Democratic Play:
crowd-sourcing through games for architectural design

by **Joshua Choi**

B.A. at Washington University in St. Louis, 2010

Submitted to the Department of Architecture
in Partial Fulfillment of the Requirements for the Degree of
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Abstract

This thesis presents a system that uses games. It allows people to participate in the process of designing an architectural space. The site for the design project of this experimental methodology is a courtyard on MIT campus.

The games are initially prepared by the architect through sampling various objects, materials, lighting, and figures from different media such as photogrammetric models around the building site and other relevant 3D modeling/animation contents. The goal of this design system is to collage those components into a final architectural form through a democratic process.

The games are distributed to students, faculty and staff who will be the users of the space being designed. Through playing these games, they provide preference about the architectural program and various design decisions regarding formal composition, details, and finishes. This crowd-sourcing occurs both implicitly and explicitly while the game is being played, and the collected feed-back informs the architect about design development.

This thesis questions the role of the architects in a democratic process of design: Are we the designer of the space, or creator of a system that controls the design process?

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GAME : democratic_design [play]
Persp

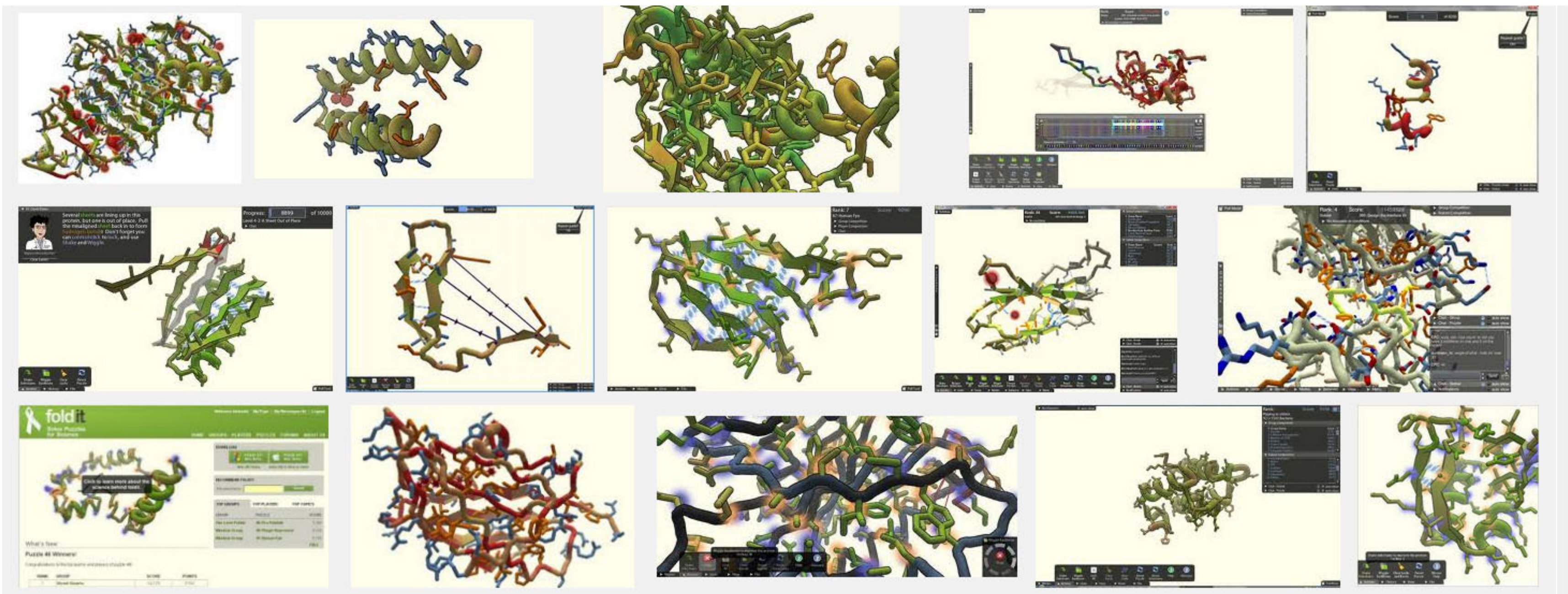
Democratic Play

by Joshua Choi

My thesis explores an alternative methodology for architectural design process by using a game as a tool for crowd-sourcing. The game invites people to participate in the process for designing architectural space. It is made to contain the necessary technical knowledge of architects, and enables ordinary people without architecture background to play. The process and result of their playing is recorded and reveals preferences people have about forms and functions of architectural design in progress. The crowd-sourced data from participants' preference then serves as a basis for further design development. This democratic design process allows architects to share decision-making power with the public.

But what is a game? It is distinguished from work, and often refers to unproductive entertaining activity. Key components of a game consist of goals, rules, challenges, and interaction to maximize fun. Yet, there are also other types of games called 'serious' game or 'applied' game: a game designed for a primary purpose other than entertainment. It serves as a problem-solving tools for education and scientific exploration. A good example of such a 'serious' but fun game is Fold-It.

Fold-It - resulting data from different players



Fold-It is an online game which has a primary goal of solving on-going scientific problem about proteins. It demonstrates the power of a game as a tool for problem solving. In this game, players interact with protein structures to unfold them using user-friendly interface and algorithms. This game resembles an advanced version of Tetris; it uses scientific information about proteins as gaming blocks instead of four different shapes of blocks used in Tetris. Most high-scorers of Fold-It are around the age of fifteen with little knowledge in bio-chemistry. But the data is still very significant, and scientists use the data for real experiments. This online game has attracted more than 50,000 players, and it is proven that its input is more powerful than computers predicting the three-dimensional structure of proteins. Recently, a fifteen-year old problem in AIDs was solved in just three weeks of game-play: user data helped decode complex protein structures. Fold-it provides optimism about having the public involved in science whose input is not scientific but creativity and energy spent in game plays, which translates into solutions for real world problems.

Two key components of a 'serious' game are the ability to simulate real world problems and potential for easy distribution to people. 'Serious' game is a powerful platform for simulating real world problems in computer language, which can handle scientific equations and algorithms that are almost impossible by hand drawings. It attracts people for entertainment purpose, serving as a tool for crowd-sourcing data. Therefore, it is crucial to create user friendly interface so that people do not need to spend time understanding the idea behind the game. They only need to play the game for fun to provide meaningful data. To adopt those two components for the thesis project, I used two emerging technological tools: game engine for crowd-sourcing; and photogrammetry for capturing architectural information for simulation.

Can residents participate in the design of their houses, because architects do not get the idea correctly?

Architecture Machine
Negroponte, 1968

During the thesis project, game engine is served as a three-dimensional platform for simulation of architectural information. Game engine can easily simulate navigation system, environment recreation such as weather, wind, and sound, human density, and physics for structures. Rather than having only the conventional architectural drawing on the two-dimensional paper, game engine, thanks to simulation tools, facilitates sharing of ideas between architects and the public. Most clients are not trained as architects, so architects often make decisions that are unexpected to the client. It is very hard for people without architectural knowledge to participate in the design process, which gives architects the sole decision-making power in designing; this diminishes the preferences of the future users. By using games for the design process, my thesis bridges the missing link between the architects and the public. Game serves a tool and a solution to bring participatory design into architecture, and generates space designed by the public.

Participatory design took off in 1970 in Scandinavian countries. It focuses not on the style of a design, but on the process of designing. It democratizes the design process, which creates an environment where the design is more responsive and suitable for future users; it achieves this by incorporating users' behaviors and preferences. My thesis creates games that focus on collecting future users' interest and preferences, and their input serves as the main source that drives the design development. This participatory design with games, that I call 'Democratic Play, encourages the public to get involved deeply in the design process to create more friendly space for them. In my model, architects incorporate all the necessary architectural knowledge into games that guide participants, who may lack architectural knowledge but can enjoy the game and provide feedback that is accurate and relevant for the design development.

The game should contain accurate and abundant architectural information to control the quality of people's input during the game play. To extract architectural data accurately and fast around the site—MIT campus—I used photogrammetry. Photogrammetry is a science of extracting three dimensional information from an object with photographic texture. For instance, Google map's three dimensional landscapes and buildings are photogrammetric information captured through satellites. Photogrammetry has been used in architecture restoration where existing condition must be kept accurate to study. However, during architecture design process, existing condition is generally re-created using 3-D modeling tool, which makes the existing condition simplified without textures. Frequently, architectural renderings shows site condition with white boxes for adjacent buildings on a flat ground without actual topography. This occurs because too much time is required to re-create real site condition manually. Photogrammetry can help architects capture 3-D models of existing condition with photographic textures. With photo-realistic setting, participants have better experience when participating in the design process, which help them provide better data.

My thesis project, Democratic Play, is consisted of three steps. In the first stage, architects prepare necessary architectural information to set up a game through intense research and capture of significant objects using photogrammetry. In step two, using collected data, architects create games with user-friendly interface. In the third step, architects distribute games to the public, or future users, for crowd-sourcing feedback. Then architects analyze the data for the design development. The last stage can be repeated multiple times for further design development with updated games.

For the first step, I began with a site research, and prepared programs for the site. The site consisted of a courtyard of MIT campus, an adjacent lobby in building 7, and architecture and mechanical department surrounding the courtyard. Through site research, I prepared ten specific program components with proper dimension found on the campus that can be used as design components: studio, labs, common room, gallery, class, office, lecture room, cafe, and garden. Also, I captured the site using photogrammetry to create a game scene with photorealistic environment.

The second step began when all initial data was collected through photogrammetry and site research. Using photo-captured site and ten programs from step one, two games were created, Section game and Navigation game. Section game collects data of programs participants prefer on the site. Navigation game records individual participant's circulation path; by letting them take photos of the spaces, it also mapped the hierarchy of people's experience throughout the play. For the photo taking part of Navigation game, it allows people to take two types of photos, like and dis-like photos.

Third step begins by distributing these two games, and crowd-sourcing starts. The future users of the space are visitors of MIT, mechanical and architecture students, and staffs. They provide the feedback. Data is analyzed to create initial design iterations, which then is distributed again to people for further developments. Step three repeats multiple times for further design developments.

Democratic design process through games can generate design iterations through game plays. Those iterations can be averaged or selected through people's involvements. Architects do not select designs; they merely create and update games for people to play and make design decisions. This democratization of design process allows the public to express their preferences. Thus, the final design is a friendly space created by the public.

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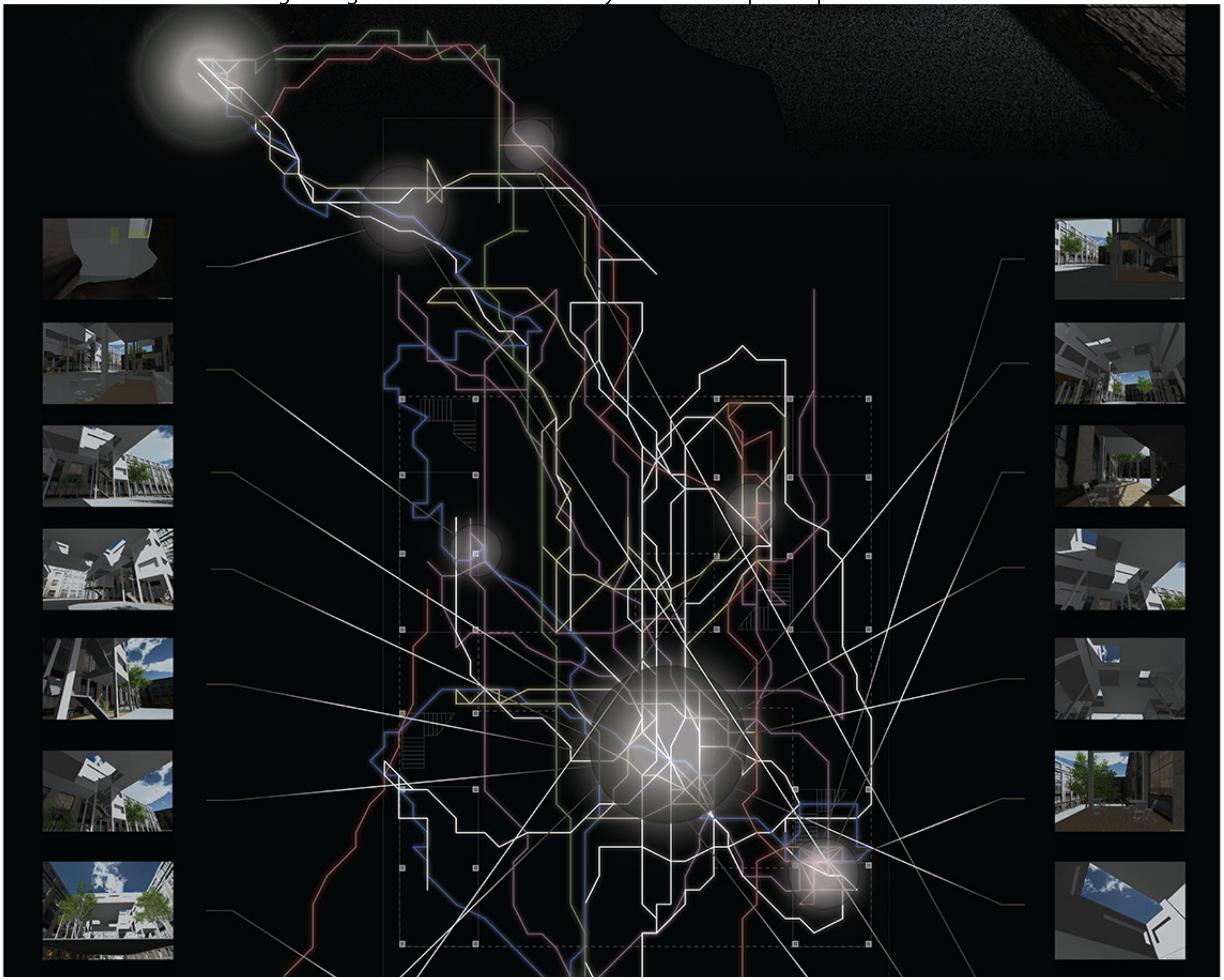
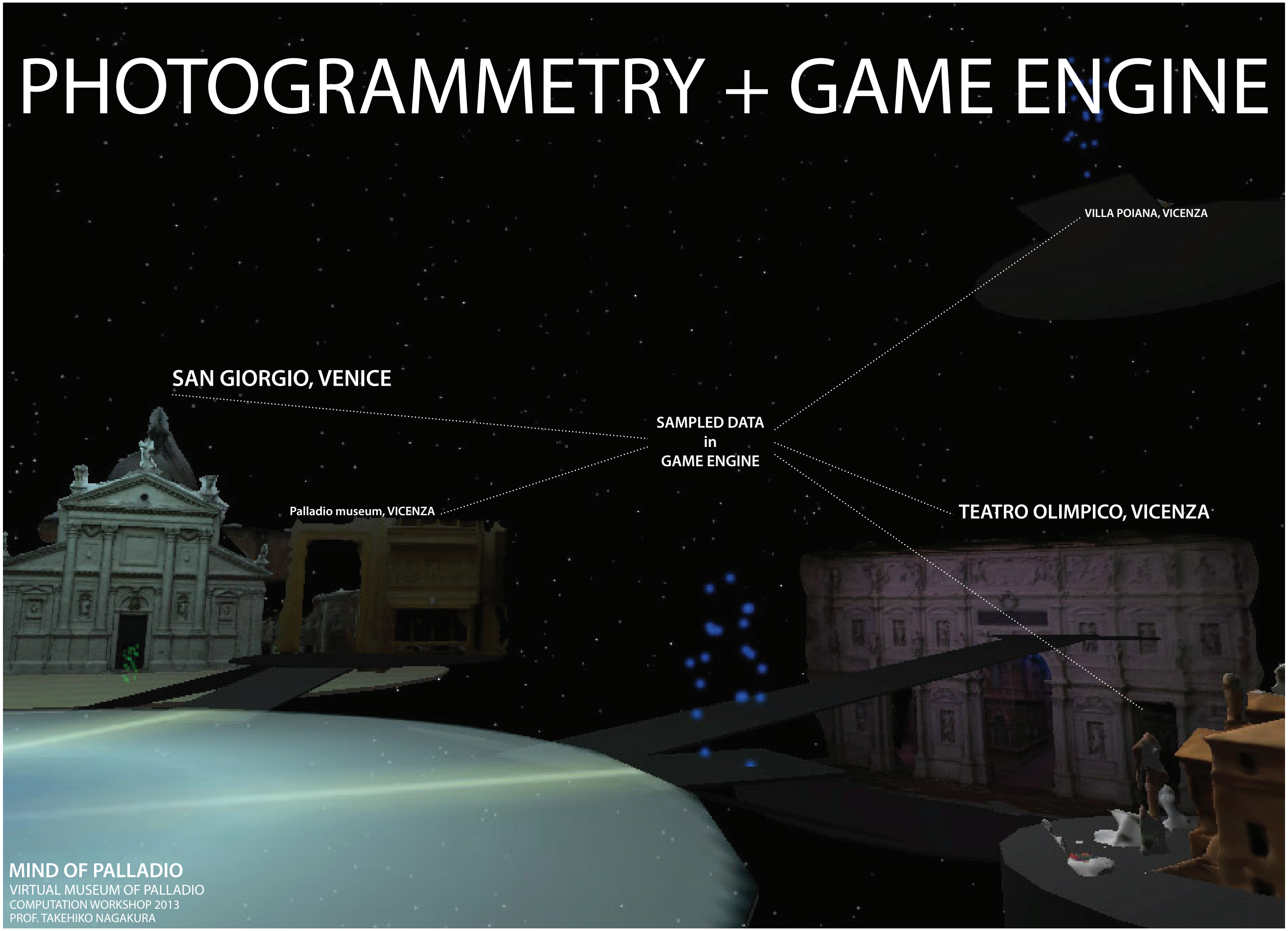
"Protein-folding Game Taps Power of Worldwide Audience to Solve Difficult Puzzles."Protein-folding Game Taps Power of Worldwide Audience to Solve Difficult Puzzles. N.p., n.d. Web. 22 Jan. 2014.

