which a generative learning model collaborates with the user in the early exploration of 3d design process.

KEYWORDS

3d modeling, generative design, data-driven 3D modeling, creativity support

GOALS

- Can a learning model support the user to be creative in 3d designing?
- How should we represent 3d shapes and its features to fit for open-ended tasks in design?
- How can the user interact with the generative model in 3d design?
- How can we leverage existing database and methods to create design space with features that reflect user's intention in the 3d design process?

PROPOSED APPROACH

Creative 3d Modeling

Creative modeling tools or methods are expected to inspire a user for modeling 3d shapes. [5] identifies types of creative modeling and analyzes with prior works.

Explorative modeling involves human user interactions to explore certain design spaces, a primary example being design galleries[14]. The user explores a parametric design space with through an interface with a visual display of random solutions. In this context, modeling inspirations are drawn from visual examination of the design alternatives with the machine facilitating the user's exploration process[5]. Also falling into the category of data-driven modeling, the work by [16] allows a user to actively navigate a space of design galleries. The user does not necessarily have a mental target of what is sought. While exploring the space of solutions, the user is inspired by what he/she sees. [10] present a method for exploring a space of polygonal meshes possessing the same combinatorics, where the space is characterized by non-linear constraints associated with mesh elements.

Example-driven synthesis involves the user starting the modeling by offering a set of examples, often objects belonging to the same category. Then, inspired by the provided examples, the machine generates more instances of the same type guided by some rules. Importantly, some of these novel synthesized new instances are unexpected, which the user did not envision, yet, they all make sense, and follow the inner logic of the input examples.[5] However this method does not address the inspiration aspect and is more of a data understanding problem. The primary goal is to understand of the commonality and variation among the input examples. This is a very hard problem in general, even within a shape category, thus most works are limited to certain types of data. A closely related modeling technique is suggestive modeling [4], where the system analyzes a given set of models offline and learn their structure and/or semantics. Then during the online, interactive modeling phase, a modeler is suggested with parts or elements to compose and alter products arising from these suggestions.

A common view is that creativity is innately linked with unpredictability or the elements of surprise [3]. Specific to 3d modeling, creative inspirations to modelers are often in the form of new models that were not envisioned and contain certain elements of unexpectedness. Encouragingly, unpredictability

Comparison and Modification of RL Agents for Parking

Mitchell Foo, Chloe Hong

***Abstract*—For our project, we explore the parking environment from *highway-env*, a collection of environments for autonomous driving and tactical decision-making tasks. Parking is a goal-conditioned continuous control task in which the ego-vehicle must park in a given space with the appropriate heading. We train policy-based, Q-learning based, and model-based reinforcement learning (RL) agents and compare their quantitative and qualitative results. We make modifications to the model-based agent's observation space and reward function as ways to improve its learning and customize the behavioral performance of the agent.**

I. Environment

The environment for our project comes from a collection of 2D environments called highway-env[1], of which we are using the parking environment. The environments are designed for decision-making in autonomous driving, where the primary agent is a car trying to navigate within a specific area or lane to avoid collisions or achieve particular goals. The parking environment consists of different parking spots where one is the designated spot for the agent to park in. The difficulty in this environment is for the agent to learn how to control the car's continuous actions of acceleration and steering.

The observations made by the agent in the environment are processed into a 6-length vector, which includes the x, y position and velocity of the agent and its angle of rotation described by $\sin\_h$ and $\cos\_h$. The episode ends when the agent vehicle is close enough to the goal, crashes, or the maximum time is reached. The agent has a continuous action space where it must control its acceleration and steering.

For our experiment, we explore ways to improve the agents against the vanilla model-based implementation by changing the rewards and observations to allow the agent more information about its environment.

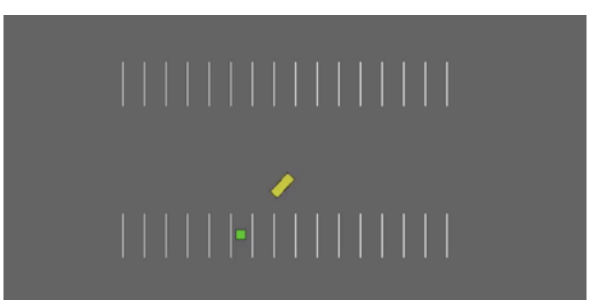


Fig. 1. Agent navigating in the parking environment

II. Reward Function

Rewards are given to the agent based on its proximity to the current parking goal. In order to calculate this distance as a reward, a weighted p-norm is used. If there are obstacles in the environment, the agent will also be given a negative collision reward.

For the reward function, let R be the total sum of rewards, let a be the agent's current position, let b be the goal's position, let w be the reward weights, and let c be the reward for obstacle collision.

$$R = \begin{cases} -\sqrt{|a-b| \cdot w} + c & \text{if colliding with an obstacle} \\ -\sqrt{|a-b| \cdot w} & \text{otherwise} \end{cases} \tag{1}$$

III. Methods

With the current agent parameters, we notice that the environment is designed such that the agent is only aware of itself and is guided to the goal via the reward function. Though we recognize that this is the original author's intention for the environment, we also notice that it limits the agent's ability to observe where it needs to go. We make modifications to explore the potential for an agent to be more efficient with the given goal-based task by modifying the agent's observations and reward weights.

A. Modification 1: Change the input domain

In the current input domain, the agent observes a six-length vector that includes its position, velocity, and rotation. Our proposed modification is to include the position of the goal within this observation, extending the observation to be an eight-length vector.

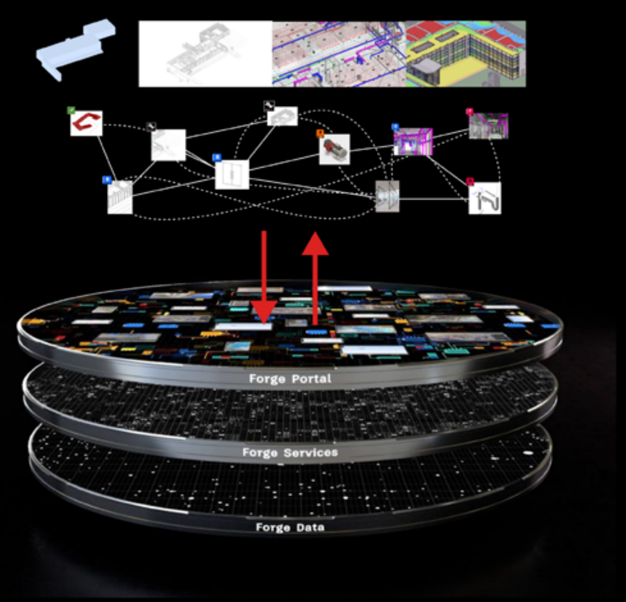
We hypothesize that information on the position of the goal can aid in the agent directing the vehicle more efficiently to the goal. Our current observation of an agent trained in the current environment is that because it does not observe the goal, it begins moving in a random direction at first to learn towards which direction it actually needs to move in. Being able to observe the goal directly could potentially eliminate this initial exploratory step.

To implement this addition, highway-env's **observation.py** handles all the different observation classes for its varying environments. The parking environment uses the *KinematicsGoalObservation* class, which allows for calling the observation of the agent, the observation of the agent's achieved goal,

AUTODESK - DESIGN DATASET FOR INTELLIGENT DATA EXCHANGE

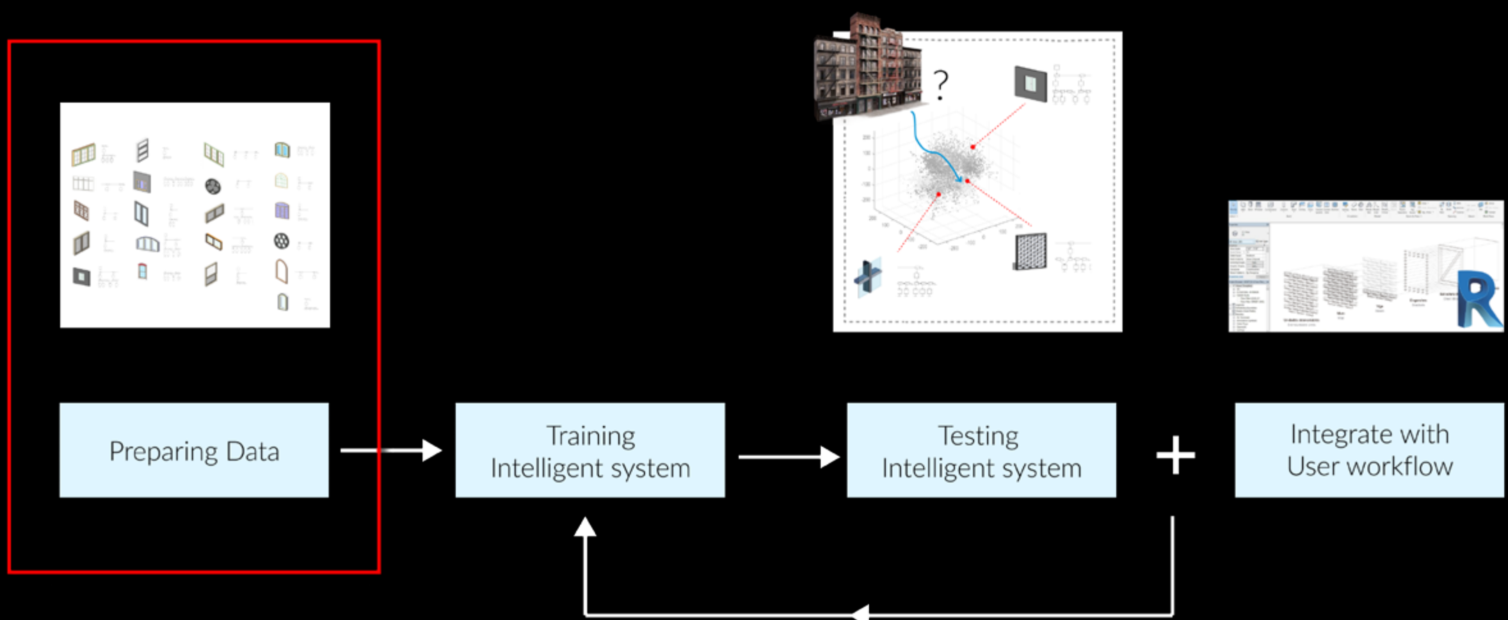
YEAR : 2021
TYPE : Professional
ASSOCIATION :
Autodesk
Experience Visualization Intern,
Strategic Technologies Division

During my internship at Autodesk, I proposed a novel way of design data exchange using machine learning(ML) within 3d modeling softwares that can predict the user intended topological structure of 3d geometry and as an initial step create a 3d dataset with labels of its compositional and relational information. This shed light on ML-based subsystems for Autodesk's cloud platform Forge to facilitate design data exchange and allow interorperability of different design softwares. I devised a novel error-based approach to extract user annotations of dimensions and geometric constraints from Revit 3d models and output a graph that encapsulates the topology of the geometry and user intentions. While developing this work, I actively gained insight from teams in Generative Design, Human-Computer Interaction, and Artificial Intelligence. With this project, I propose a machine-learning based system infornation.