Data visualization from Navigation game from Democratic Play <circulation path & photos taken>



TECHNOLOGY
USED FOR **DEMOCRATIC PLAY**


PHOTOGRAMMETRY + GAME ENGINE
VILLA POIANA, VICENZA
SAN GIORGIO, VENICE
SAMPLED DATA
in
GAME ENGINE
Palladio museum, VICENZA
TEATRO OLIMPICO, VICENZA
MIND OF PALLADIO
VIRTUAL MUSEUM OF PALLADIO
COMPUTATION WORKSHOP 2013
PROF. TAKEHIKO NAGAKURA

TECHNOLOGY
USED FOR **DEMOCRATIC PLAY**

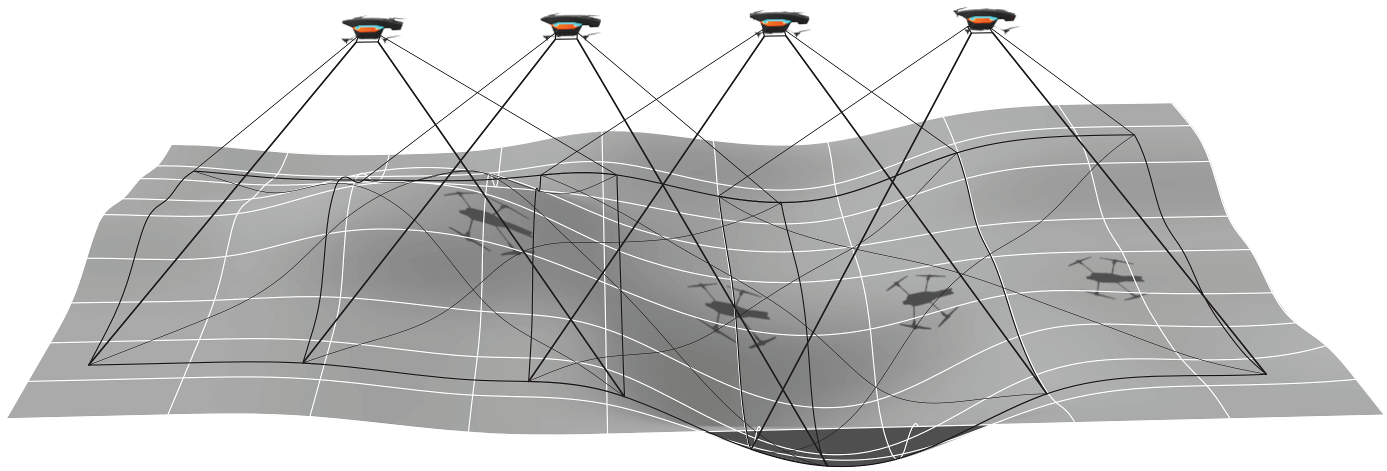
PHOTOGRAMMETRY

Photogrammetry is science of extracting 3D geometry and photographic textures through multiple pictures taken in different angles.

The benefit of using photogrammetry is efficiency for sampling an object very fast, yet accurately to obtain 'good data.'

The sampling of an object and simulation of it can help architects to understand the pattern of a specific setting to set up rules and to iterate different designs. Also, architects can come back and apply in other contexts in future for further development.

For the thesis, photogrammetry made possible for architect to capture meaning objects, such as a portion of MIT campus to set up site context within game environment.



MAPPING THROUGH PHOTOGRAMMETRY

GOOD DATA

Q1 : WHY PHOTOGRAMETRY?

A : GOOD WAY TO GAIN "GOOD DATA"

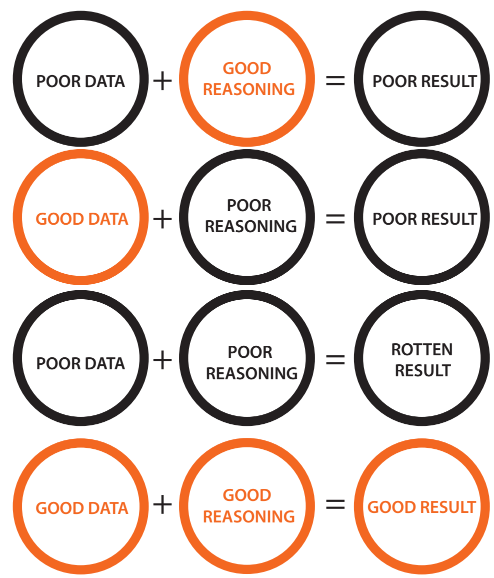
Q2 : WHY "GOOD DATA"?

A : Census data, site descriptions, transportation statistics, activity constraints, economic criteria, and material specifications are all part of design project, especially a scale of urban projects.

Architects have to control complex information, so data can be prepared to support any design when necessary

Q3 : HOW TO USE GAME ENGINE?

A : VISUALIZE & SIMULATE "GOOD DATA" IN DESIGN PROCESS



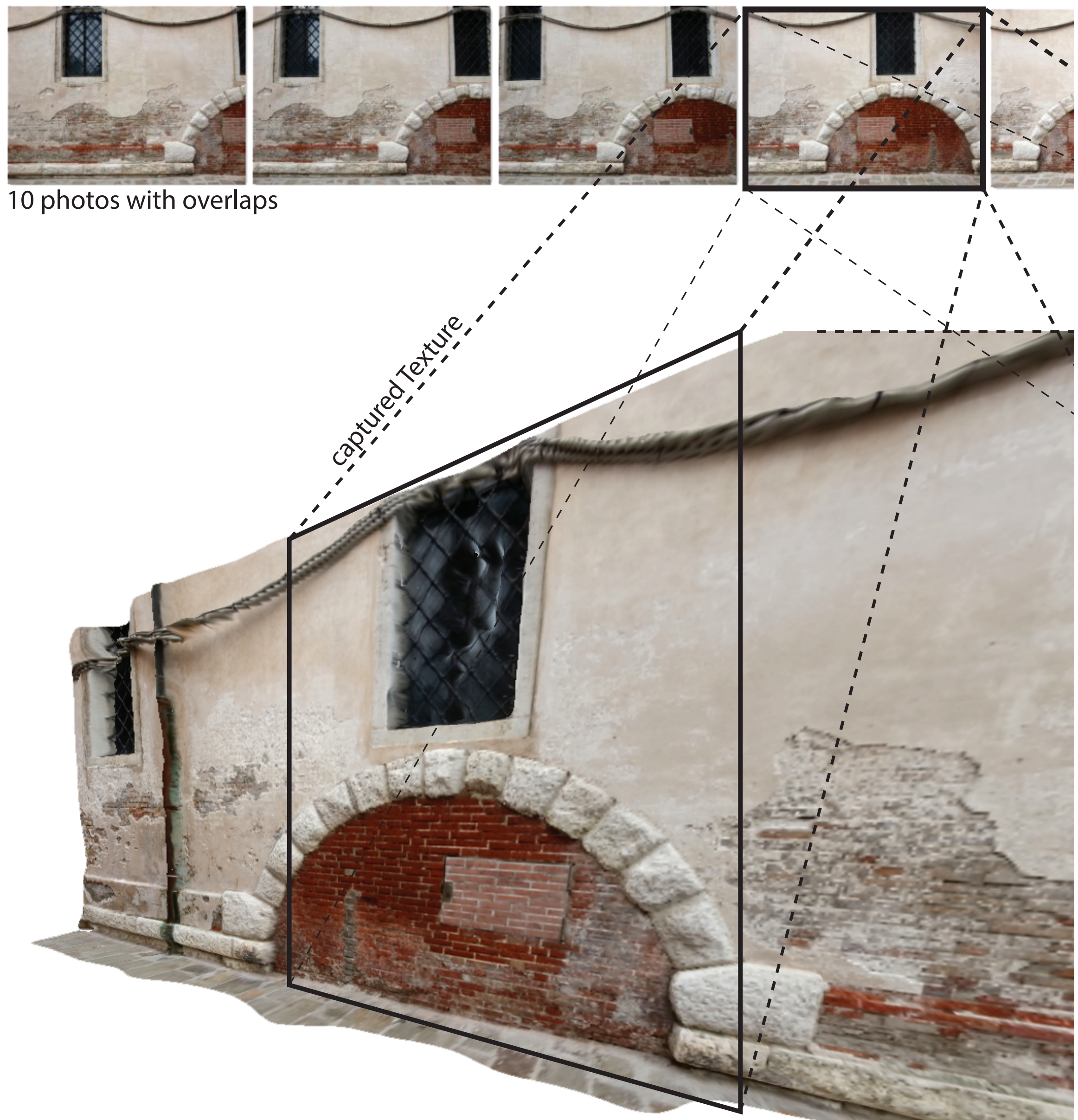
-EDMUND BERKELEY 1967

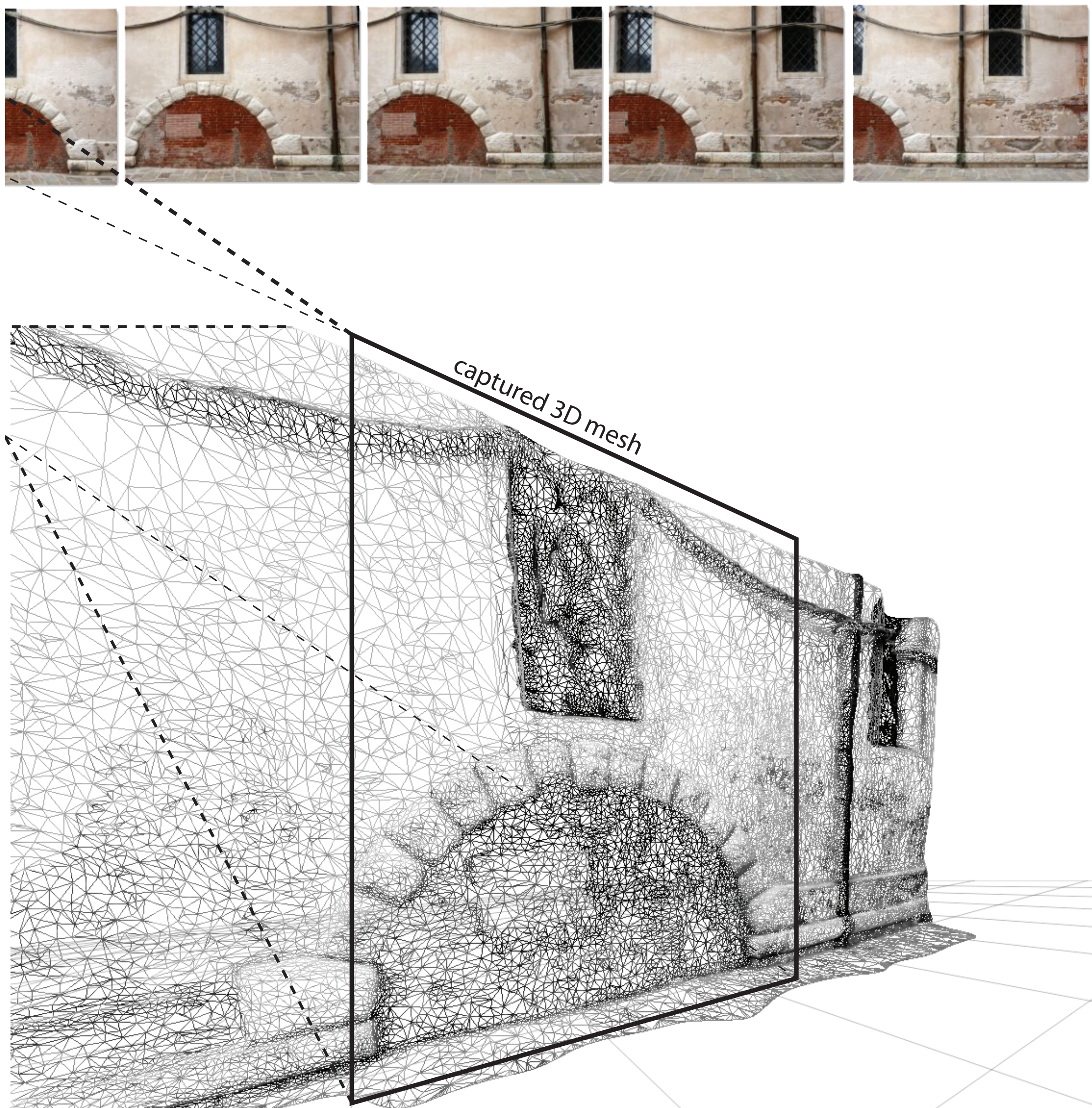
HOW DOES
PHOTOGRAMMETRY
WORK?

To sample an object with photogrammetry, First step is to take multiple photos in different angles with at least 60% overlap, so that software can track different points in the picture.

This is a exterior wall of Convento della Carita from Venice city, which was genereated through only 10 images. It is a 3D model with a photographic texture.

As seen in the photo, people can study even a minimal detail such as a crack on the wall. It is a great way to capture to archive the artifacts for further study.





Example 3D model of a wall from Venice

area around building 9 of MIT campus

DEMO GAME
MIT + Palladio

The space is created in game engine with a part of building 9 in MIT. The building 9 is sampled through photogrammetry and optimization process.

Then, the space is collaged with Palladian artifacts, which were captured in Venice City and v in Italy.

This was the experimental test for an architect to explore the ways to use sampled objects through photogrammetry. Also, the game engine provided an opportunity for people to experience the sampled objects as if they are navigating through virtual museum of Palladio.

Throughout the thesis project, the photogrammetry is used to capture important objects around the site, such as a part of MIT campus, textures, and furniture around the area.

PALLADIO
ARTIFACTS FROM
VENICE & VICENZA

detail from
The Teatro Olimpico

interior detail

Corinthian capital
Palladio Center

Convento della Carita
exteior wall from Venice

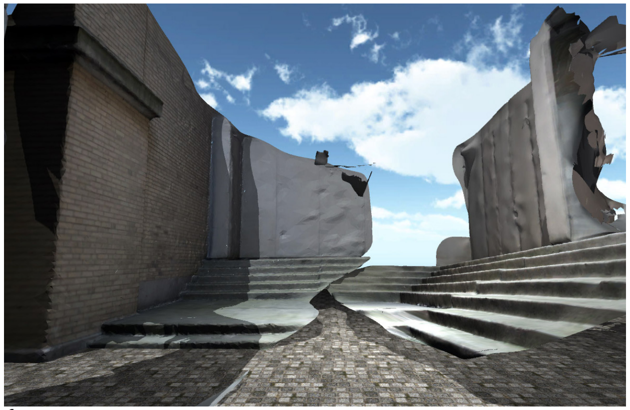
Chest
Villa Foscari

wall fragment
Palladio Center

bench
Palladian Villa

MIT CAMPUS
<BUILDING 9>

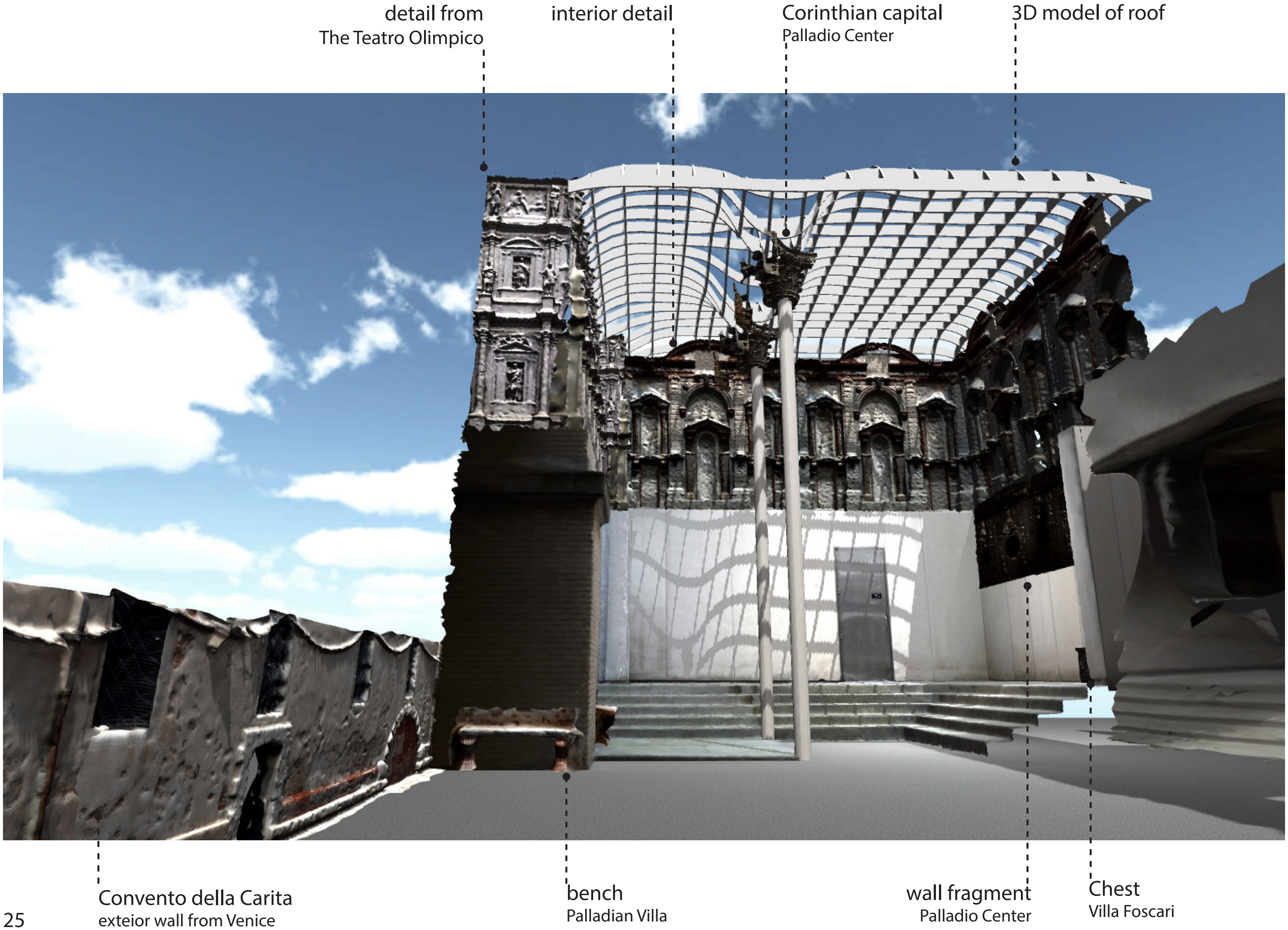
This is an **optimization** process. Photogrammetrically captured 3D model can have broken meshes and have unnecessary meshes. The captured 3D model is brought into 3Ds Max for clean up meshes. Also, the broken mesh is replaced with photographic textures.