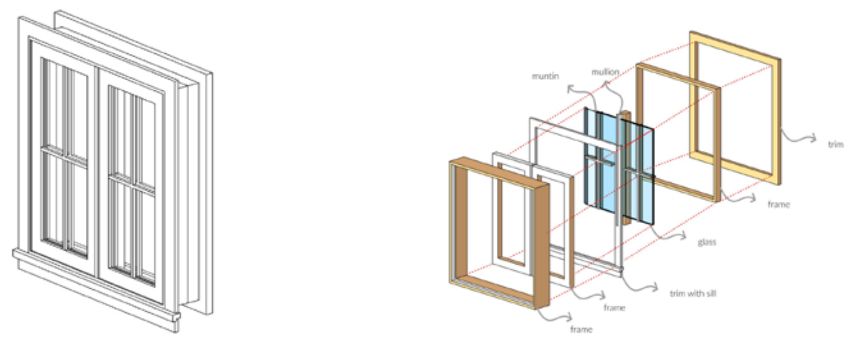
Autodesk's Cloud Platform Forge seeks to facilitate the exchange of design data which is complex.

How do we represent, encode and decode users' intentions in design data effectively?

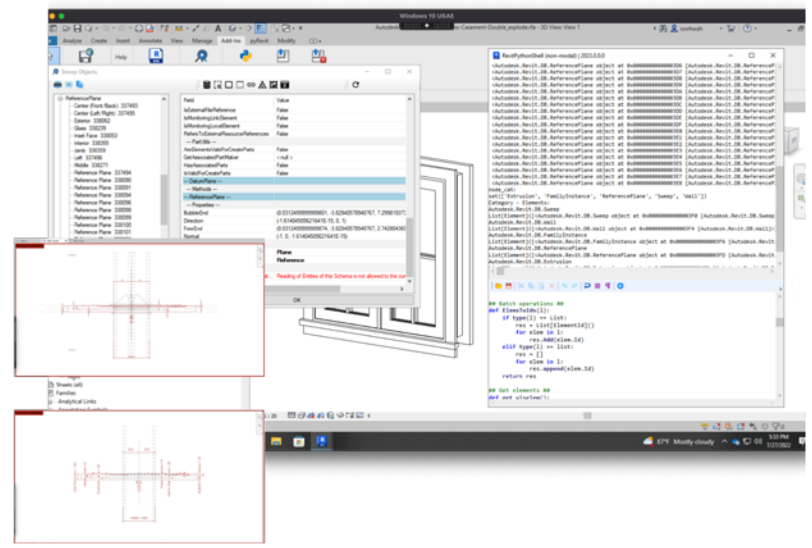


With this project, I propose a machine-learning based system that can predict the user intended topological structure of 3d geometry and as an initial step create a 3d dataset with labels of its compositional and relational infornation.

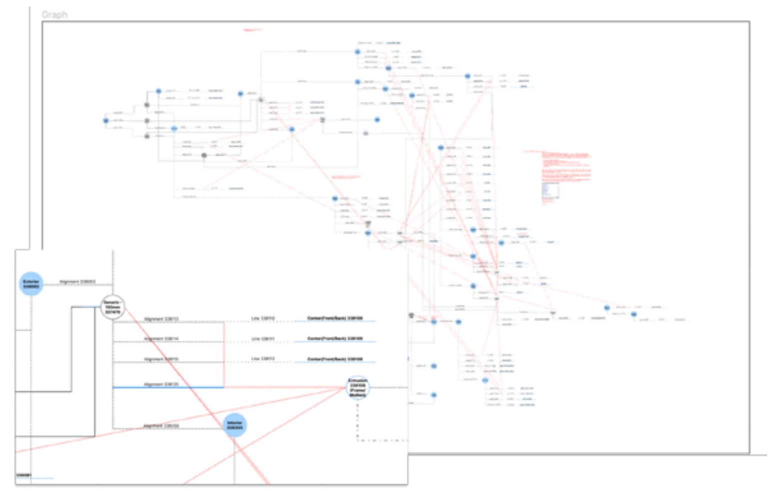
1. The compositional and semantic topological information of 3d models is easy for the human expert user to define, but is a non-trivial task for the computer.

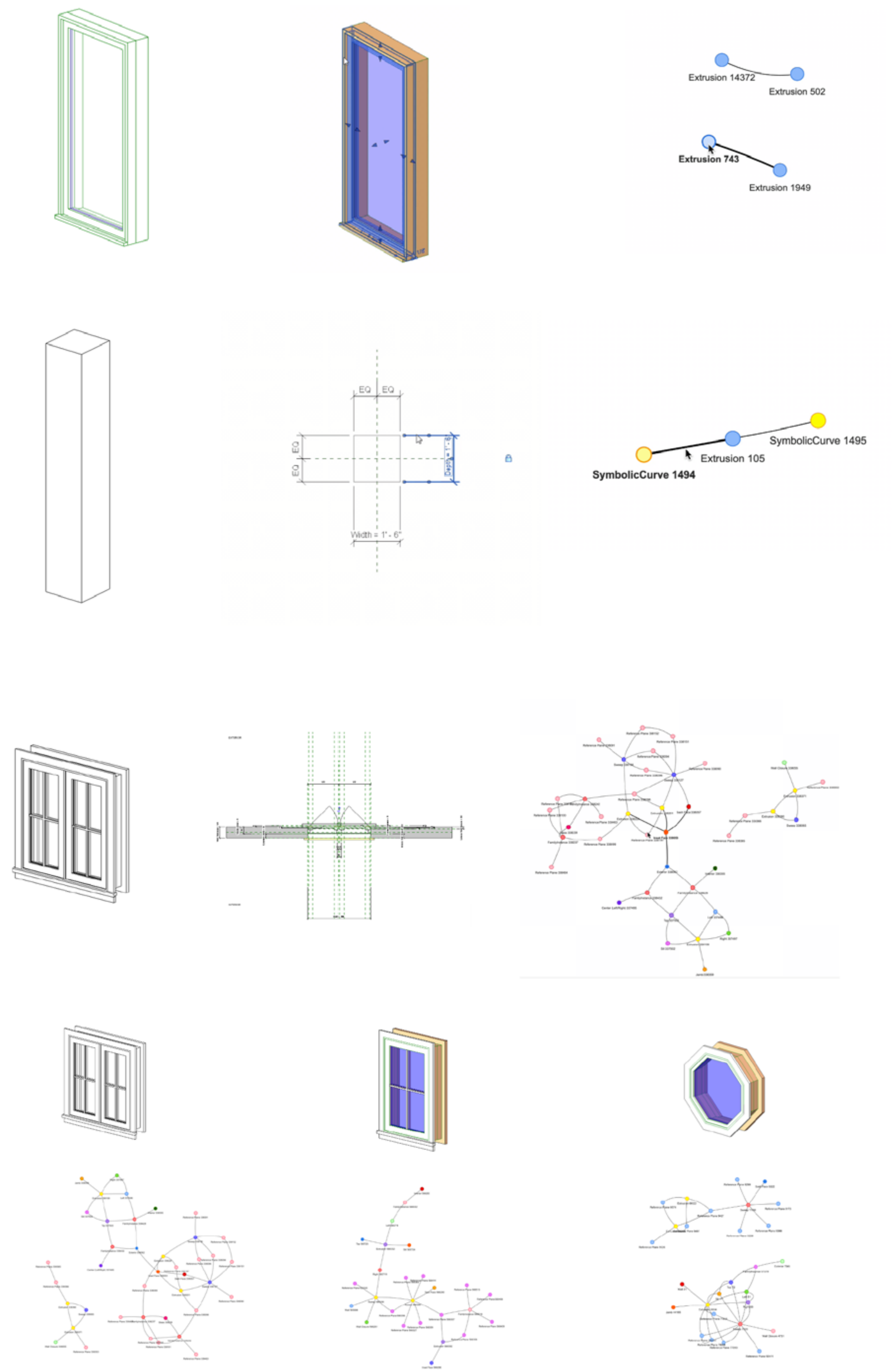


2. Structures of 3d models within Revit and their annotations reveal the designer's intentions.

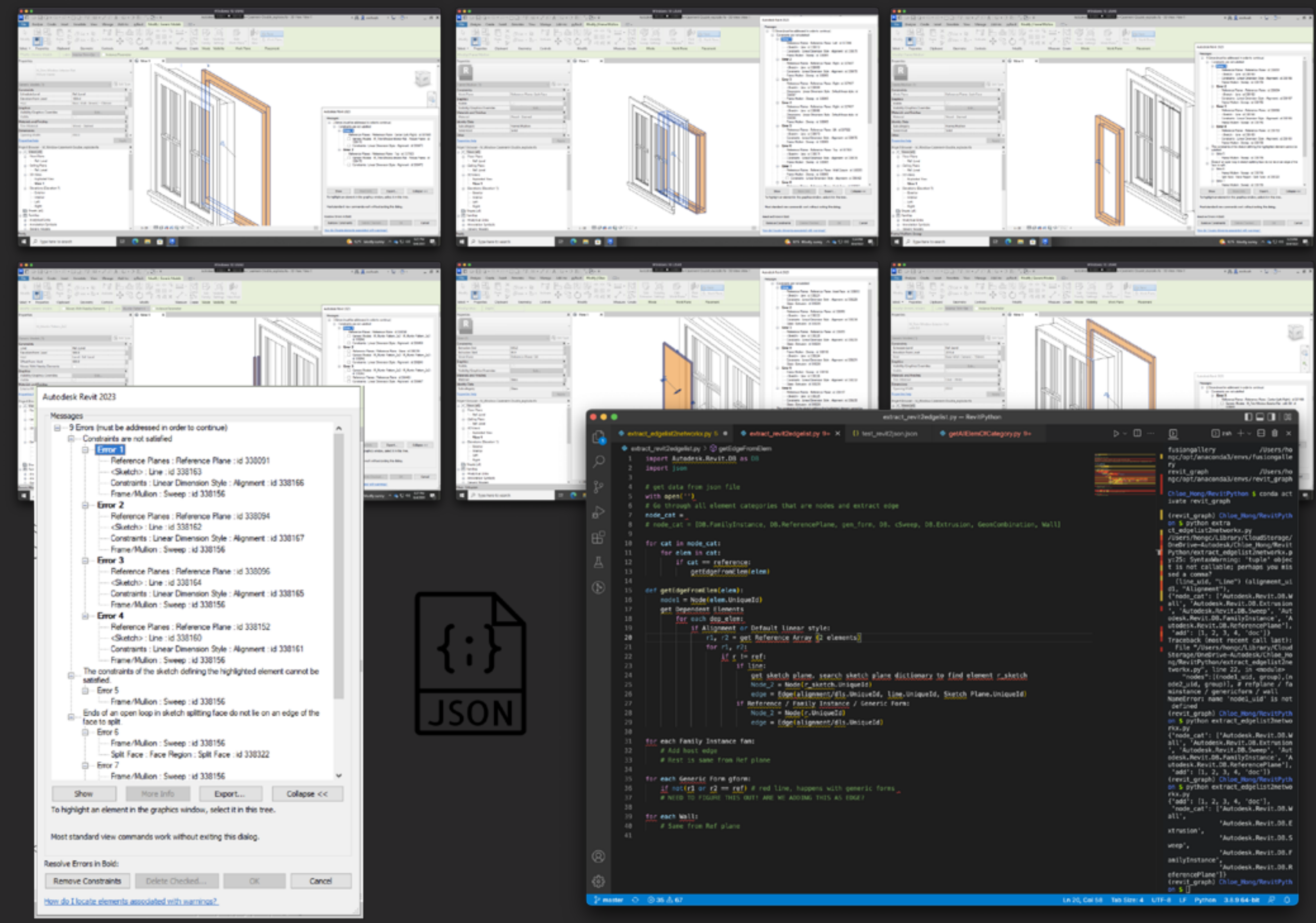


3. Graph structure from geometric elements and their alignment constraints embed the the topology of the 3d model.

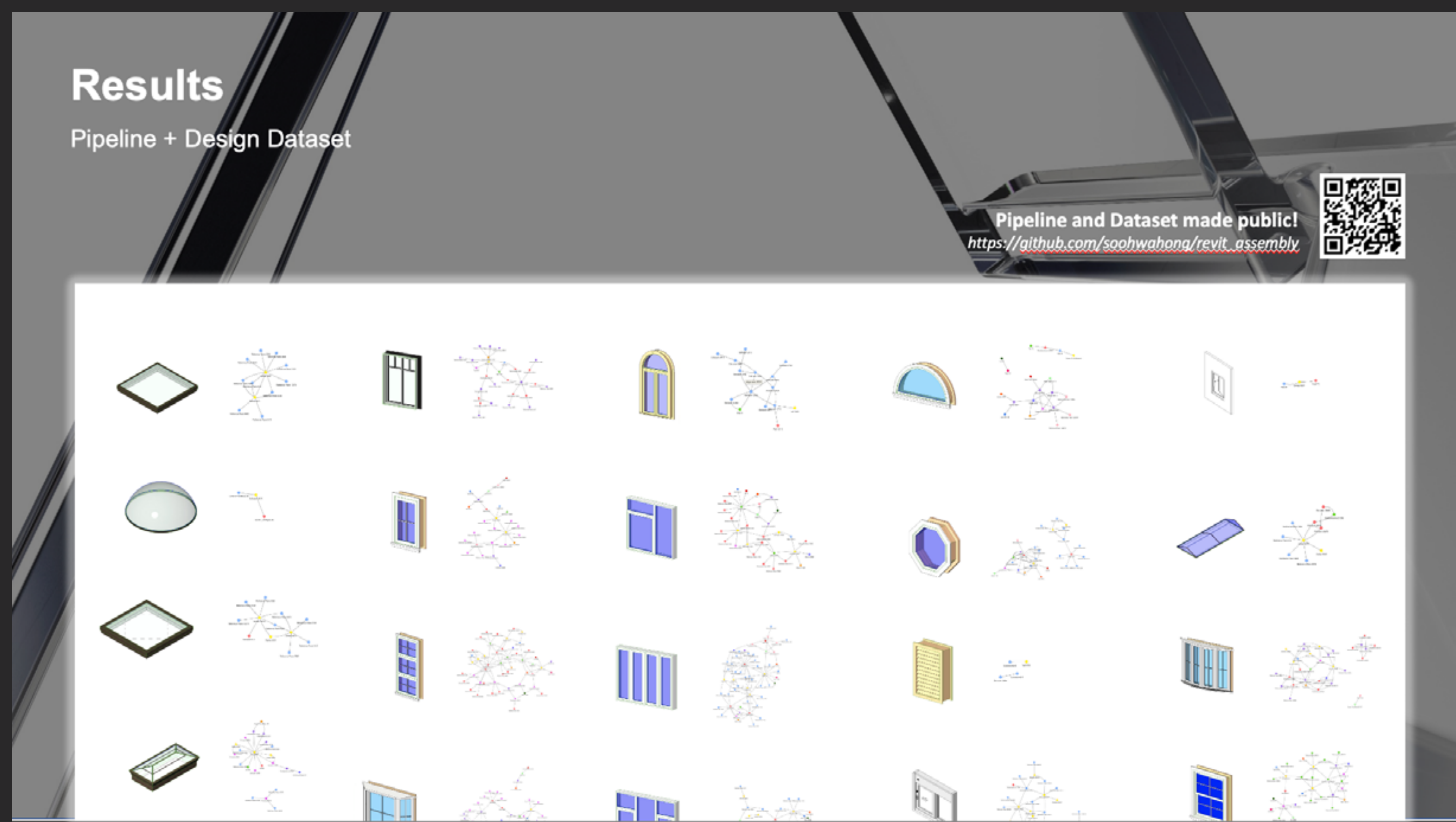




3d model to graph structures : Nodes are geometric elements (solids, reference planes) and edges are alignment constraints. Graph structures of various windows reveal potential representations of distinctive features which can be interpreted by a machine learning model.



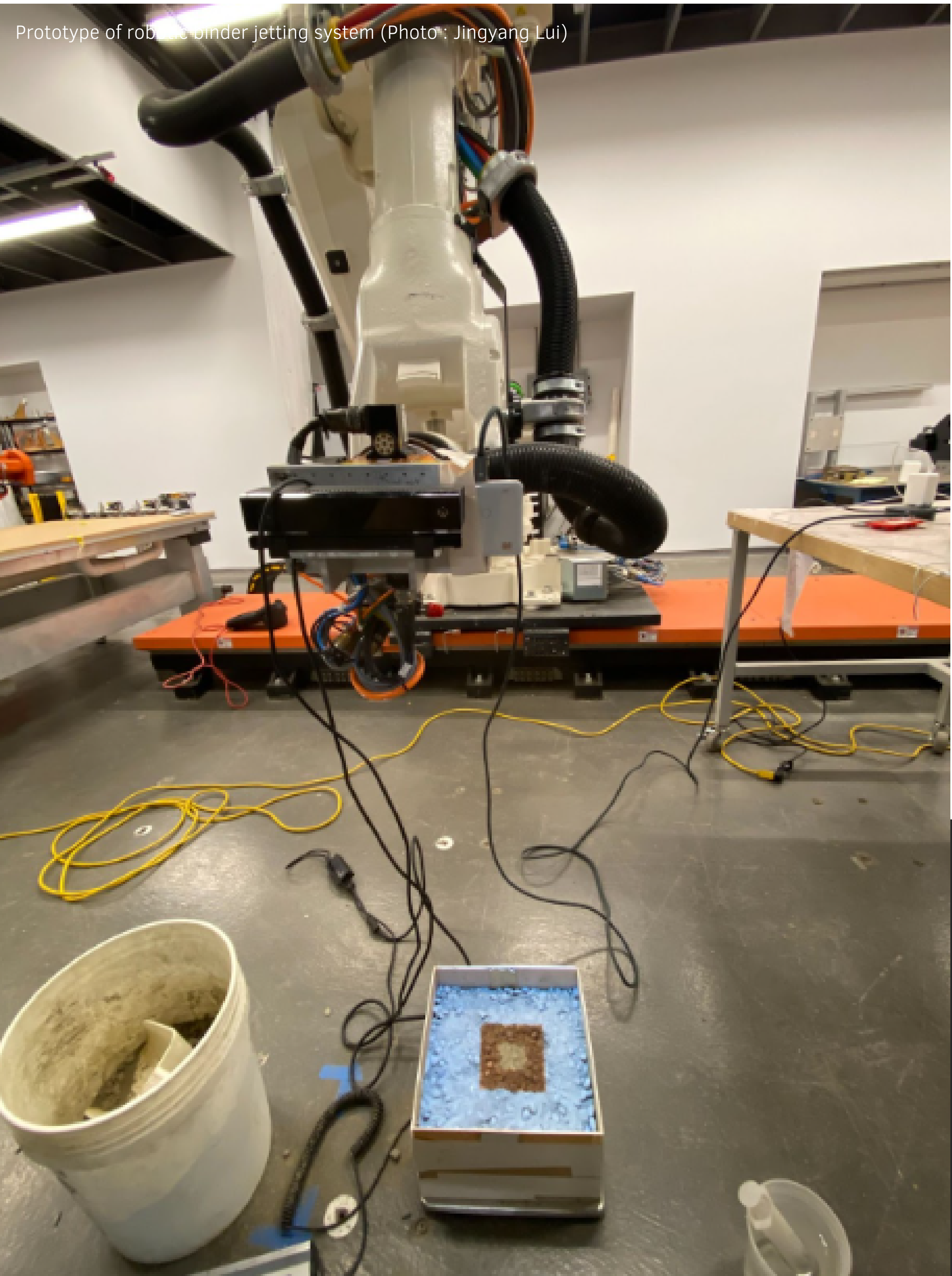
3d model to graph structure : I devise an error-based pipeline within Revit to extract the graph structure from 3d models.