1

2

3


detail from
The Teatro Olimpico
interior detail
Corinthian capital
Palladio Center
3D model of roof
Convento della Carita
exteior wall from Venice
bench
Palladian Villa
wall fragment
Palladio Center
Chest
Villa Foscari

TECHNOLOGY
USED FOR **DEMOCRATIC PLAY**

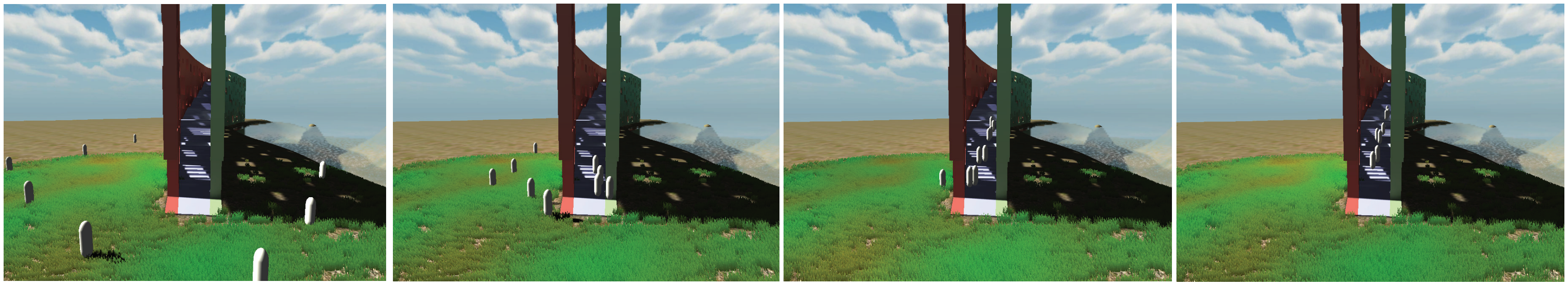
GAME ENGINE

Game engine can easily simulate navigation system, environment recreation such as weather, wind, and sound, human density, and physics for structures.

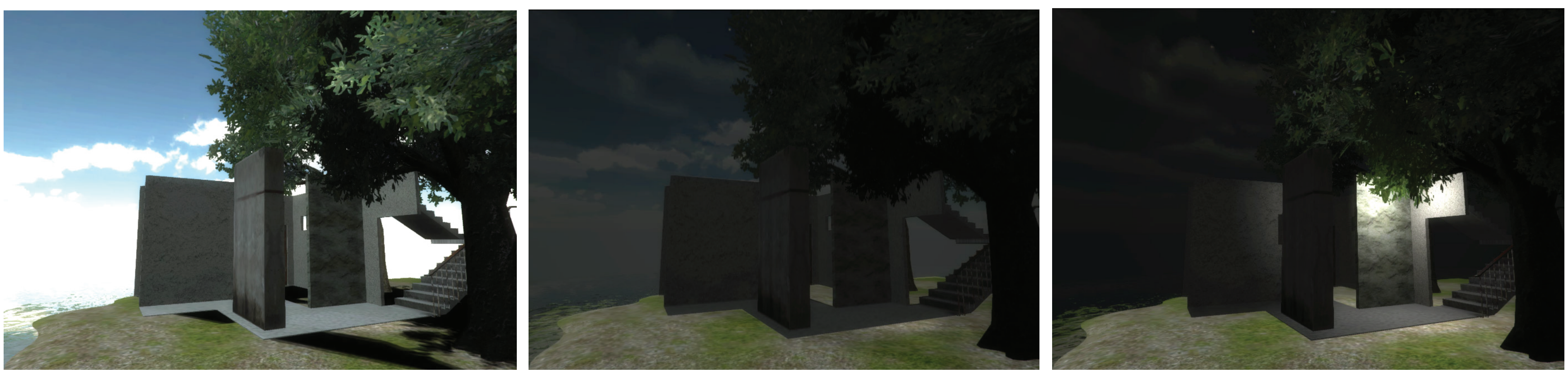
Rather than having only the conventional architectural drawing on the two-dimensional paper, game engine, thanks to simulation tools, facilitates sharing of ideas between architects and the public. Most clients are not trained as architects, so architects often make decisions that are unexpected to the client. It is very hard for people without architectural knowledge to participate in the design process, which gives architects the sole decision-making power in designing; this diminishes the preferences of the future users.

By using games for the design process, my thesis bridges the missing link between the architects and the public. Game serves a tool and a solution to bring participatory design into architecture, and generates space designed by the public.

Simulation example 1 : movement & density



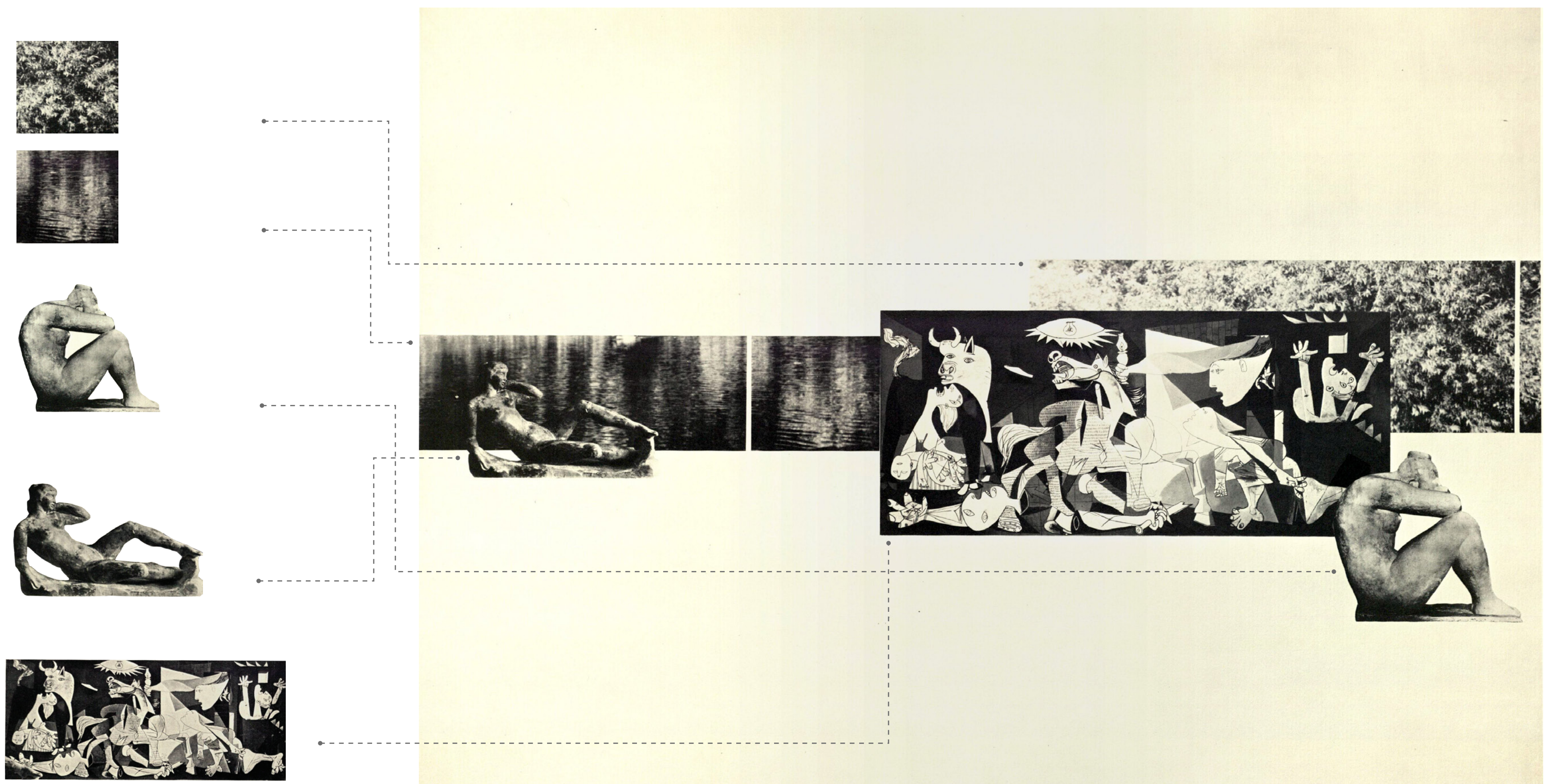
Simulation example 2 : time change & lighting



MIES VAN DER ROHE
collage drawing

Extracted objects
from the drawing

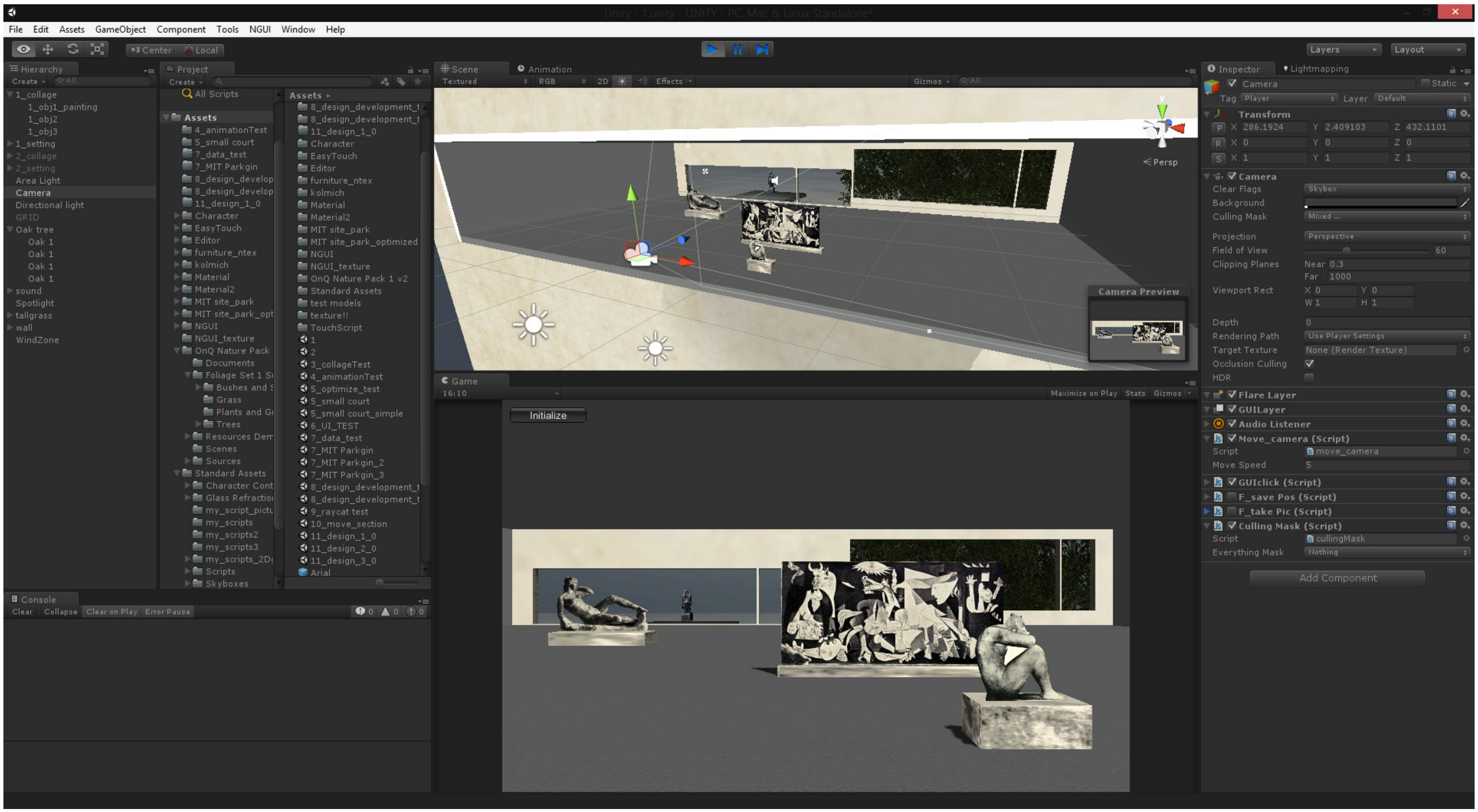
"Mies's building produce complex optical effects that can never be simulated or predicted by drawings: the play of light, shadow, and atmosphere, as well as parallax effects produce by the movements of the spectator and the intricacies of peripheral vision."
-Stan Allen



2D DRAWING to **3D SPACE**

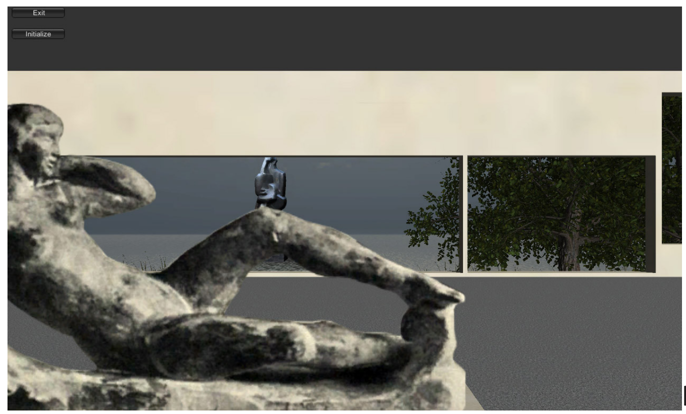
The 2D drawing of Mies Van Der v has been re-created as 3D space using game engine.

In this 3D space, the sound of water, light, wind blowing through trees, and structures are added. Then, people can navigate into the drawing to experience the space.



NAVIGATION
INTO
3D
DRAWING

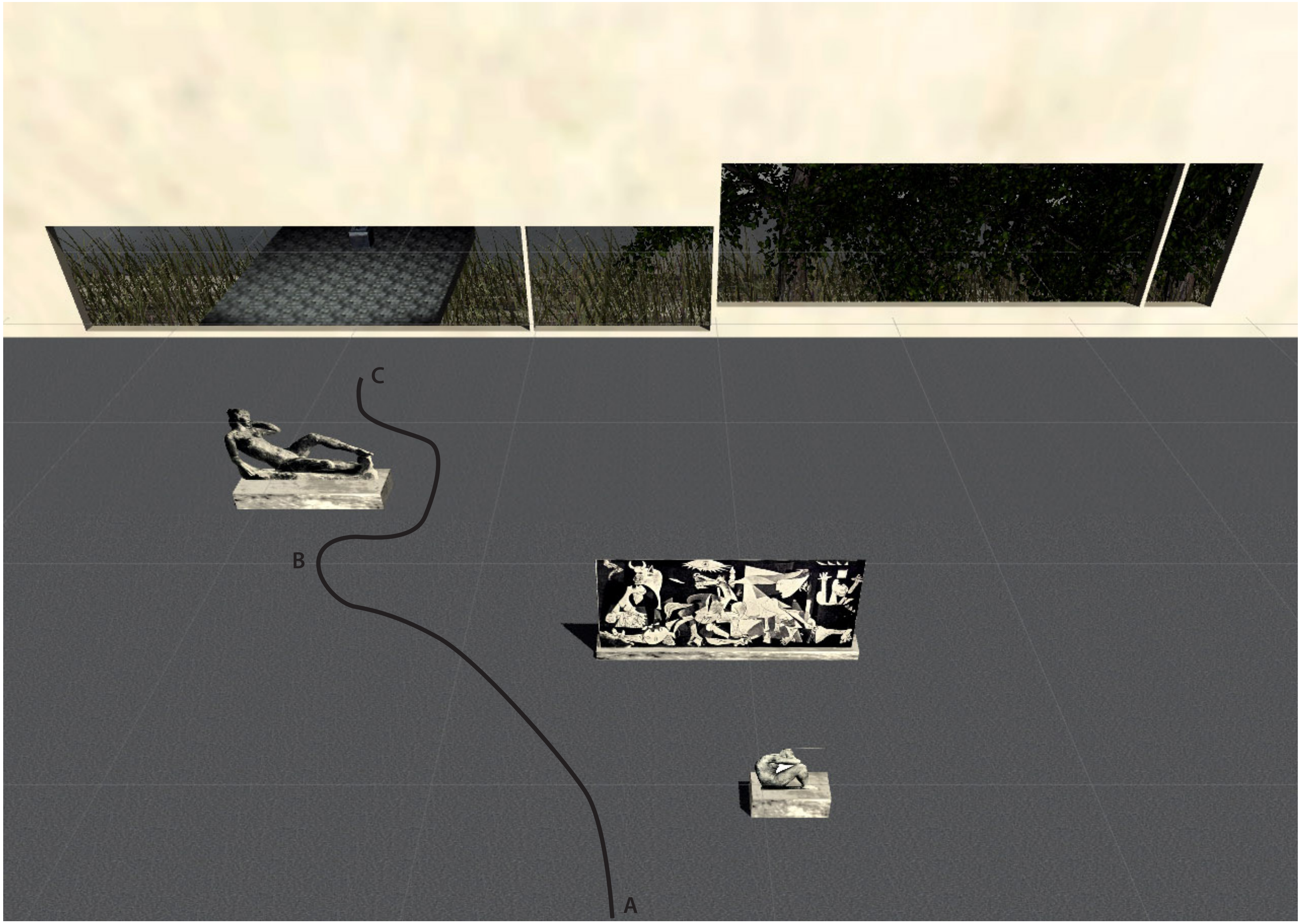
A



B

C

CIRCULATION PATH



INTRODUCTION

DEMOCRATIC PLAY

DESIGN PROCESS WITH GAMES

Democratic Play works in following three steps.

In step 1, architects prepare necessary architectural information to set up a game through intense research and capture of significant objects using photogrammetry.

In step 2, using collected data, architects create games with user-friendly interface.

In step 3, architects distribute games to the public, or future users, for crowd-sourcing feedback. Then architects analyze the data for the design development. The last stage can be repeated multiple times for further design development with updated games.

democratic_play

JOSHUA CHOI
TAKEHIKO NAGAKURA
CRISTINA PARRENO
SKYLAR TIBBITS

synopsis

The thesis will create a game.

The game will be created through
collaging objects from photogrammetry.
Then it will be distributed
to people for crowdsourcing.

scenarios

Architect(me) will use game engine
to create an initial design.
People will play and also
provide feedback
for design development.