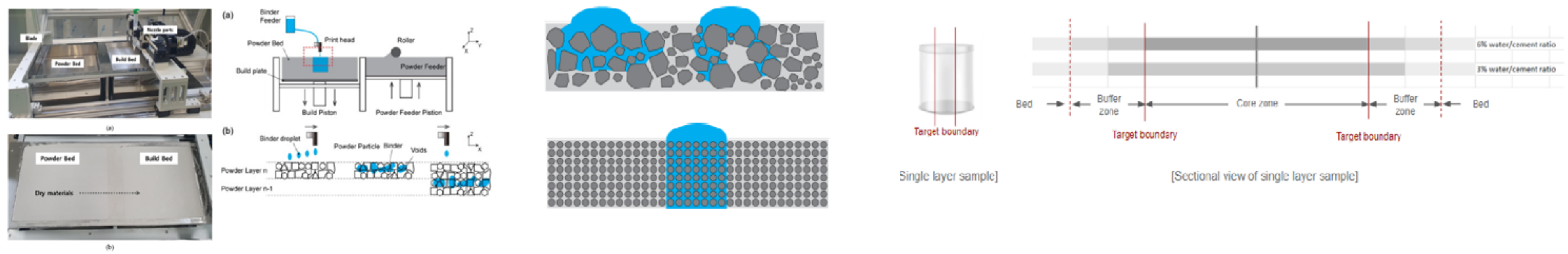


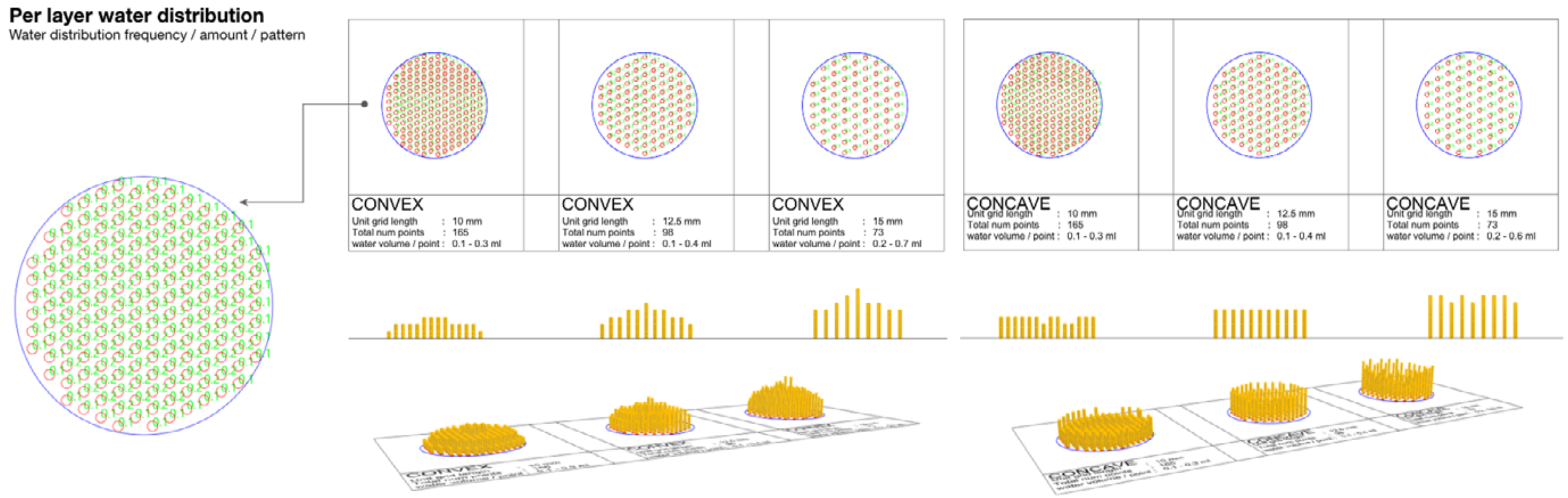
CONCRETE BINDER JETTING

YEAR : 2021
TYPE : Academic
ADVISOR : Prof. Joshua Bard
TEAM : Jingyang Liu, Linxiaoyi Wan, Jiying Wei
ROLE : material experimentation design and execution, computational simulation tool development

I took part in research developing a robotic concrete additive manufacturing system at CMU with Professor Joshua Bard. This research project presents a selective binding approach to produce highly customizable concrete components and contributes to the domain of concrete selective binding. I designed material studies to visualize and quantify the permeation patterns of the binder within the concrete batch at a macro level and developed a physics-based particle simulation tool with Grasshopper that predicts water absorption and penetration at the micro level. The experiments and dynamics models informed the software printing parameters such as binder-to-aggregate ratio, print layer thickness and printing speed, and hardware design such as the printing nozzle.


Prototype of rob... binder jetting system (Photo: Jingyang Lui)

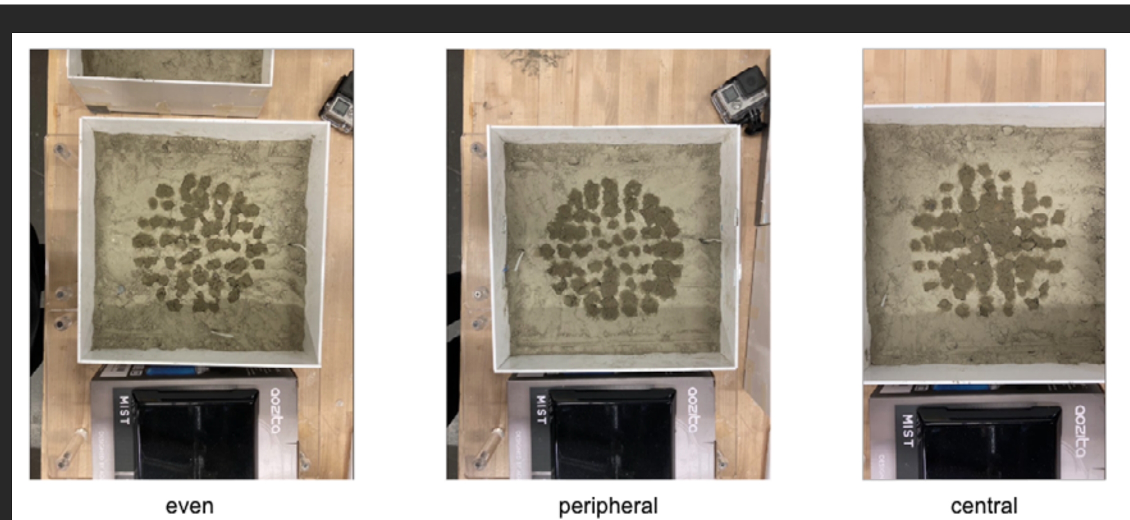




(top)
1. Applying Binder Jetting mechanics to concrete building.
2. Cement batches are composed of heterogeneous particles that demand different hardware and modulation of binder deposition patterns. 3. Defining target boundaries in terms of water spread

(middle)
Variations in water deposition patterns given fixed total amount.

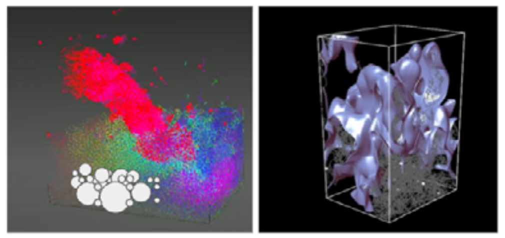
(bottom)
Experiments of water deposition patterns on concrete batch.



Material - Computational Simulation

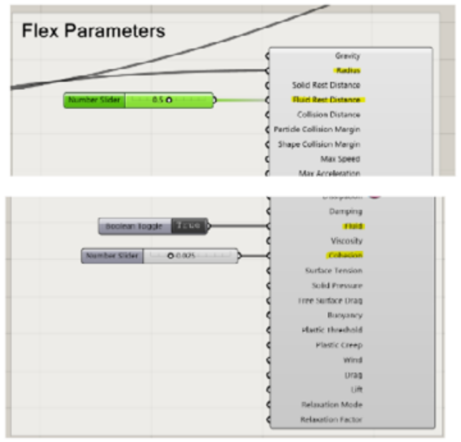
Physics-based Modeling
(Micro-level) Binder migration in concrete aggregates
(Macro-level) Saturation Rate, Capillary Pressure
Model properties
Adjust model
Empirical Study
Hypothesize
Identify deciding factor

Computational Simulation

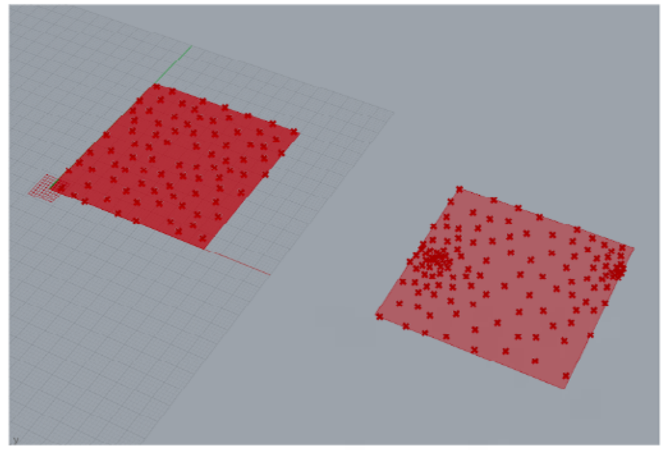


Flexhopper
Grasshopper plugin
CFD (Computational Fluid Dynamics) software
Uses NVIDIA Flex as computation core
https://www.youtube.com/watch?v=BzEqzd0iF2Q

Guide for 3d printing parameters
(layer thickness, water droplet spacing, water volume, printing speed)

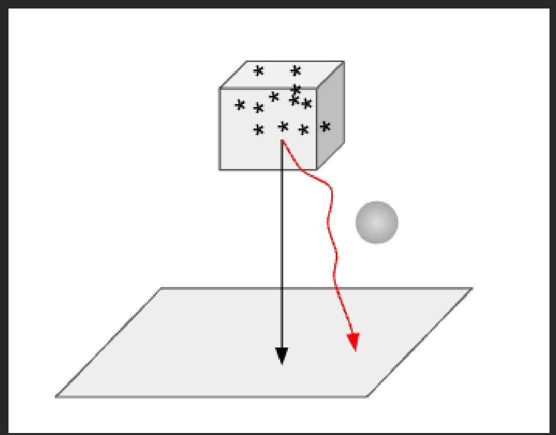


Parameters	Documentation	Test Parameters
Radius	most important parameters for the simulation because it specifies the maximum interaction distance of particles.	5
Fluid	When True : use a fluid density constraint to maintain a fixed rest density. The particle radius specifies the "smoothing radius" of the fluid kernels.	True
Rest Distance	The rest distance determines the particle density for fluids. This parameter is a fraction of the particle radius.	0.5
Cohesion	Cohesion is an attractive force between particles. It is responsible for much of the behavior we assign to fluids. ** Cohesion acts similarly to surface tension but tends to generate longer filaments of fluid rather than rounded droplets.	0.025
Surface Tension	Surface tension is the tendency for liquids to try and minimize their surface area. This is what gives rise to spherical droplets and the "pinching off" of a stream of water as it separates. ** Surface tension is quite expensive to calculate so it should not be enabled unless the situation warrants it.	0

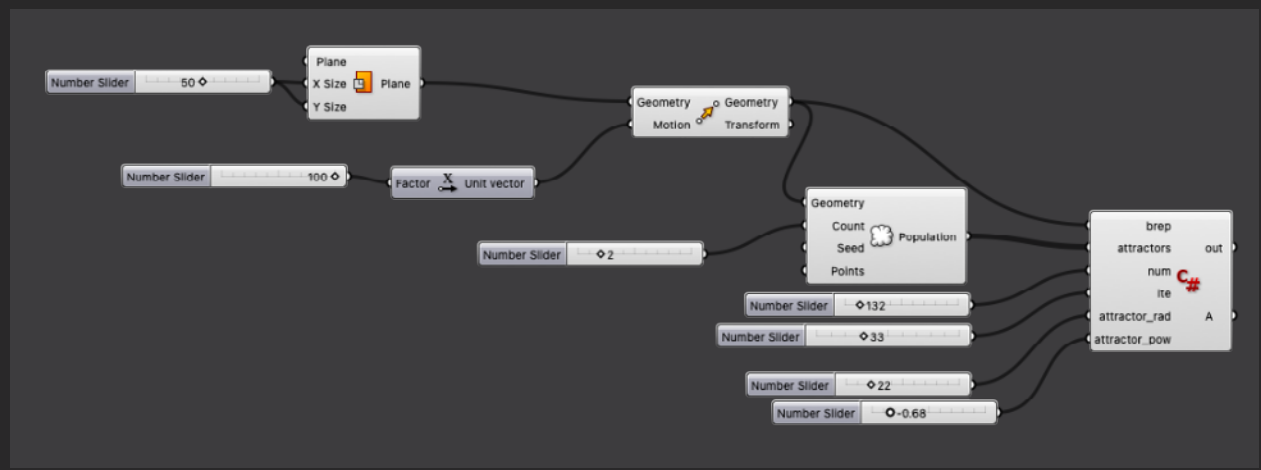


Rewrite Populate Geometry

Custom Populate Geometry (with attractors)

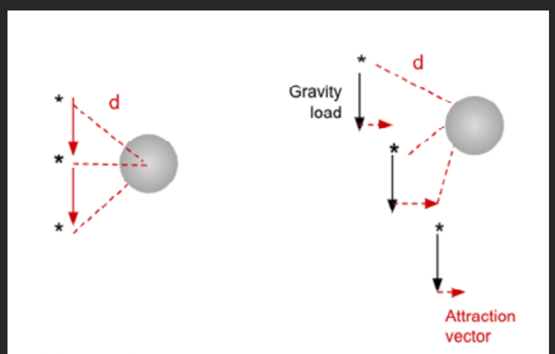


Dynamics of water droplet with attraction and bp-sorption from cement particle

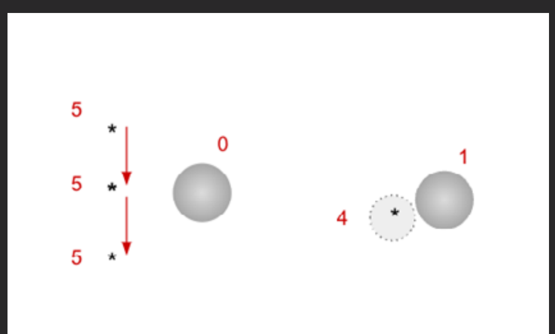


Custom Grasshopper component for water and cement particle attraction dynamics simulation

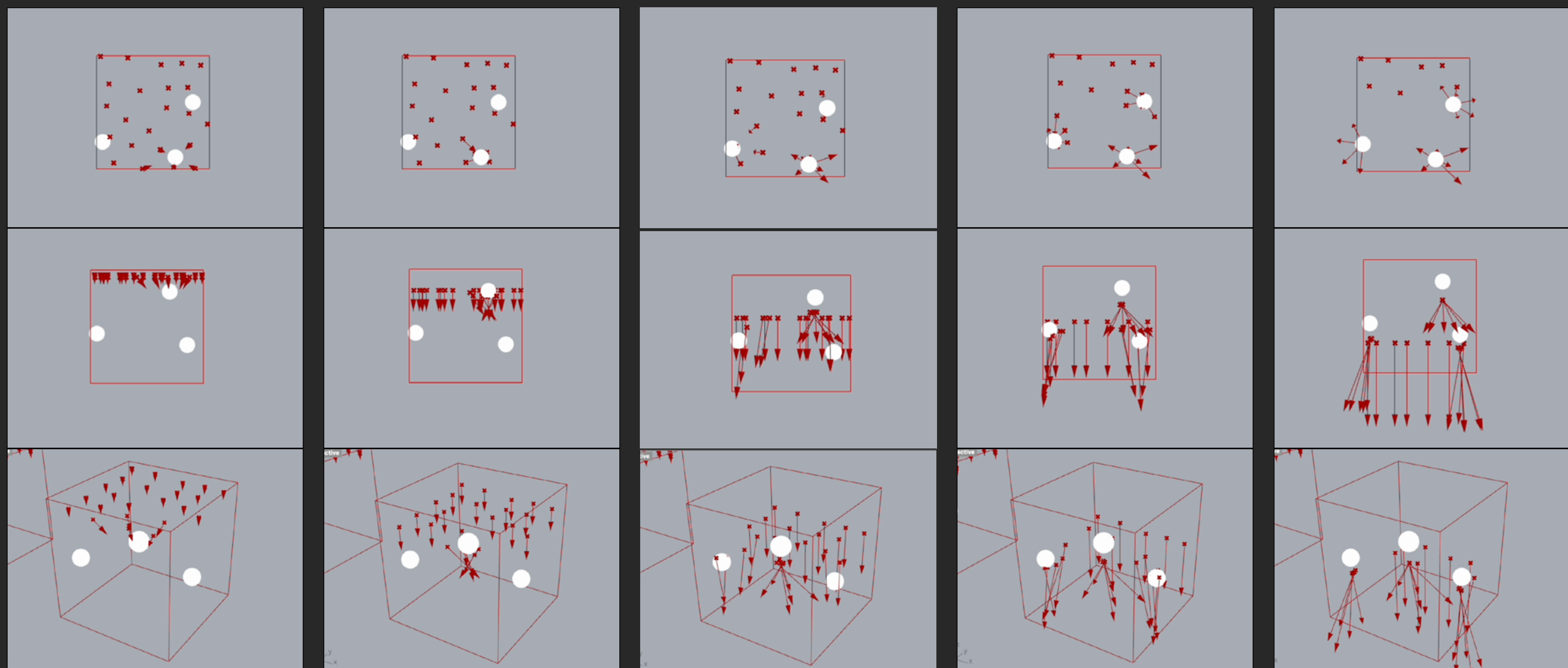
brep (BRep / Item) : bounding box to place particles on
attractors (Point3d / List) : list of attractor cement particles
num (Integer / Item) : number of cement particles
ite (Integer / Item) : randomization factor
attractor_rad (Double / Item) : size of cement particles
attractor_pow (Double / Item) : cement particles attraction factor