DEMOCRATIC PLAY
DESIGN PROCESS WITH GAMES

STEP 1 : prepare programs

- site study
- program research
- photogrammetric capture of the site

STEP 2 : create & distribute games

STEP 3 : crowd-sourcing & design development

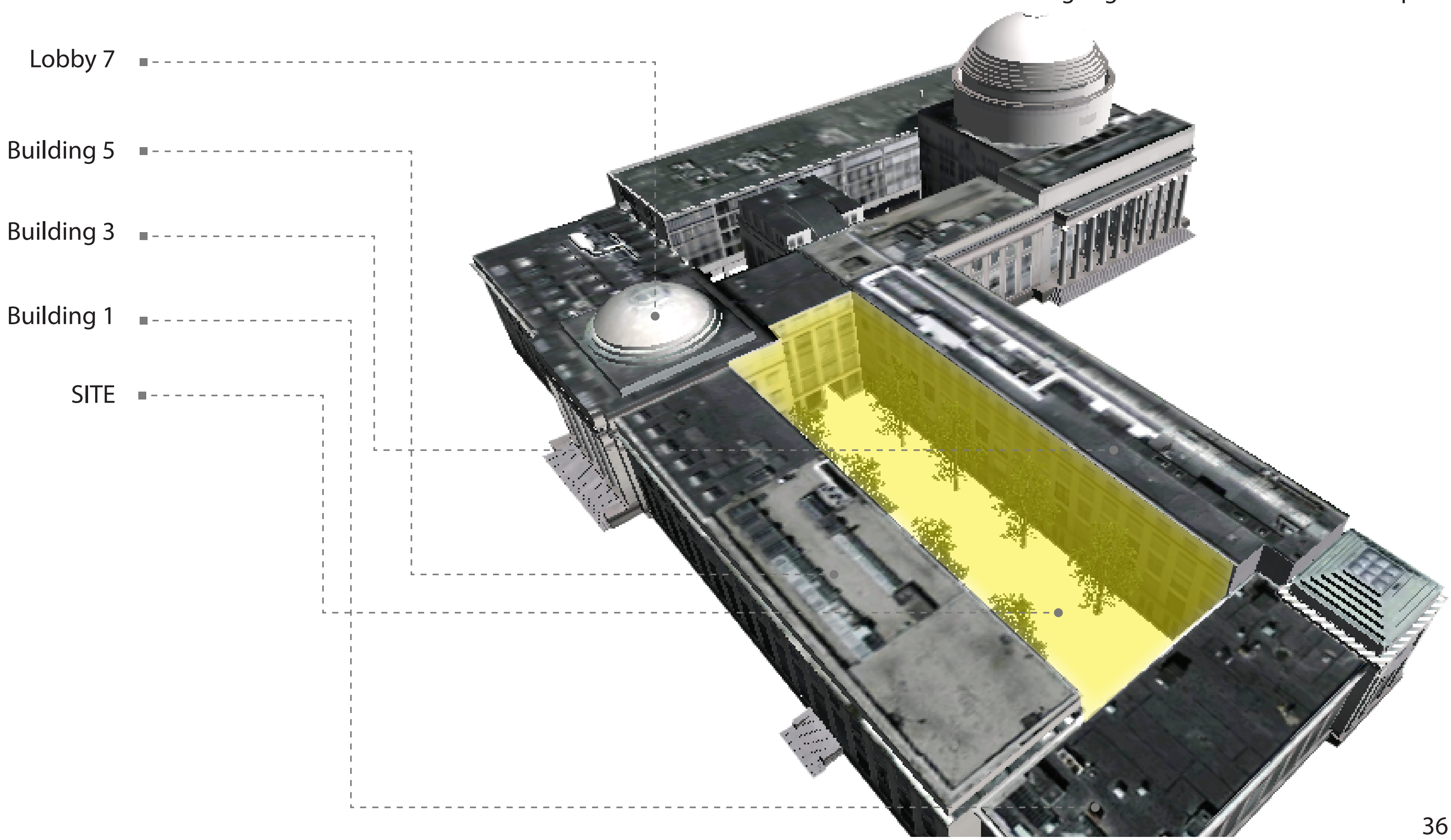
Step 1, architect prepares programs through intense research of the given site. For this particular thesis project, the site was a courtyard/parking space.

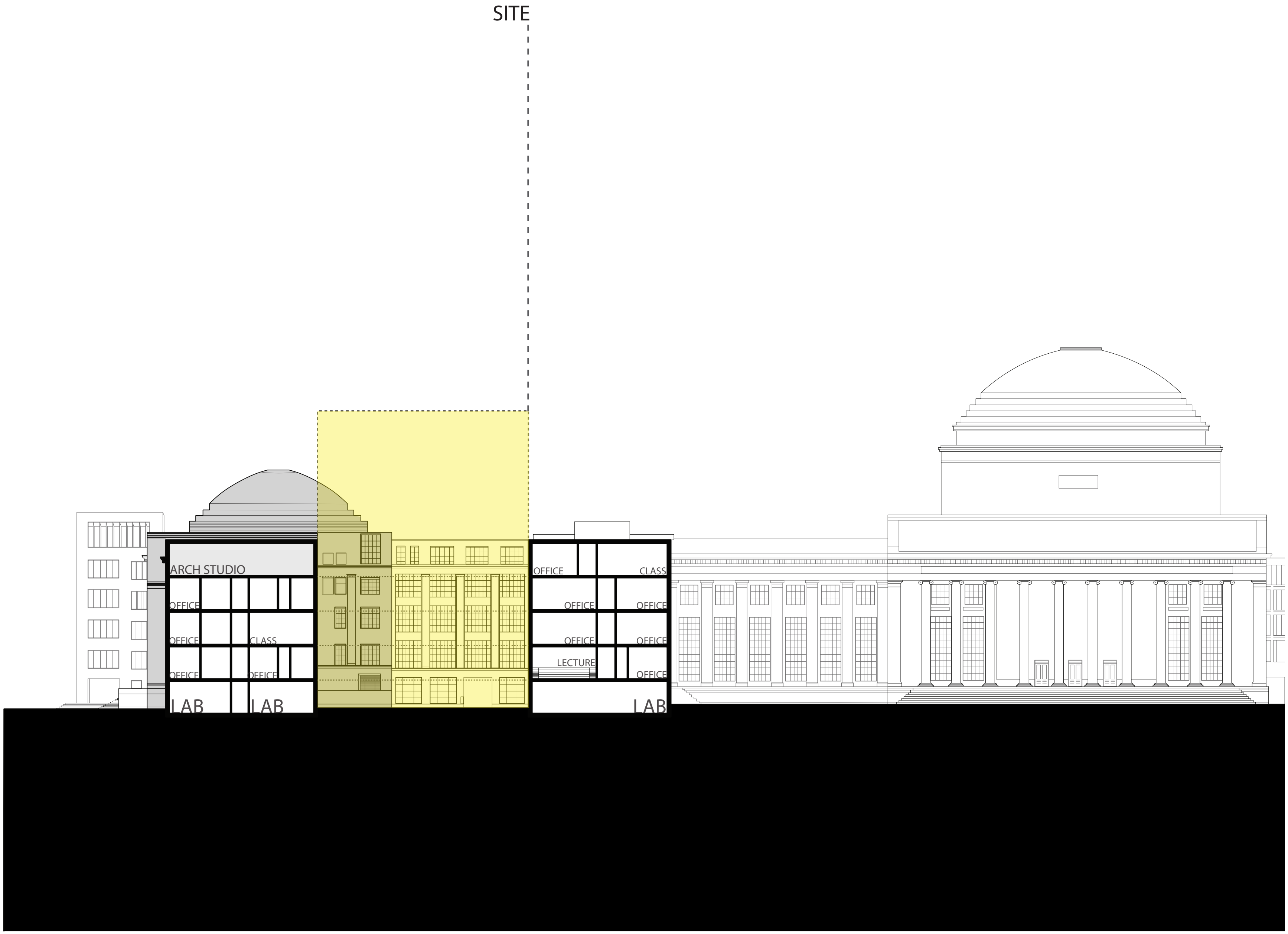
The site is consisted of a lobby 7 which is a main public space of MIT campus, and architecture and mechanical departments surrounding the site.

The ten specific programs are prepared with proper dimension found on the campus that can be used as design components: studio, labs, common room, gallery, class, office, lecture room, cafe, and garden. Also, the site is captured using photogrammetry to create a game scene with photo-realistic environment, so that participants feel comfortable during crowd-sourcing process in future.

SITE STUDY

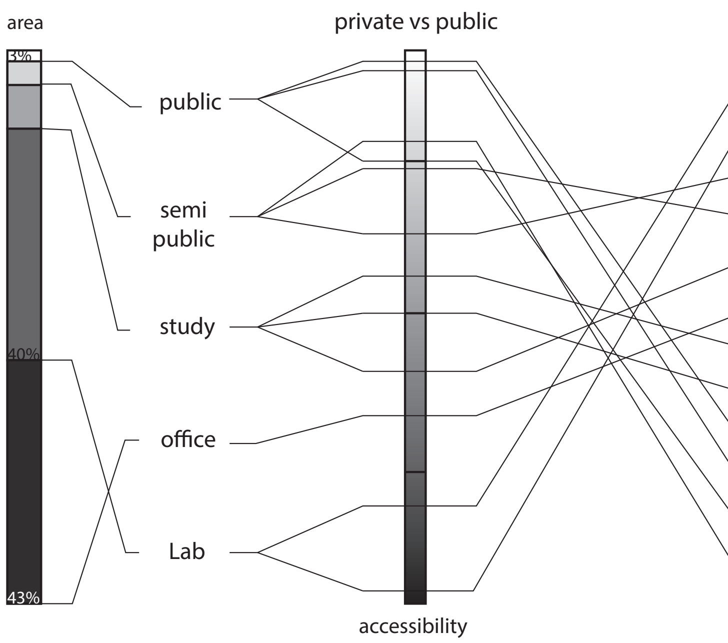
google earch model of MIT campus

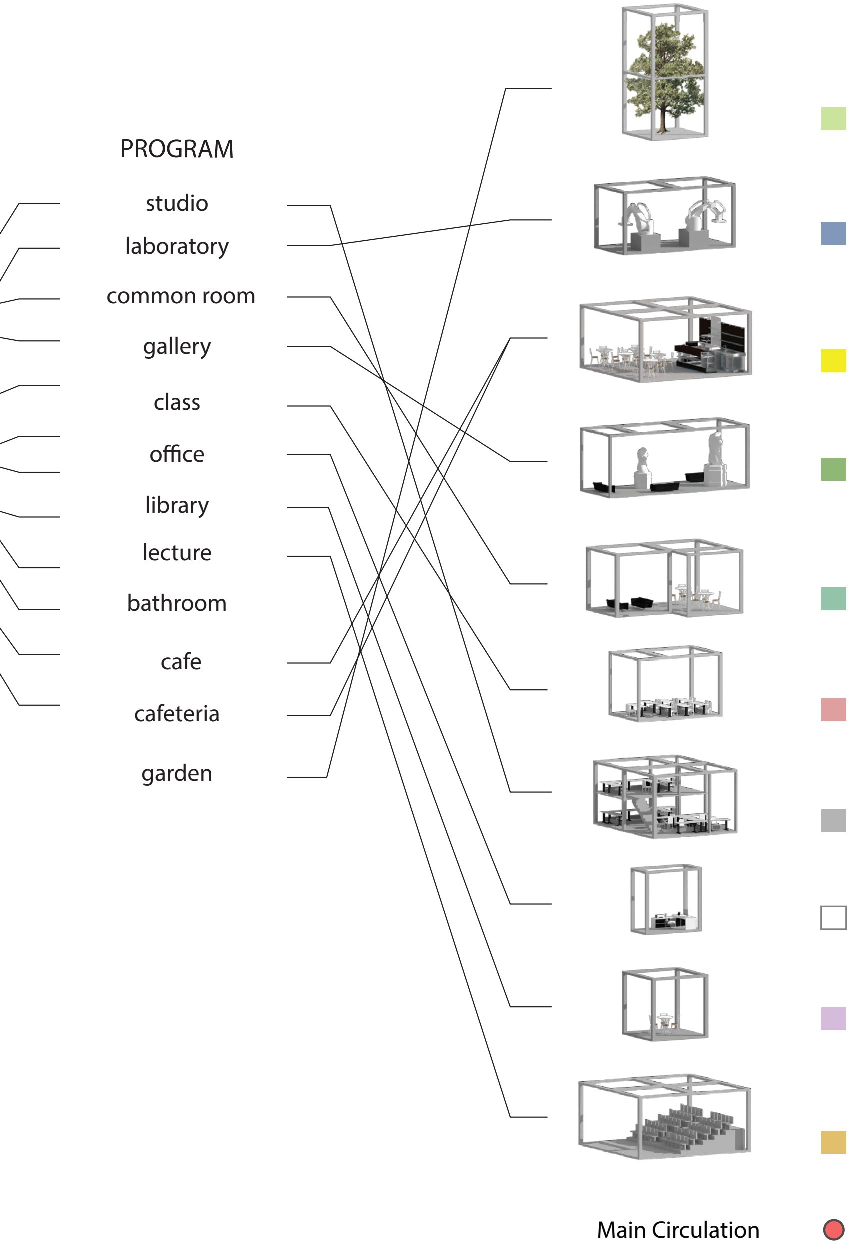


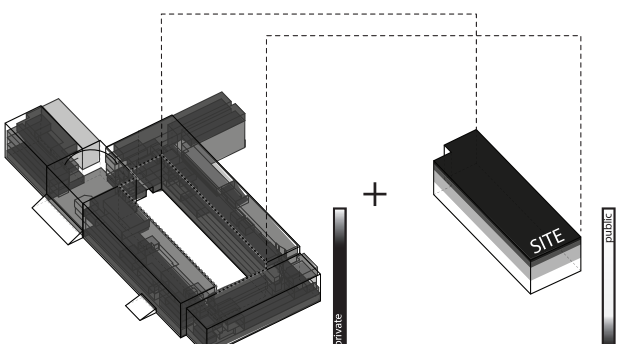


SITE
ARCH STUDIO
OFFICE
OFFICE
CLASS
OFFICE
OFFICE
LAB
LAB
OFFICE
CLASS
OFFICE
OFFICE
OFFICE
OFFICE
LECTURE
OFFICE
LAB

PROGRAM RESEARCH



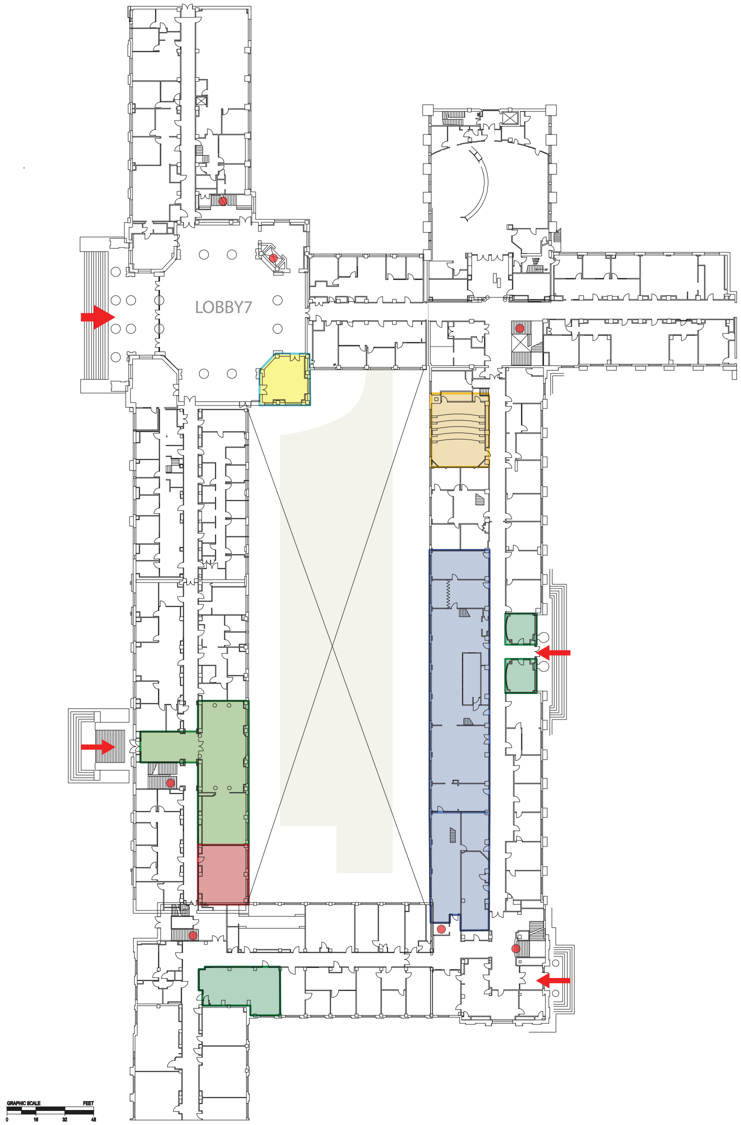


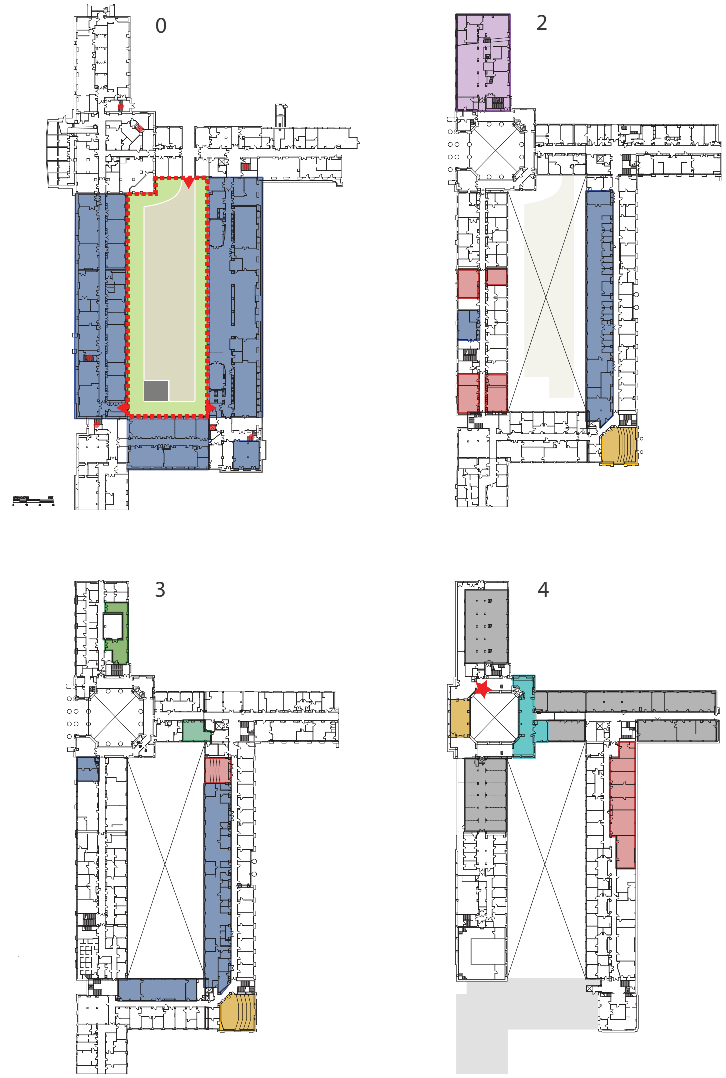


CAMPUS AS PRIVATE VS. PUBLIC

CREATE PUBLIC SPACE

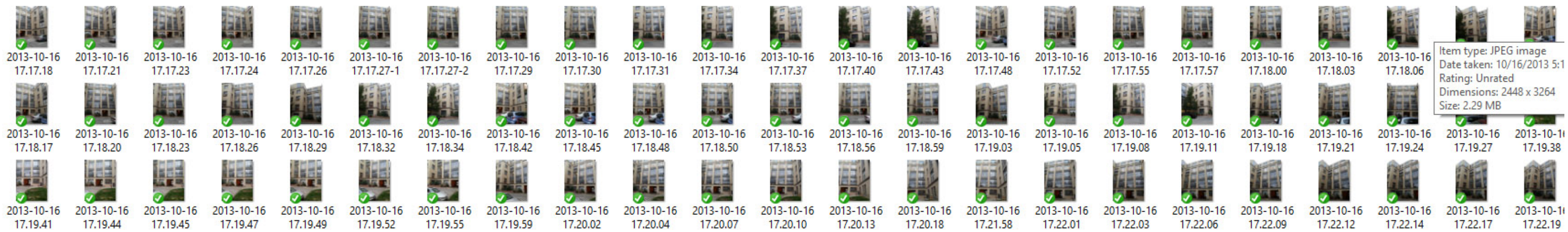
Plan drawings of MIT, building 1,3,5, and 7
different colors represent different programs from previous page