Movement : vector of gravity load + attraction (attraction = attraction factor * distance between water and cement particle)



Absorption : water content exchange between cement particles and water droplet



CUBESCAPER

YEAR : 2021
TYPE : Academic

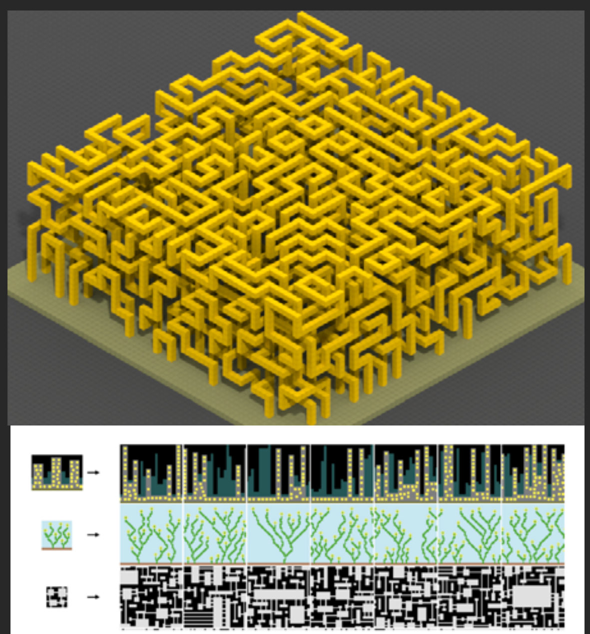
This project is a constraint based 2.5D world generation. It involves a set of tiles in the form of cubical 2.5D isometric geometry and the Wave Function Collapse algorithm (WFC) (Gumin,2016) to place tiles according to the tile set's connectivity rules.
Existing applications are mostly in 2d and the very few that are in 3d are implemented in game engines and written in C#.
This project seeks to implement a higher dimension world generation in python within the CMU graphics framework. This would involve resolving performance issues by scaling the setting and constraints. Also it will provide a novel 3d tile set that can serve as a maze or generate interesting 3d patterns.

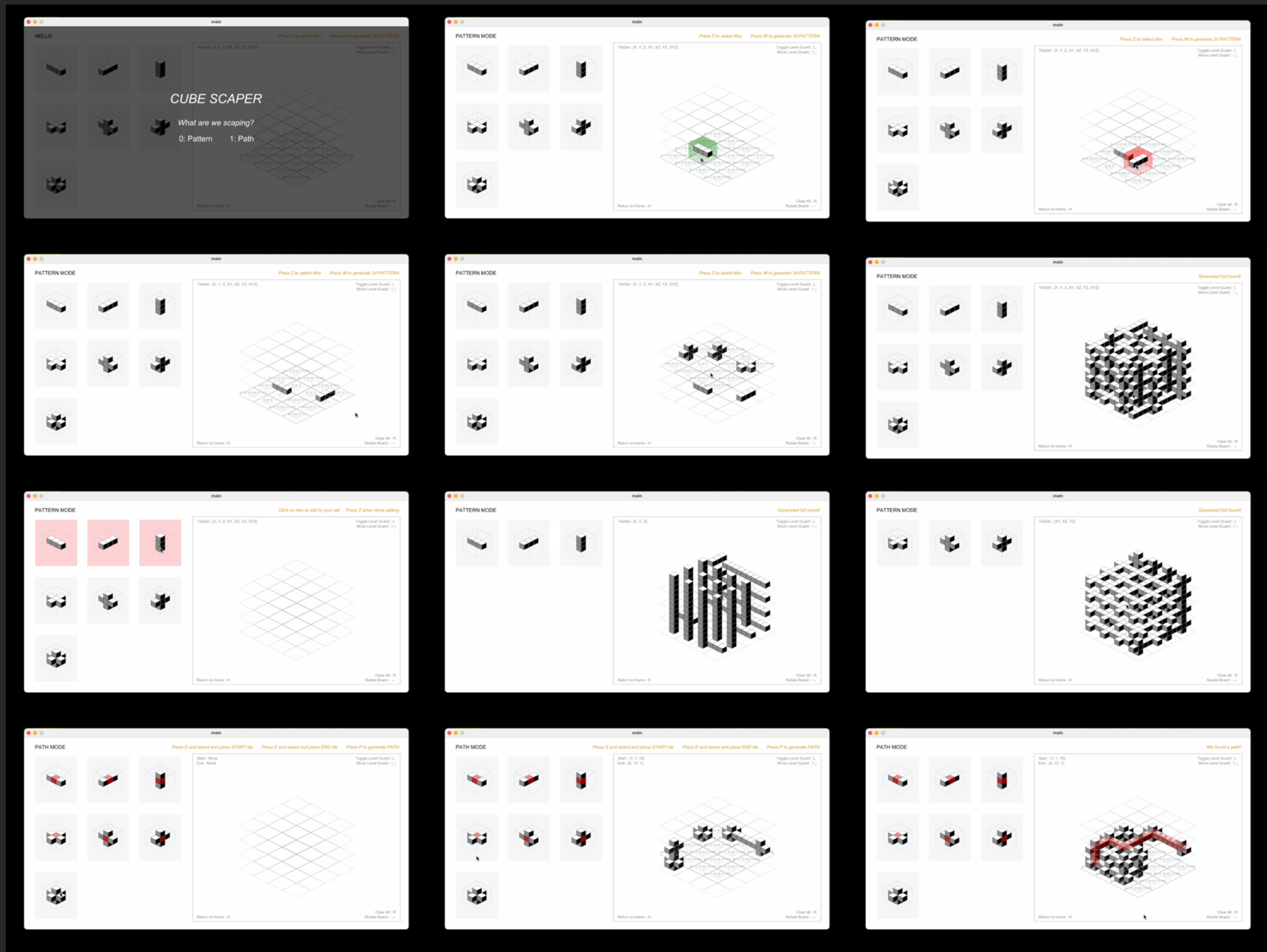
(row 1)
Selection of pattern generation & path finding mode
(row 1)
Blocks can be placed if adjacency constriaints are satisfied across the grid
(row2)
User can scroll through levels to place intial blocks within the cube shape board
(row 2)
Given the initial blocks, the system can auto generate a pattern across the grid
(row3)
The user is given the option to select a subset of blocks to use for pattern generation
(row 4)
The path finding mode finds a path that goes through a given collection of blocks

GITHUB page
YouTube page

Resources
- Gumin, M. (2016). Wave Function Collapse. https://github.com/mxgmn/WaveFunctionCollapse.
- CMU Graphic framework

example of 2d and 3d pattern generation with Wave Function Collapse algorithm.

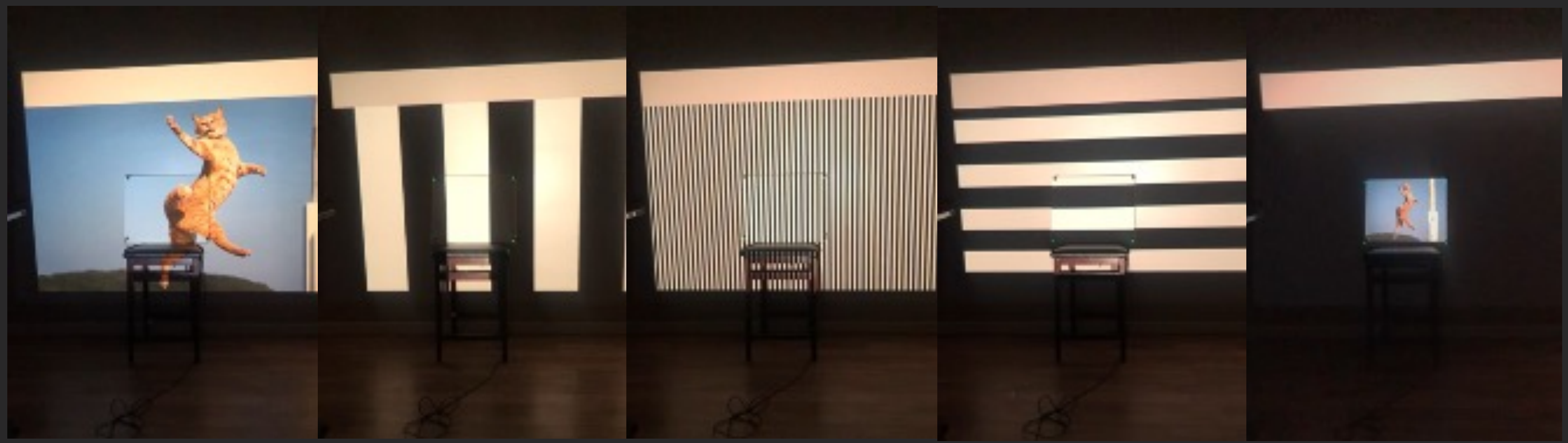


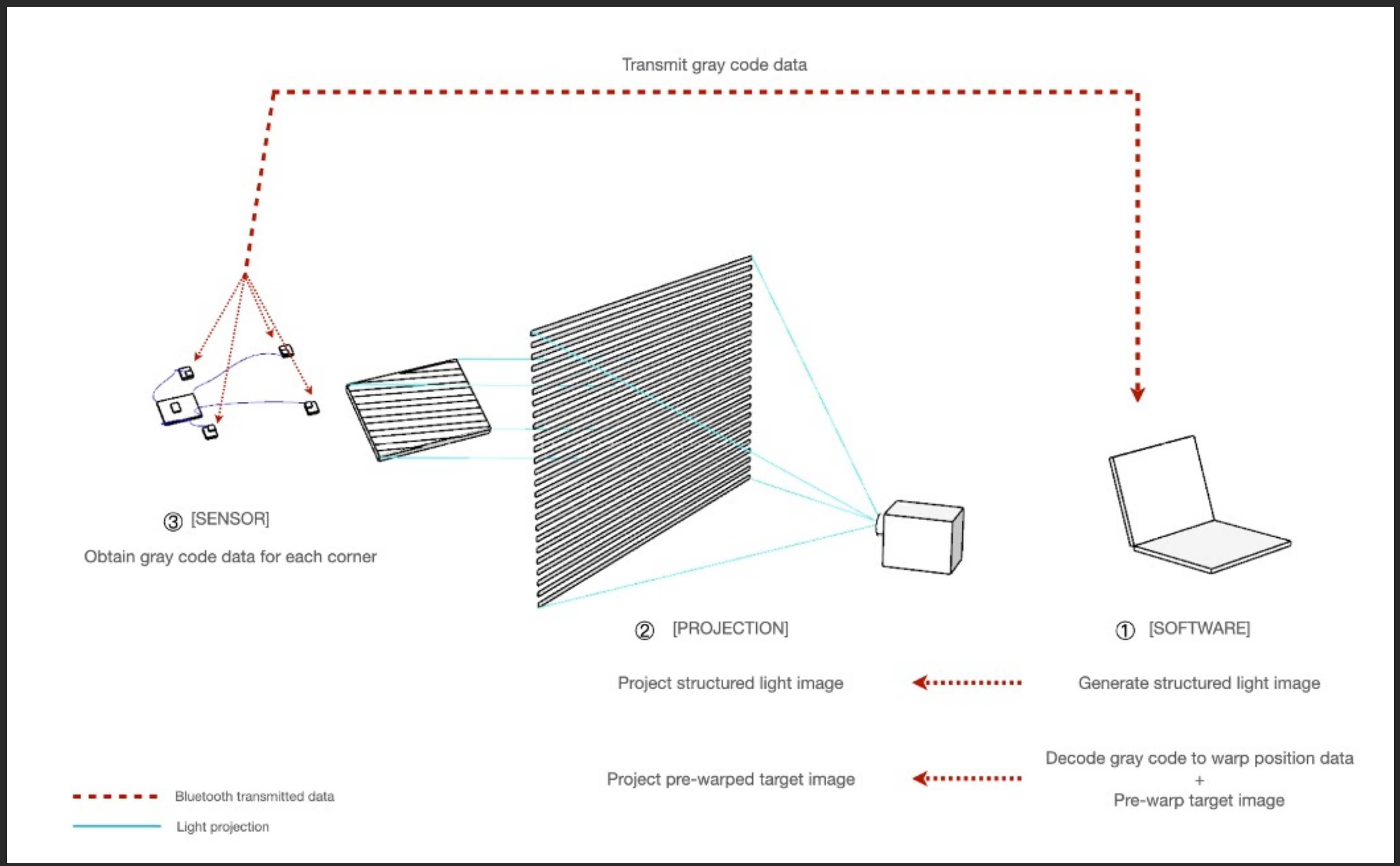


ACTIVE PROJECTION

YEAR : 2021
TYPE : Academic

In this project, I present a sensor based projection mapping system as a preliminary step towards making dynamic projection mapping accessible and using projection to visualize and prototype with 3d forms. Projection mapping involves the a computational process of spatially mapping the display image or video interacting with the projector to fit any desired image onto the surface of a 2d or 3d target object. Conventional projector systems are restricted to project onto planar surfaces and place several constraints on the geometric relationship between the projector and projection surface which limits its use in prototyping 3d geometry which involves non planar surfaces that change with iterations. I propose a robust and simple and low-cost method that eliminates many of these constraints. The system involves embedded light sensors in the target surface, project Gray-coded binary patterns to discover the sensor locations, and then prewarp the image to accurately fit the physical features of the projection surface.

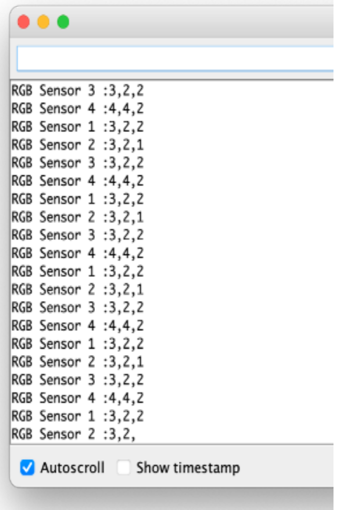


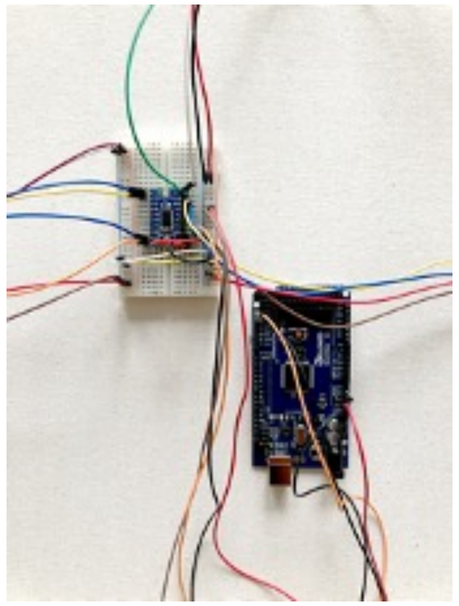


I2C Multiplexer
(TCA9548A)

RGB Sensor
(TCS34725)

```
// *************************************** general setup
    Wire.begin();

    Serial.begin(115200);
//    Serial.println("\nTCAScanner ready!");

    for (uint8_t t=0; t<8; t++) {
      tcaselect(t);
//      Serial.print("TCA Port #"); Serial.println(t);

      for (uint8_t addr = 0; addr<=127; addr++) {
        if (addr == TCAADDR) continue;

        Wire.beginTransmission(addr);
        if (!Wire.endTransmission()) {
//          Serial.print("Found I2C 0x");  Serial.println(addr,HEX);
        }
      }
    }
//    Serial.println("\ndone");
```

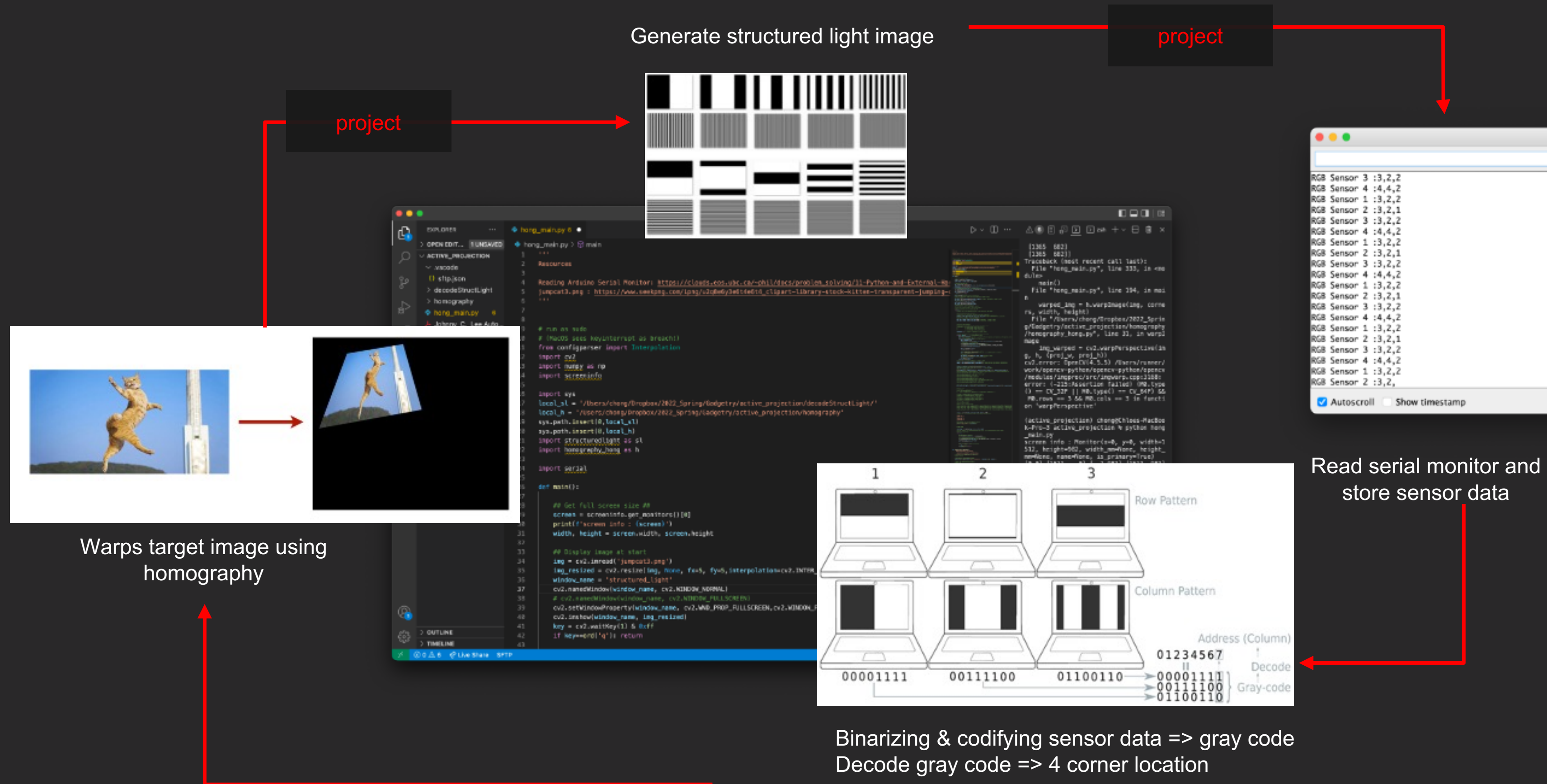




(left top)
projection mapping demo
(left bottom) system diagram
(right top) sensor data encoding
(right bottom)
target surface prototype