CAPTURE SITE WITH PHOTOGRAMMETRY

multiple photos taken in different angles for photogrammetry



3D model of the site with photo-realistic textures

OPTIMIZATION OF SITE

DEMOCRATIC PLAY

DESIGN PROCESS WITH GAMES

STEP 1 : prepare programs

STEP 2 : create games for distribution

- game 1 : Section game
- game 2 : Navigation game

STEP 3 : crowd-sourcing & design development

Step 2 begins when all initial data was collected through photogrammetry and site research.

Using photo-captured site and ten programs, two games are created, Section game and Navigation game.

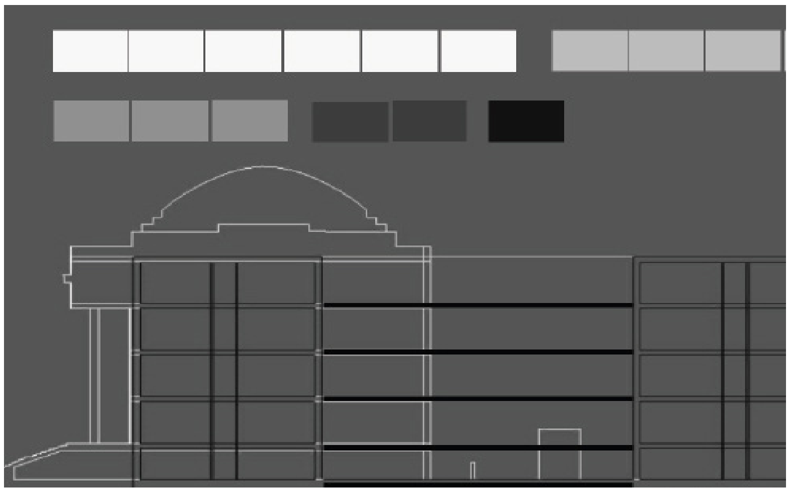
-**Section game** samples a preference of programs.

-**Navigation game** records participant's circulation path. Also, by letting them take photos of the spaces, it maps the hierarchy of people's experience throughout the space. For the photo taking part of Navigation game, it allows people to take two types of photos, like and dis-like photos.

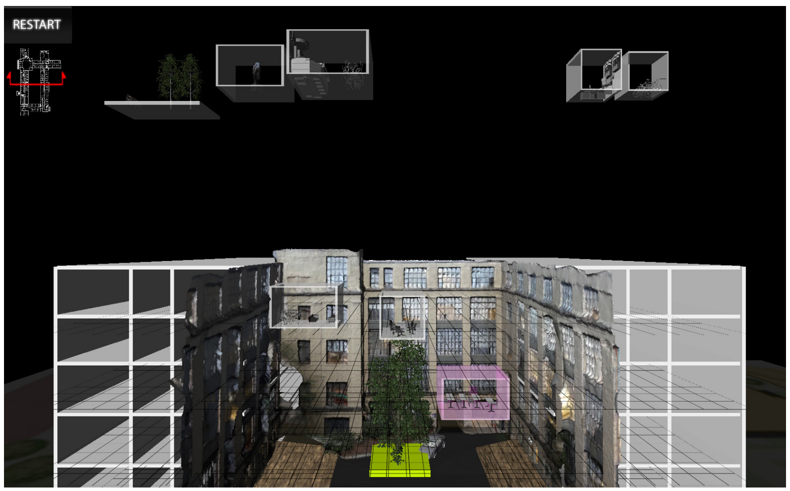
GAME 1 : SECTION GAME

This is the process of the development of Section Game from the initial sketch to the game which is distributed for people to play.

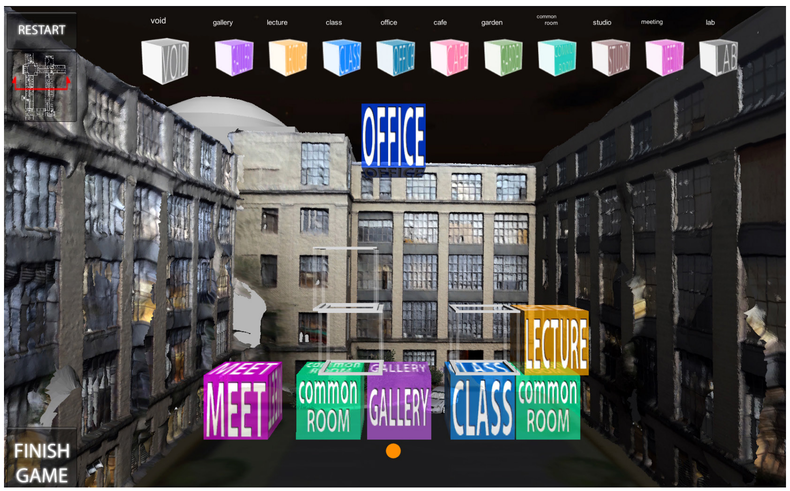
The Section game samples **functions & locations** of ten programs.



1 CONCEPT SKETCH : The white box represents public and black represents private programs. Players drag the box to produce a sectional public vs. private diagram.



2 TEST GAME : Each program box extracted from MIT campus. Players can drag and organize boxes, the way they prefer.



3 SIMPLE-BOX MODE: previous game provided too much freedom for players to organize. So, this one has a limiting factor, gravity. If a player wants to put box on the upper floor, they can use a empty structural box, void box.

4 DISTRIBUTED GAME: ten program boxes to pick from the top. And there is one box called, void, which is a empty structural space.

INSTRUCTION

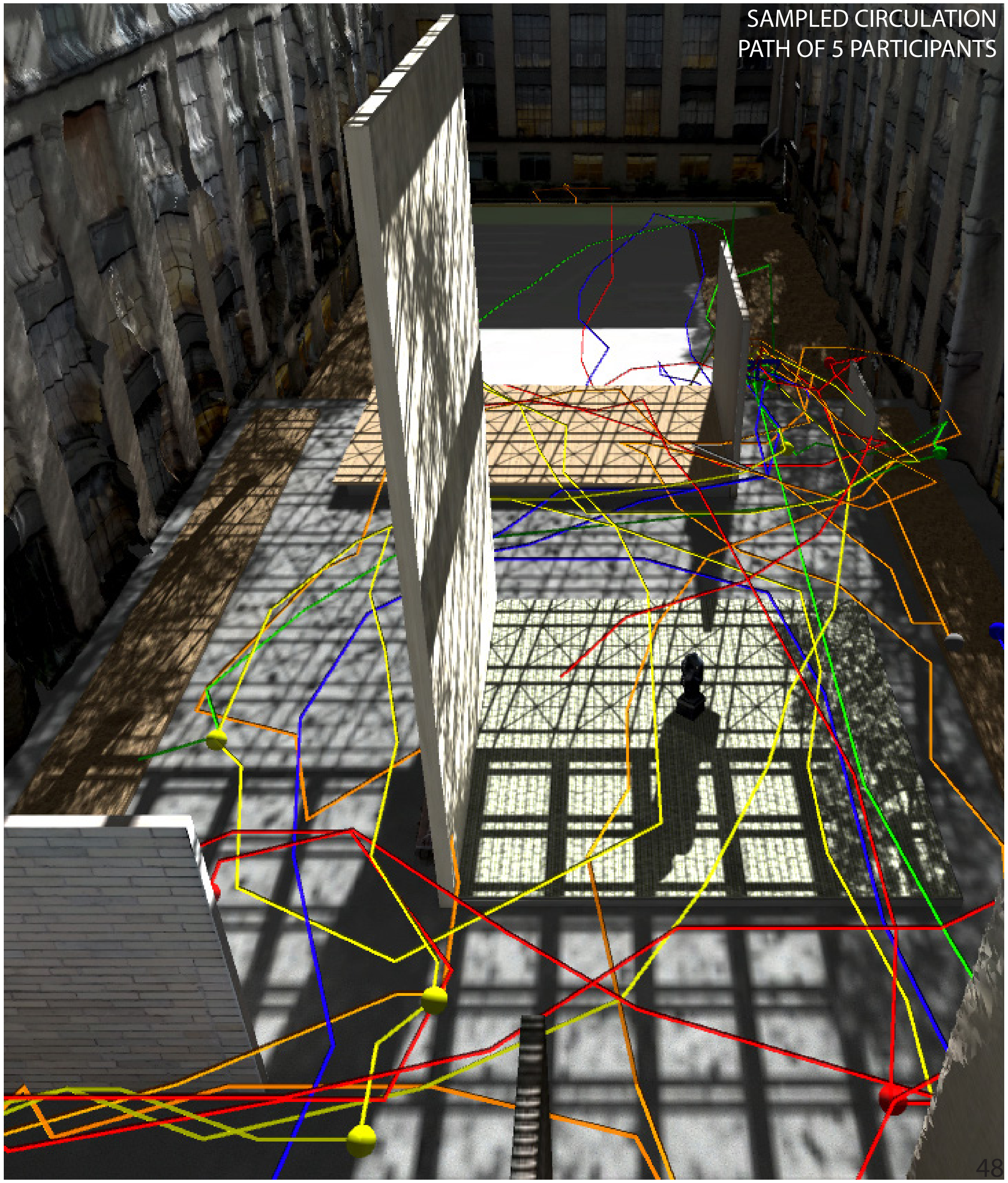
Zoom-in & out to design in more specific manner.

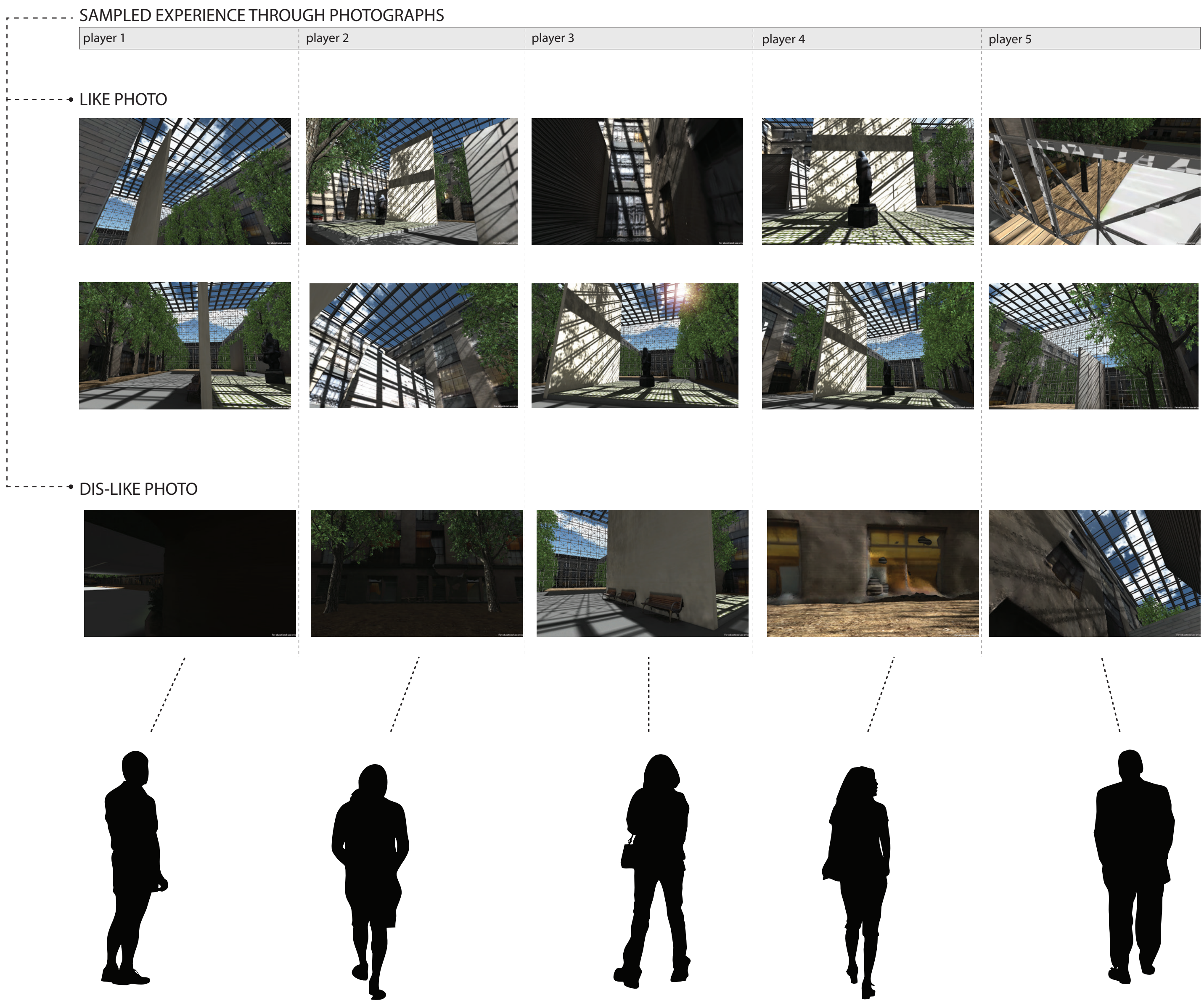
Rotation of a view to design in both sections. However, during crowd-sourcing process, rotation was disabled for simplicity.

GAME 2 : NAVIGATION GAME

Navigation game records individual participant's circulation path; by letting them take photos of the spaces, it also mapped the hierarchy of people's experience throughout the play.

For the photo taking part of Navigation game, it allows people to take two types of photos, like and dislike photos.




SAMPLED EXPERIENCE THROUGH PHOTOGRAPHS
player 1
player 2
player 3
player 4
player 5
LIKE PHOTO
DIS-LIKE PHOTO

DEMOCRATIC PLAY

DESIGN PROCESS WITH GAMES

STEP 1 : prepare programs

STEP 2 : create & distribute games

STEP 3 : crowd-sourcing & design development

- step 3A : collect & analyze data
    - data from section game
    - prepare design iterations
    - initial design selection
- step 3B : design development
    - data from navigation game

Step 3 begins by distributing the two games, Section game and Navigation game. Then **crowd-sourcing** starts to collect people's preferences.

The future users of the space are visitors of MIT, mechanical and architecture students, and staffs. Architect approaches to find them to provide feedback. Data is analyzed to create initial design iterations, which then is distributed again to people for further developments as games.

Step three must repeat multiple times for further design developments.

step 3A : DATA analysis from SECTION GAME

Twenty people have participated in the process, producing twenty different results in a form of section diagrams.

The analysis process has taken in following steps.

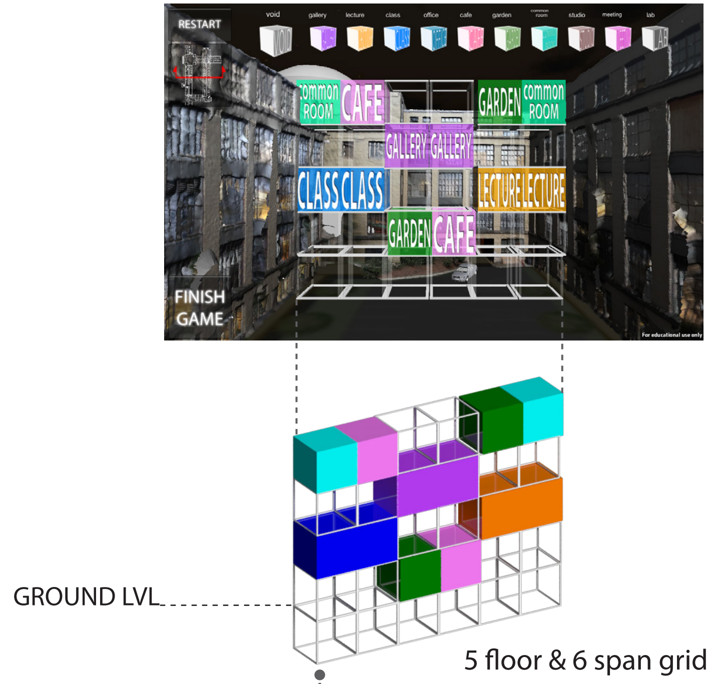
1. Each data from individual player is **exploded** into individual programs in more preferred order.