Demo of active projection

Software system diagram



Experiments with orientation and tilt
1. orientation
2. forward tilt
3. extreme orientation

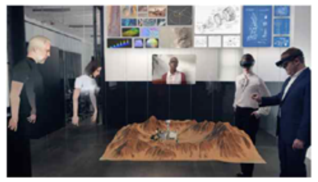
BIDIRECTIONAL TELEPRESENCE SYSTEM FOR CO-LIVING

YEAR : 2021
ADVISOR : Prof. Youngki Kim
(Human-Computer Interaction)

I propose a human-centered projection-based bidirectional telepresence system that enables two parties in different locations to feel as if they are co-living. The proposed system integrates computer vision techniques to sense user attention through gaze and involves translation of coordinates of two different spaces based on their functional and spatial features.

Limitations of contemporary telepresence systems

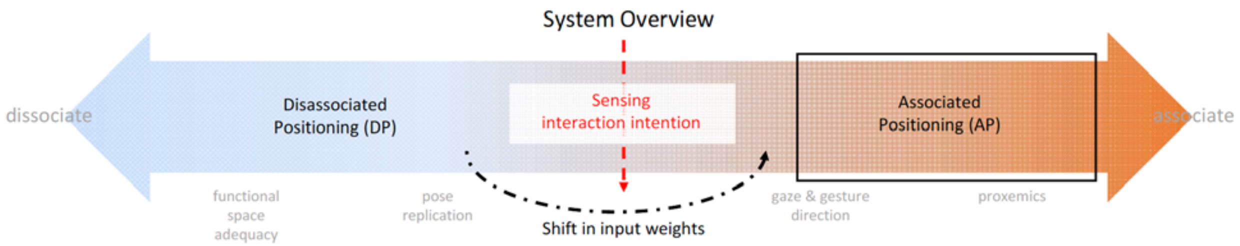

requires full attention

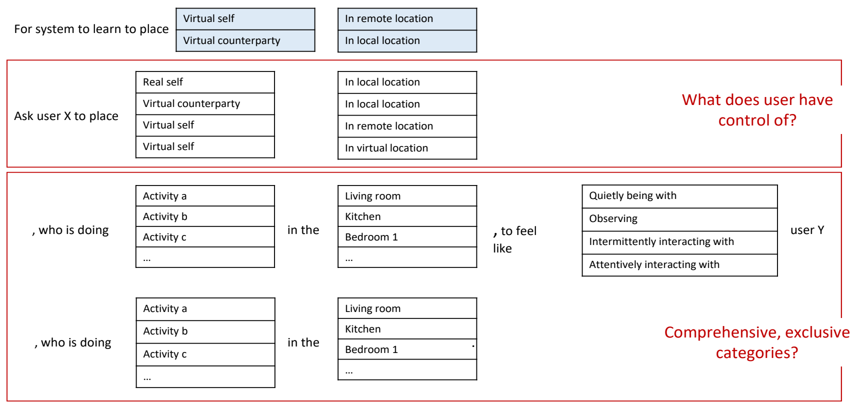

bounded to limited activity space


cognitive strain in navigation


asymmetry in view field, mobility, expression, self awareness

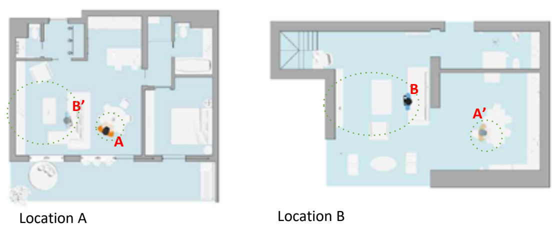
Telepresence system that supports co-living





Quiet Companionship

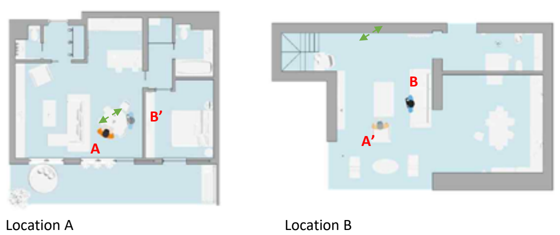
- disassociated
- users focused on own task but "feels" presence of other



activity accommodation ↑
functional space ↑
interpersonal distance and direction ↓

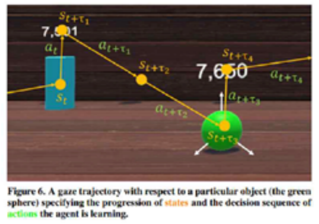
Close Interaction

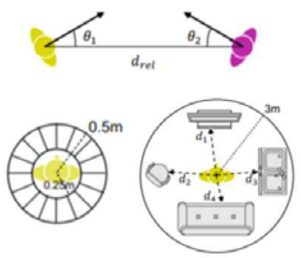
- associated
- facing each other, referring to common object, surface

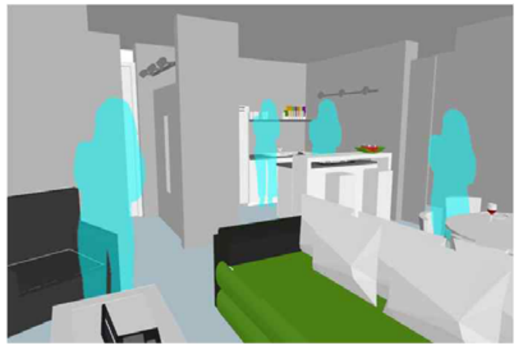


activity accommodation ↓ ↓
functional space ↓
interpersonal distance and direction ↑ ↑

Projection location logic based on user gaze and space program

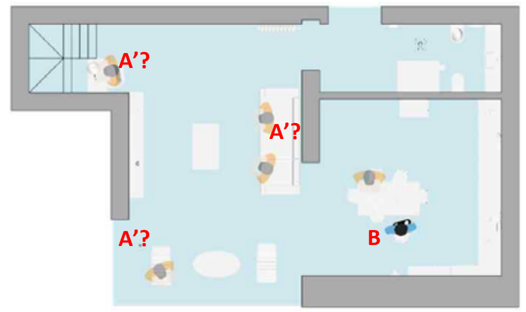





A view point

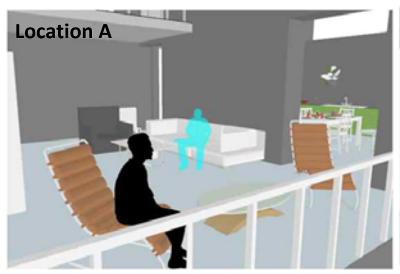

B view point

Location A



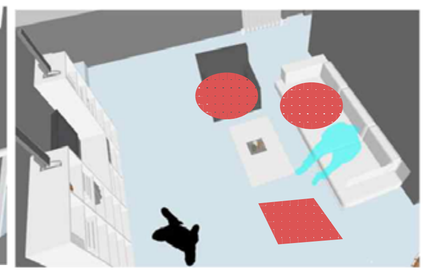
Location B

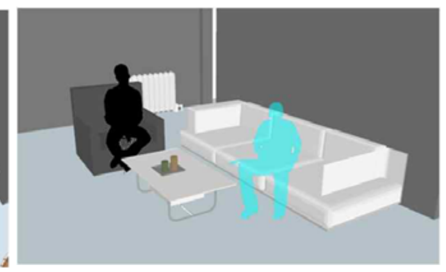
Example situation: starting a conversation

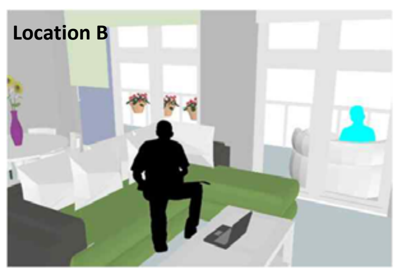


Virtual user B' in DP (default)

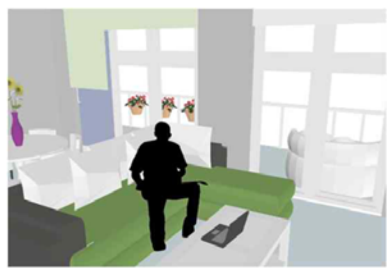

Interaction intention of local user A is sensed

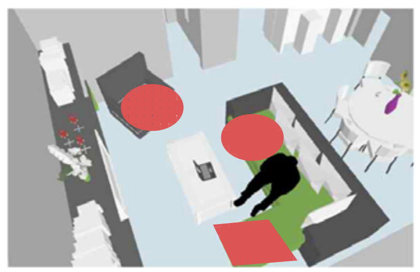

System suggests plausible interaction points for A to move to.
(Position of B' is unchanged)


A moves to interact with B and settles.



Virtual user A' in DP (default)


When A' is in movement, does not project.


System indicates A is initiating interaction.
(A' is not shown until settled)


System places virtual user A' in AP