2. Data is **simplified** into three categories, which are public, semi-private, and private in three colors.

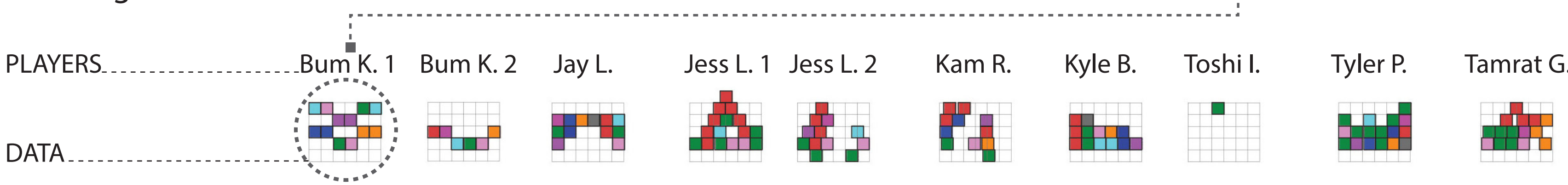
3. Data is **collapsed** in those three categories. (data has been neutralized and democratized)

4. Averaged data produces **design hypothesis** or iterations for design development process.

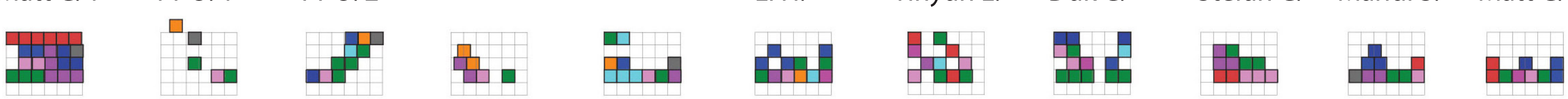
Example Data
by Bumjin Kim



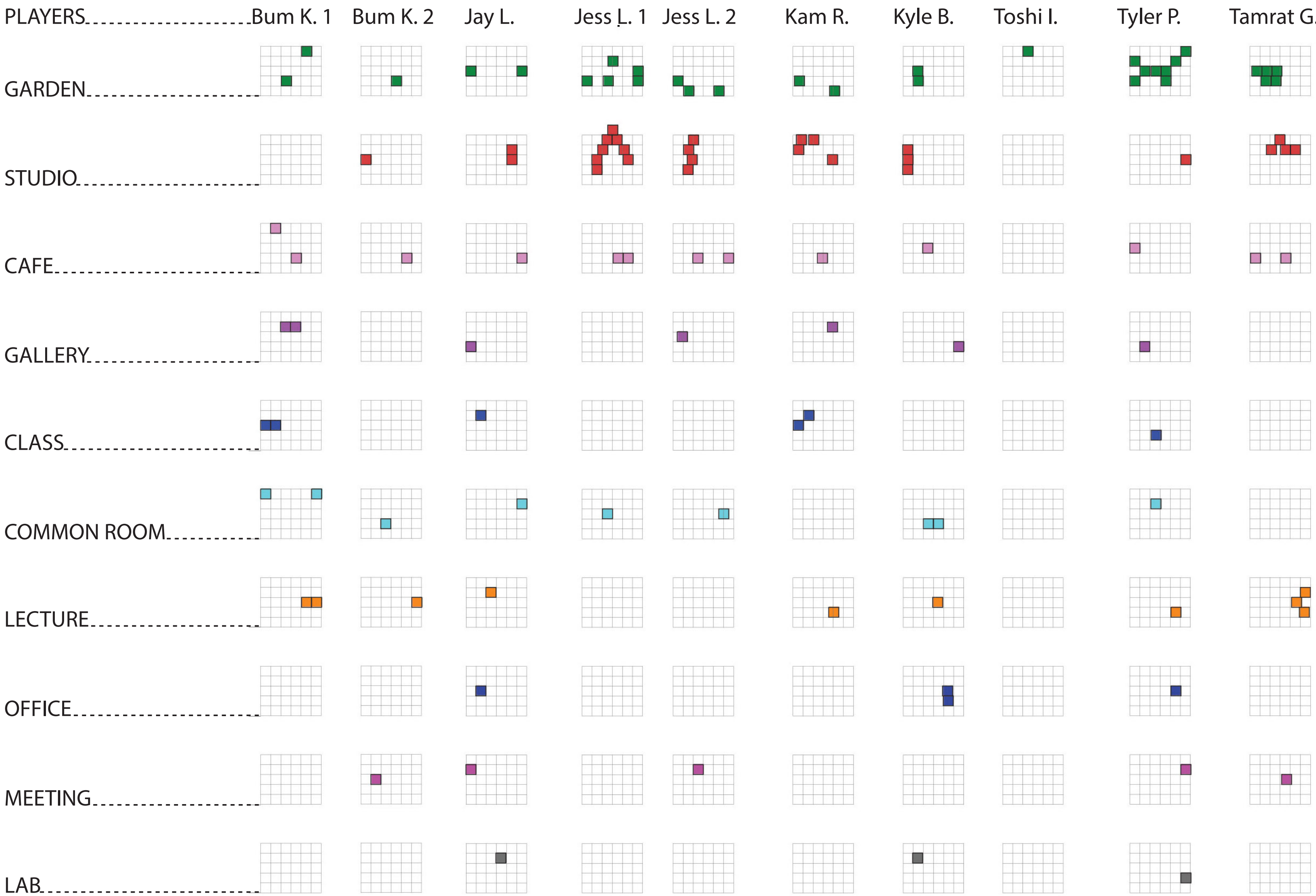
resulting **DATA** OF 20 PLAYERS

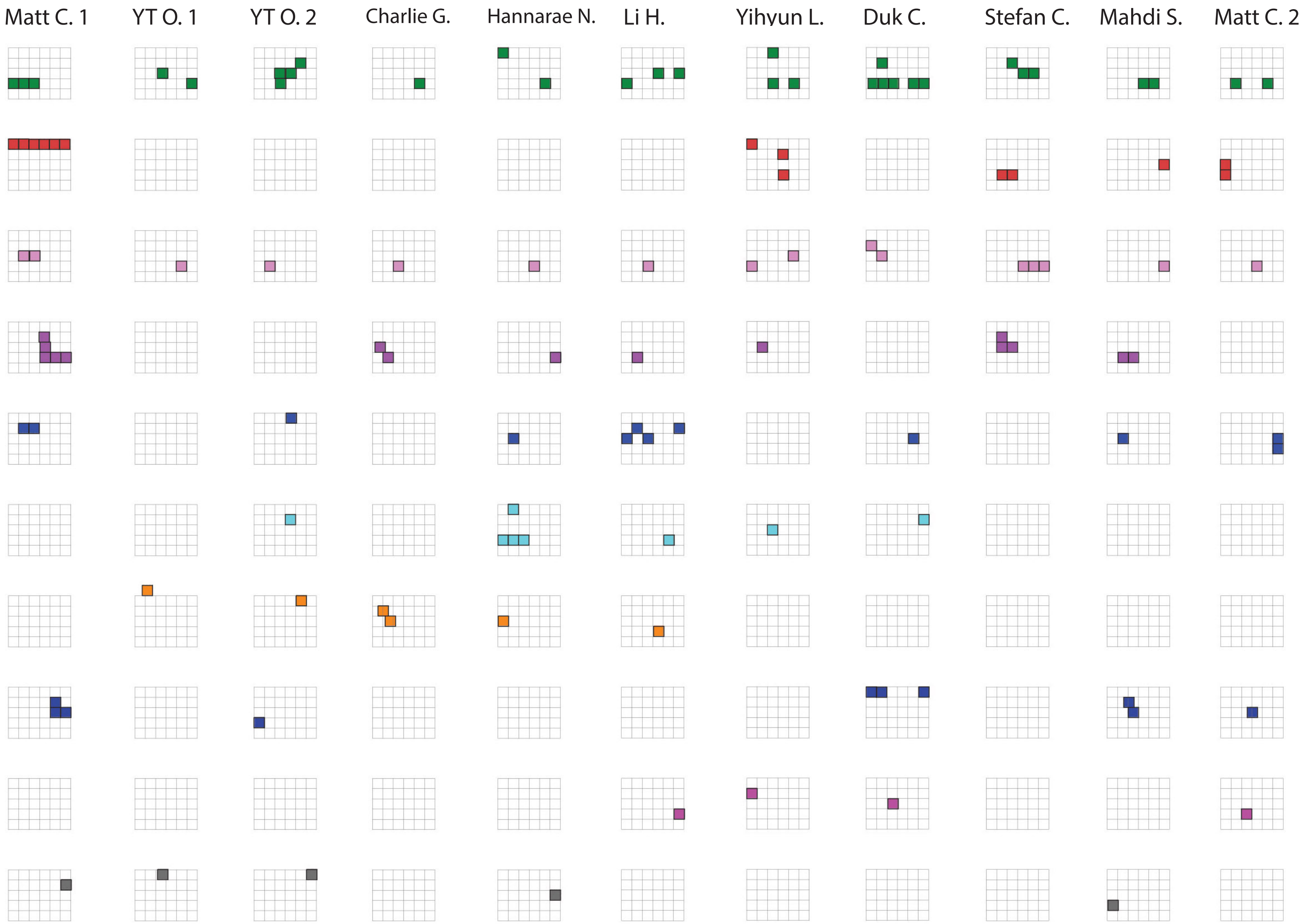


Matt C. 1 YT O. 1 YT O. 2 Charlie G. Hannarae N. Li H. Yihyun L. Duk C. Stefan C. Mahdi S. Matt C. 2



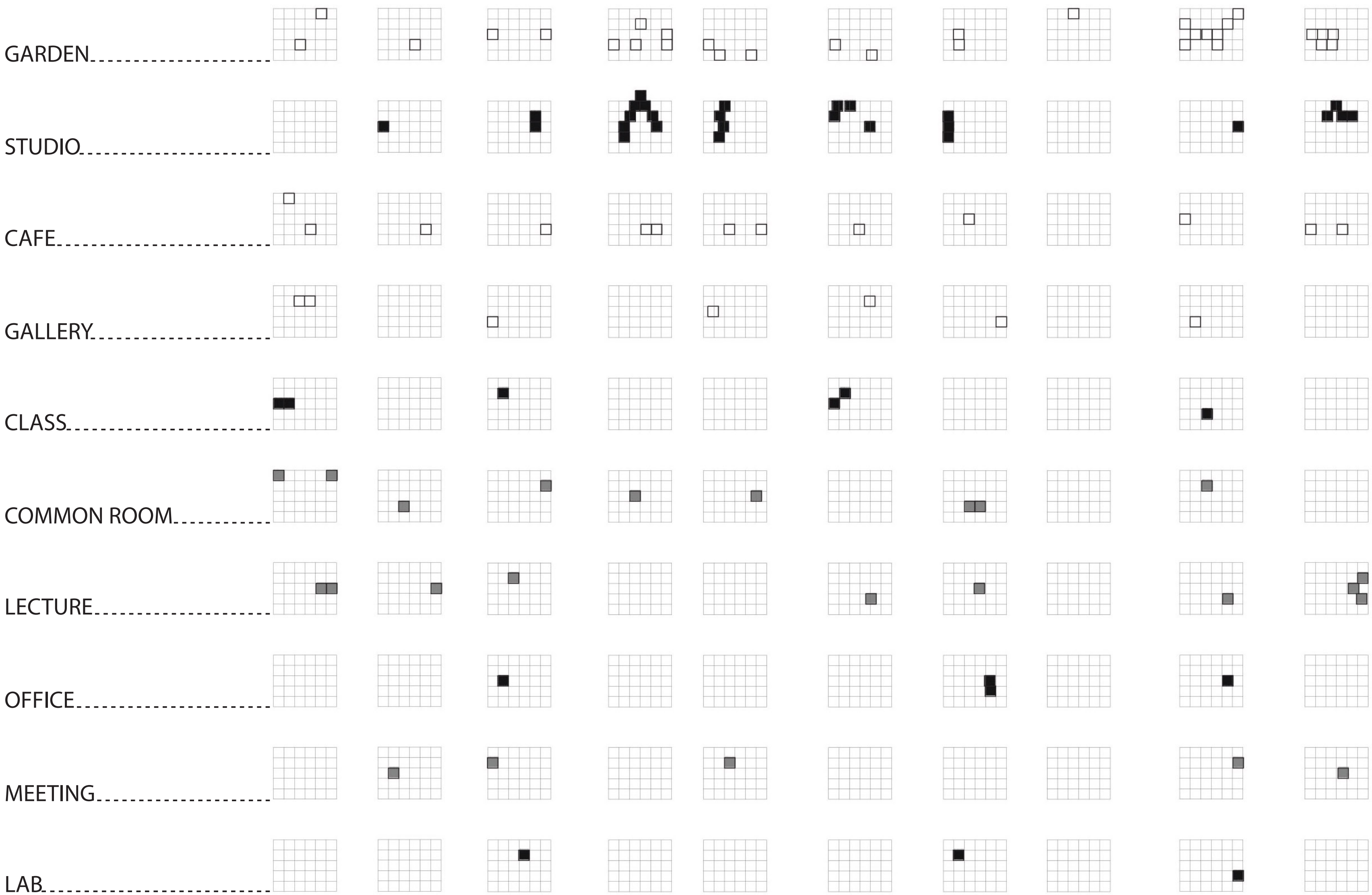
EXPLODED **DATA** INTO EACH PROGRAM

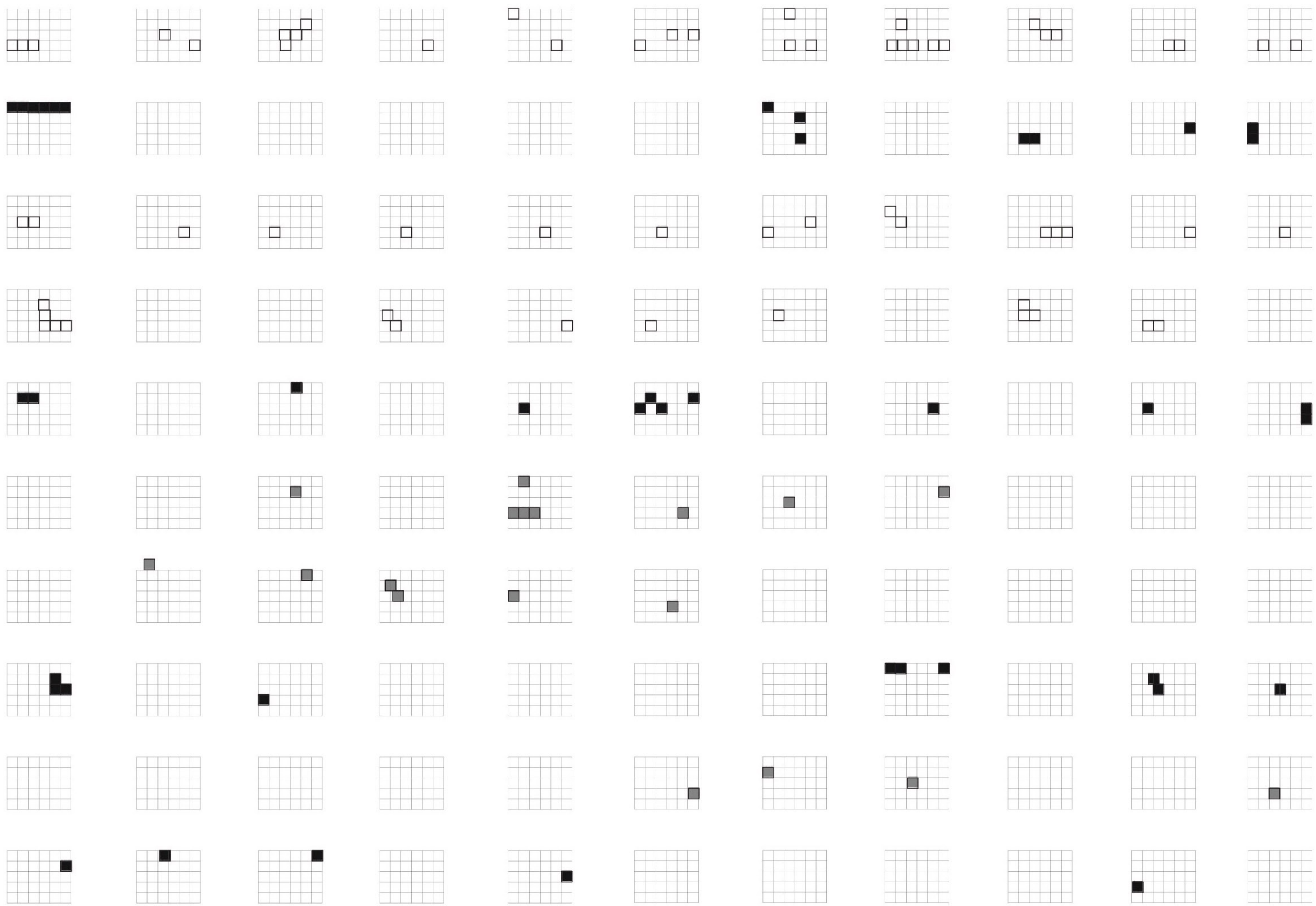



Matt C. 1
YT O. 1
YT O. 2
Charlie G.
Hannarae N.
Li H.
Yihyun L.
Duk C.
Stefan C.
Mahdi S.
Matt C. 2

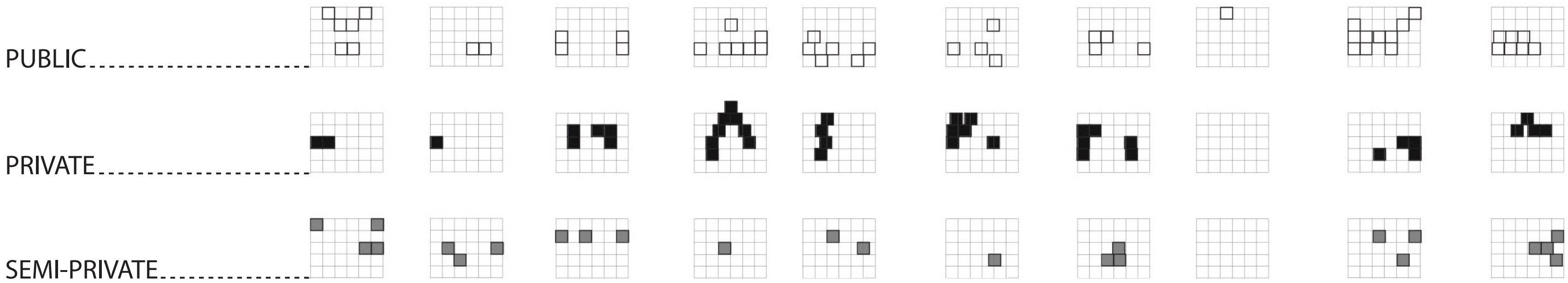
SIMPLICATION OF EXPLODED **DATA** INTO THREE CATEGORIES

<PUBLIC (WHITE), SEMI-PRIVATE(GREY), PRIVATE(BLACK)>





COLLAPSING SIMPLIED **DATA** INTO EACH CATEGORY
<PUBLIC VS. PRIVATE>

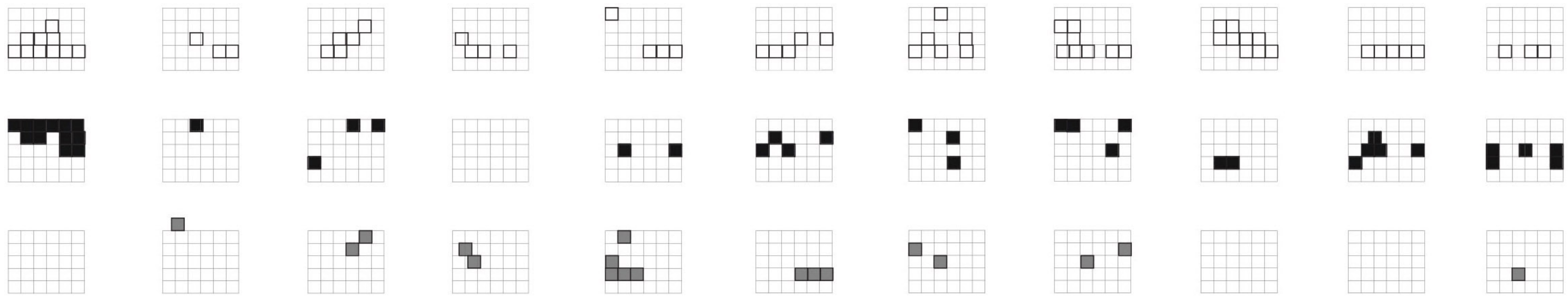


step 3A : prepare design iterations

Data sampled from Section game is exploded, averaged, and re-collapsed as a way of understanding their preferences. Those 'new' data produces design hypothesis that can be used as initial design sketches.

For this particular thesis, three initial designs are created based on the users' preferences about relationship between public and private spaces.

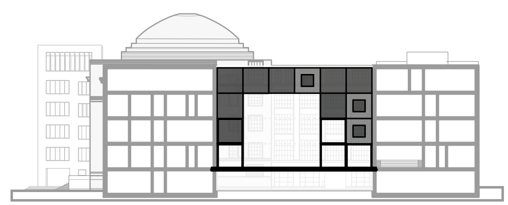
Those three iterations will be voted for selection to be developed, and then selected designs will be put into Navigation game for design development.



DESIGN A

private spaces form a wall on each side leaving the middle portion as the public space.

DESIGN B



private spaces form a roof for public space on the ground level.

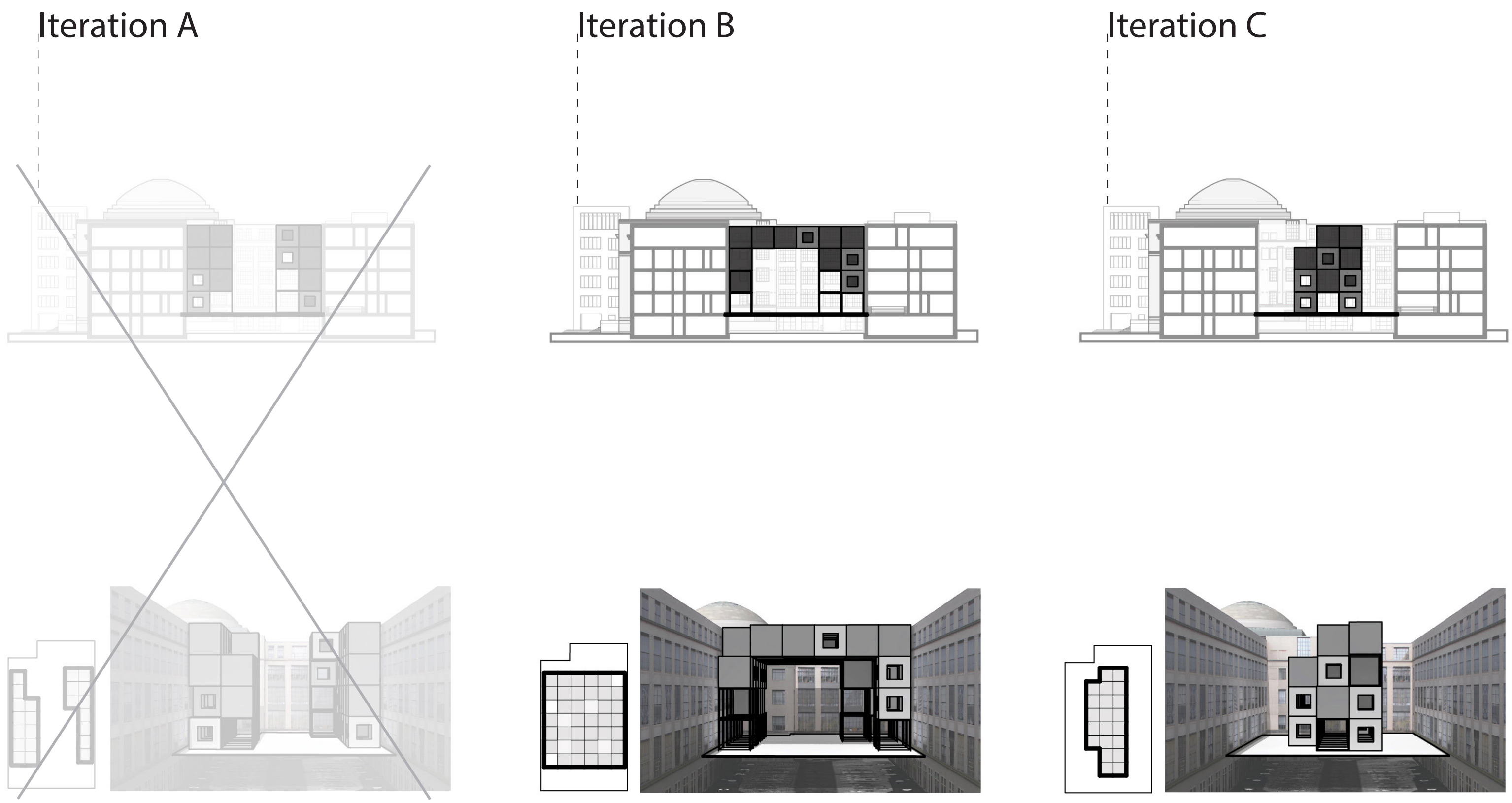
DESIGN C

private space occupies center portion and creates public space around it.

step 3B : Design development

Three iterations were distributed to people to vote, which organization is more preferable. During this process, design A was least favored, and as a result it was eliminated. Then **design B & C** are designed into **Navigation game** for crowd-sourcing.

Navigation game will generate data for design development. Another iteration of designs can be generated through this process, or one of out two can be even eliminated. Design development process is purely up to people's preference.



DESIGN B

People favored design B for its big open public space on the ground level. They also mention that the roof, consisted of private spaces, creates dynamic lighting, while providing them safety from the weather.

DESIGN C

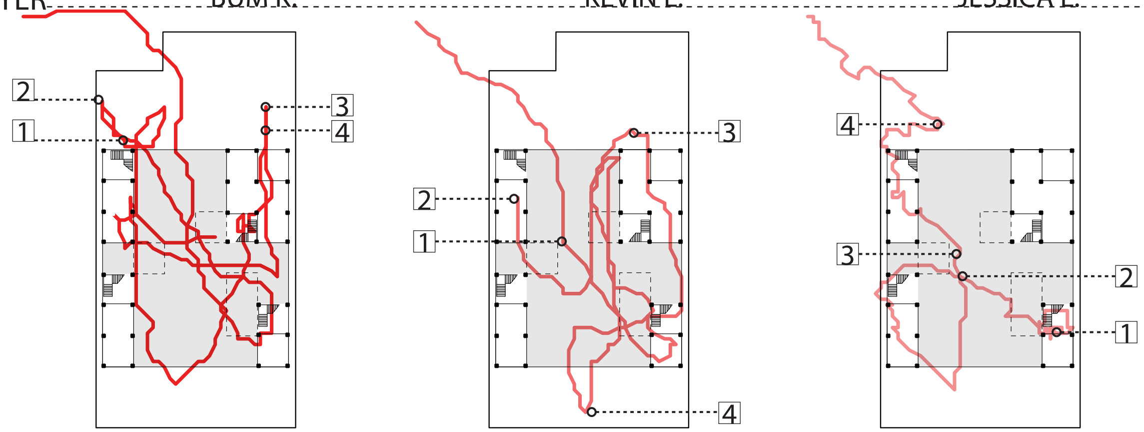
People favored design C, because of its interesting relationship with existing exterior of MIT campus on the both sides. They also like the corridor-like public space around the design.

data for **DESIGN [B]**

data from
NAVIGATION GAME

Seven people have participated in Navigation game. Sampled data is circulation path and photos taken by players.

PLAYER | BUM K. | KEVIN L. | JESSICA L.



PHOTOS TAKEN

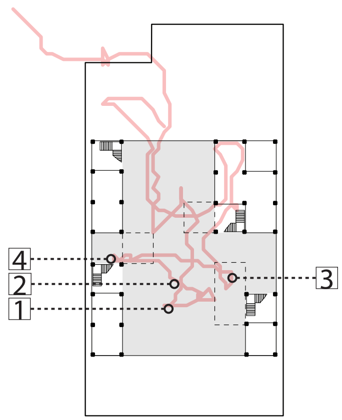
1 : LIKE

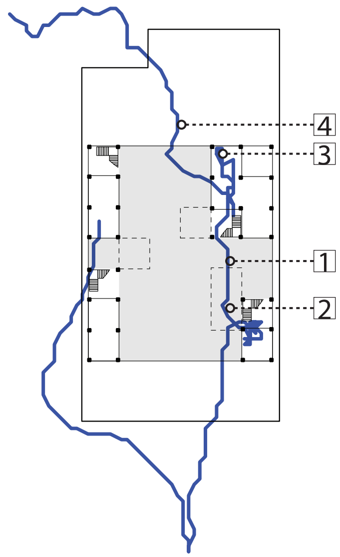
2 : LIKE

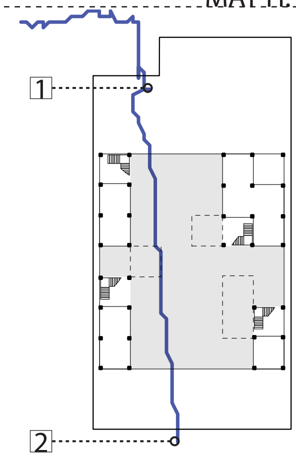
3 : DIS-LIKE

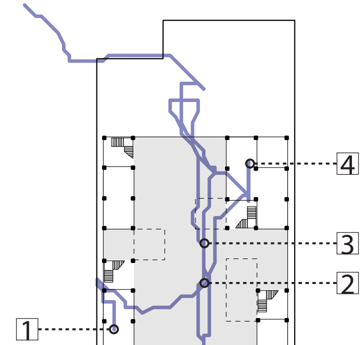
4 : DIS-LIKE

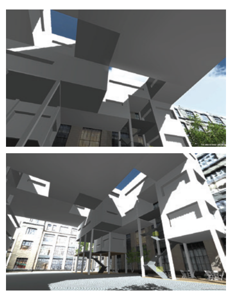
JOSHUA C. | MATT C. | MAY H. | RENA Y.

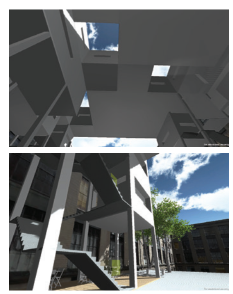


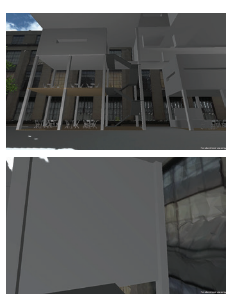


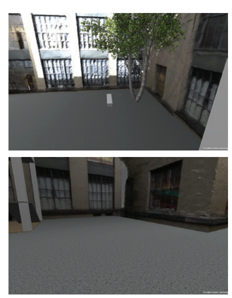


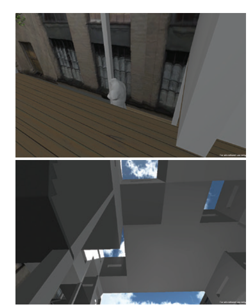










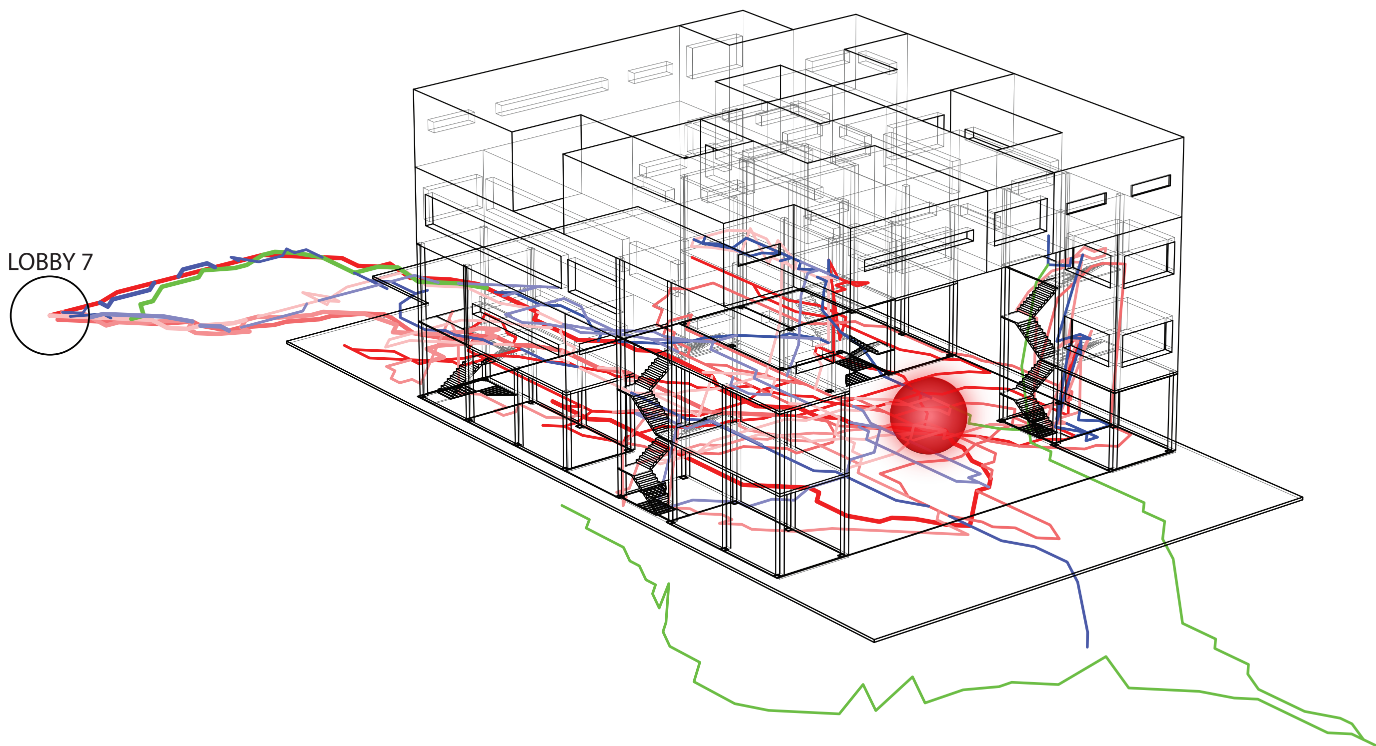


N/A

N/A

COLLAPSED CIRCULATION DATA

Individual circulation path is combined to study overall circulation density relationship to the architecture design. Also, the red spot shows the most popular location for people taking photos.



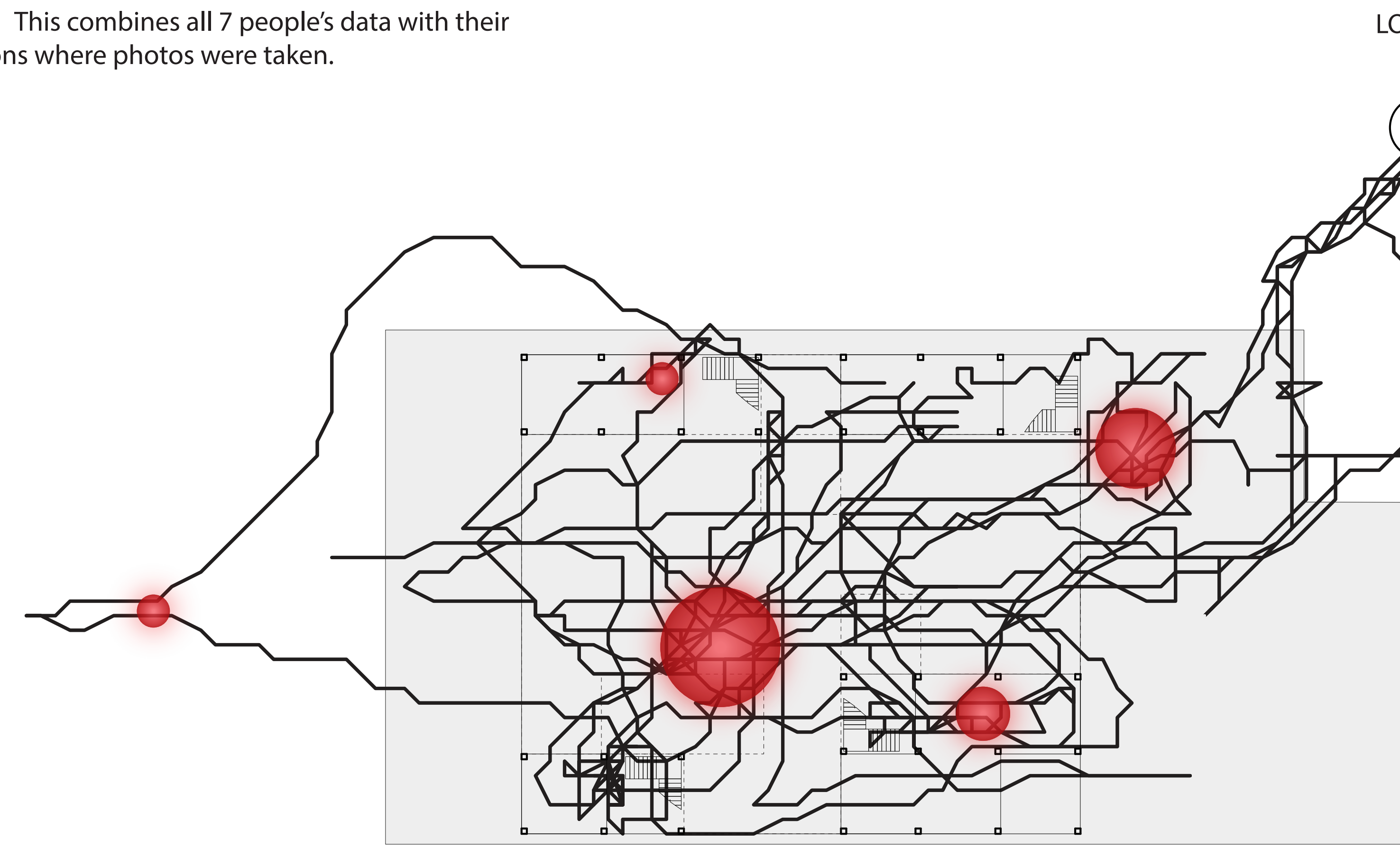
MOST POPULAR EXPERIENCE

This view is the most popular view, and the main reason was the skylight on the given time period.

MAPPING DENSITY OF PHOTOS TAKEN

< the bigger the red spot, the more photos taken>

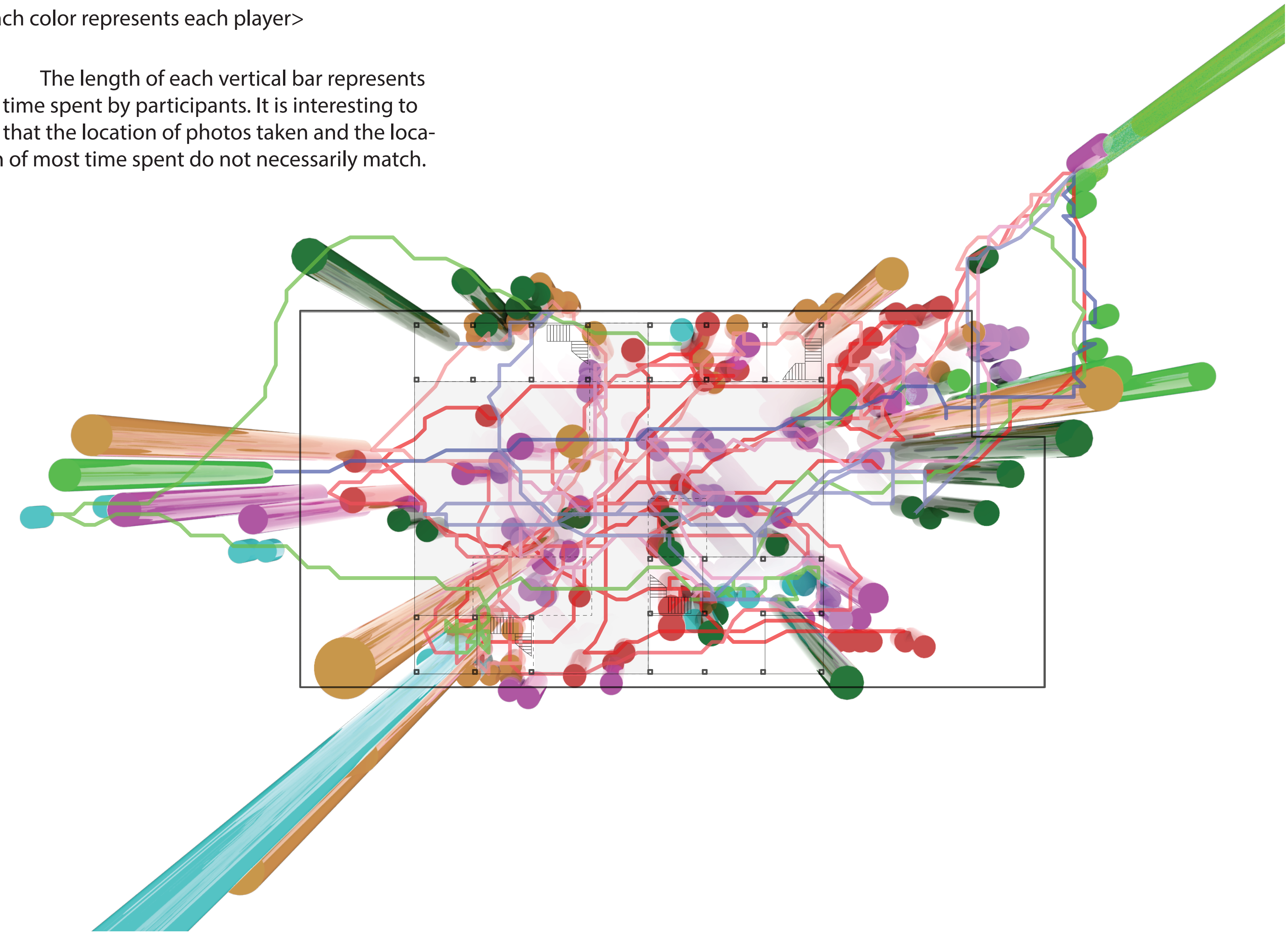
This combines all 7 people's data with their locations where photos were taken.



MAPPING TIME SPENT

<each color represents each player>

The length of each vertical bar represents the time spent by participants. It is interesting to see that the location of photos taken and the location of most time spent do not necessarily match.



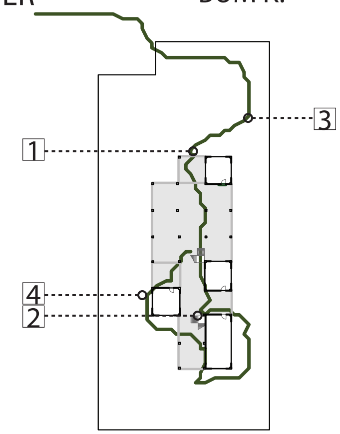
data for **DESIGN [C]**

data from
NAVIGATION GAME

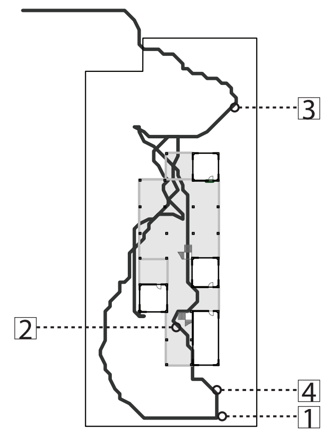
Seven people have participated in Navigation game. Sampled data is circulation path and photos taken by players.

PLAYER

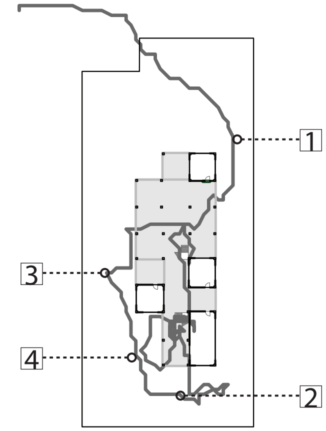
BUM K.



KEVIN L.



JESSICA L.



PHOTOS TAKEN

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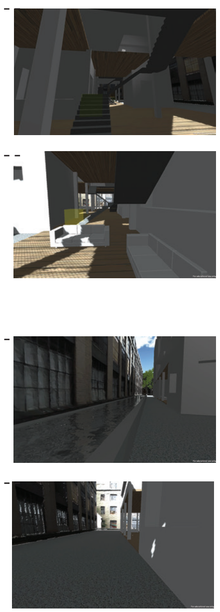
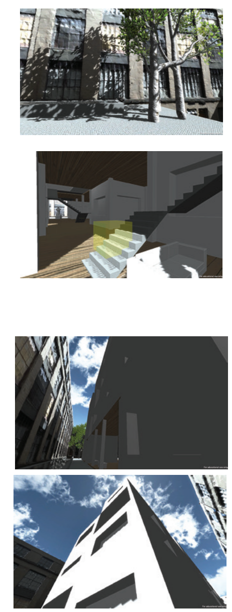
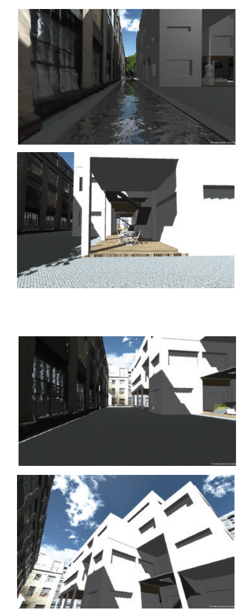
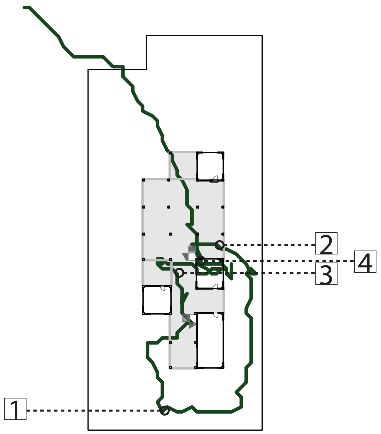
4 : DIS-LIKE



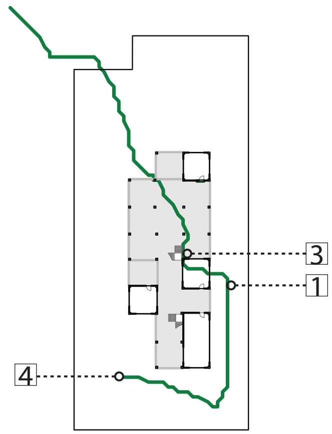




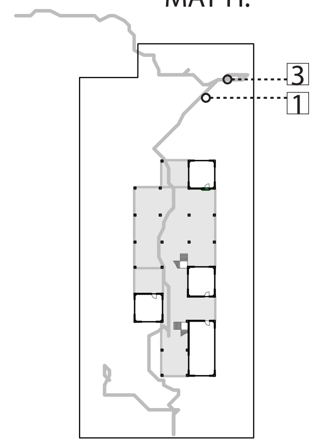
JOSHUA C.



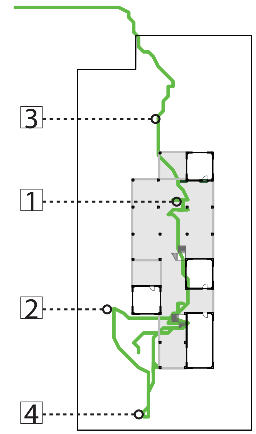
MATT C.

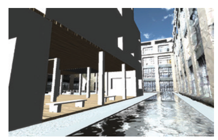
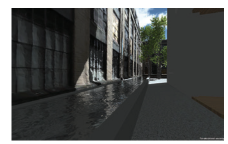
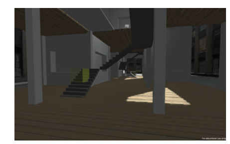


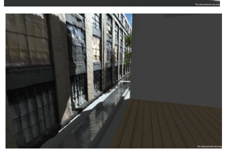
MAY H.



RENA Y.

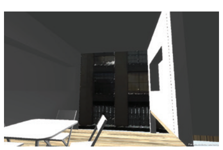


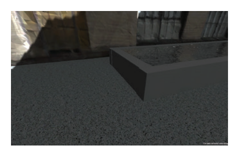







N/A

N/A







N/A

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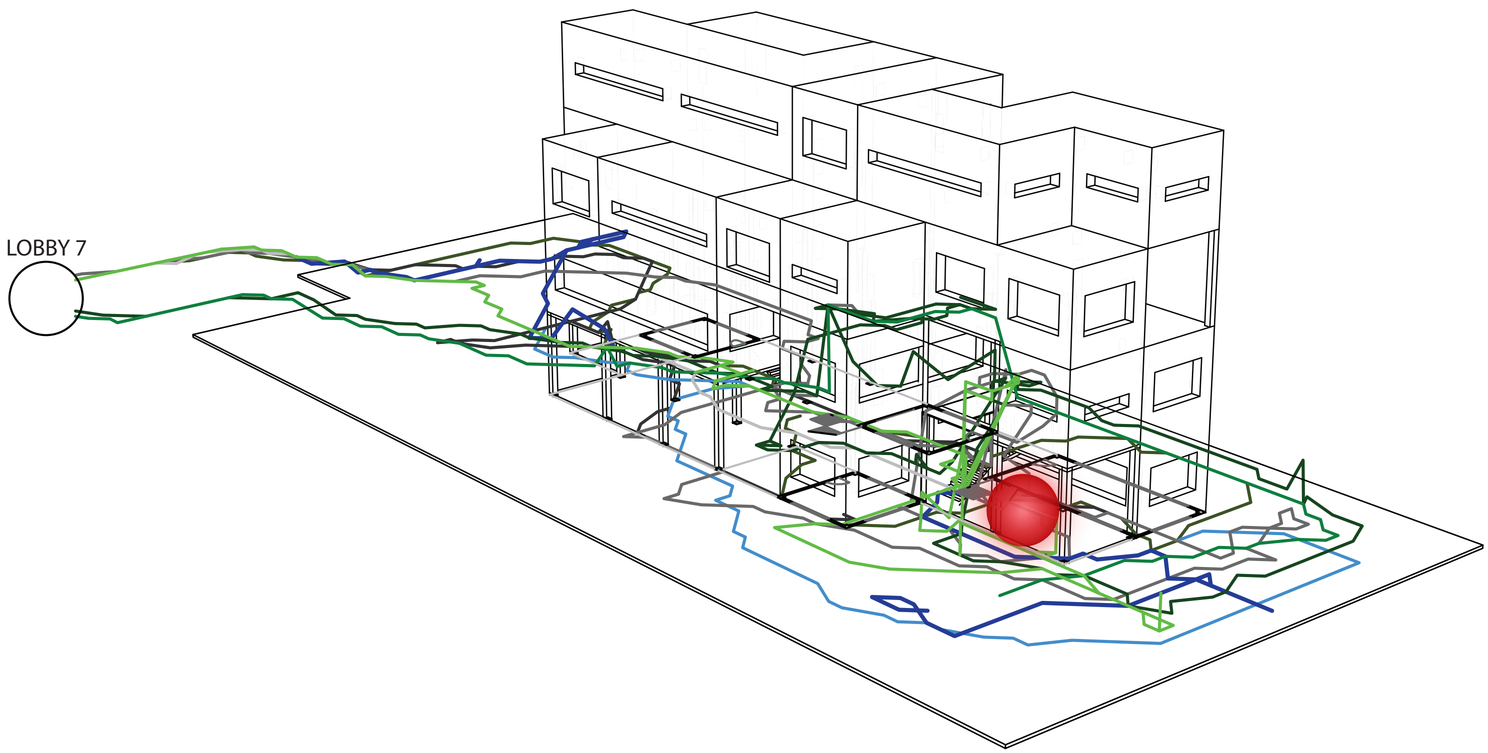
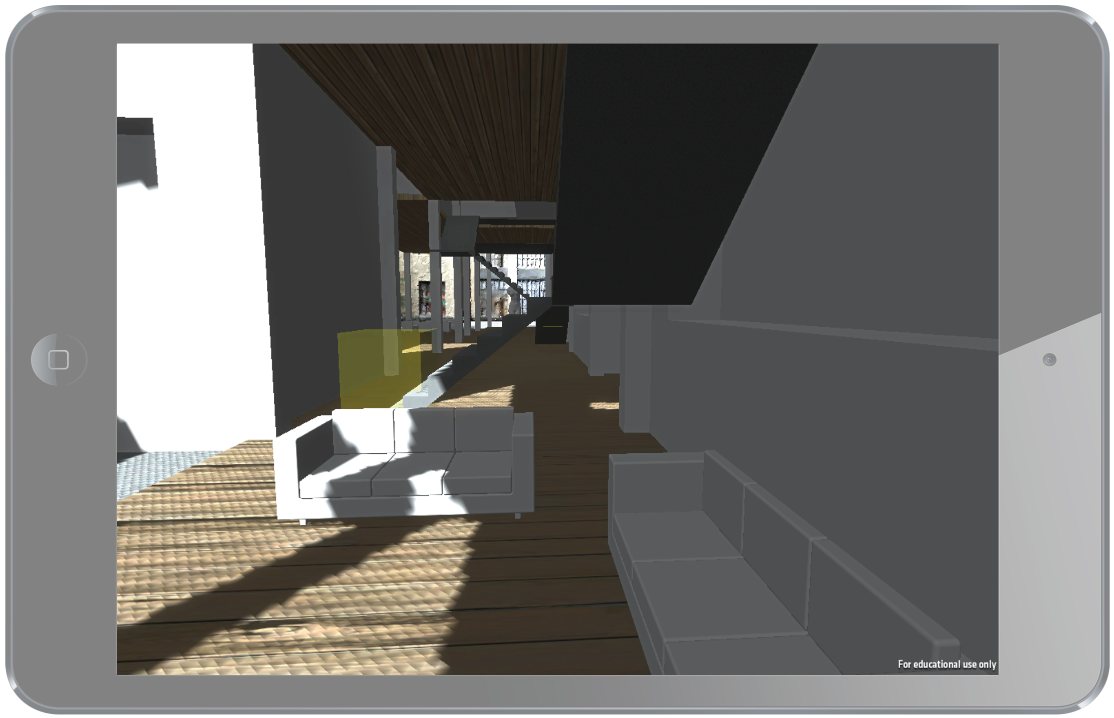


MOST POPULAR EXPERIENCE

The gallery space on the ground level was most popular view by participants.



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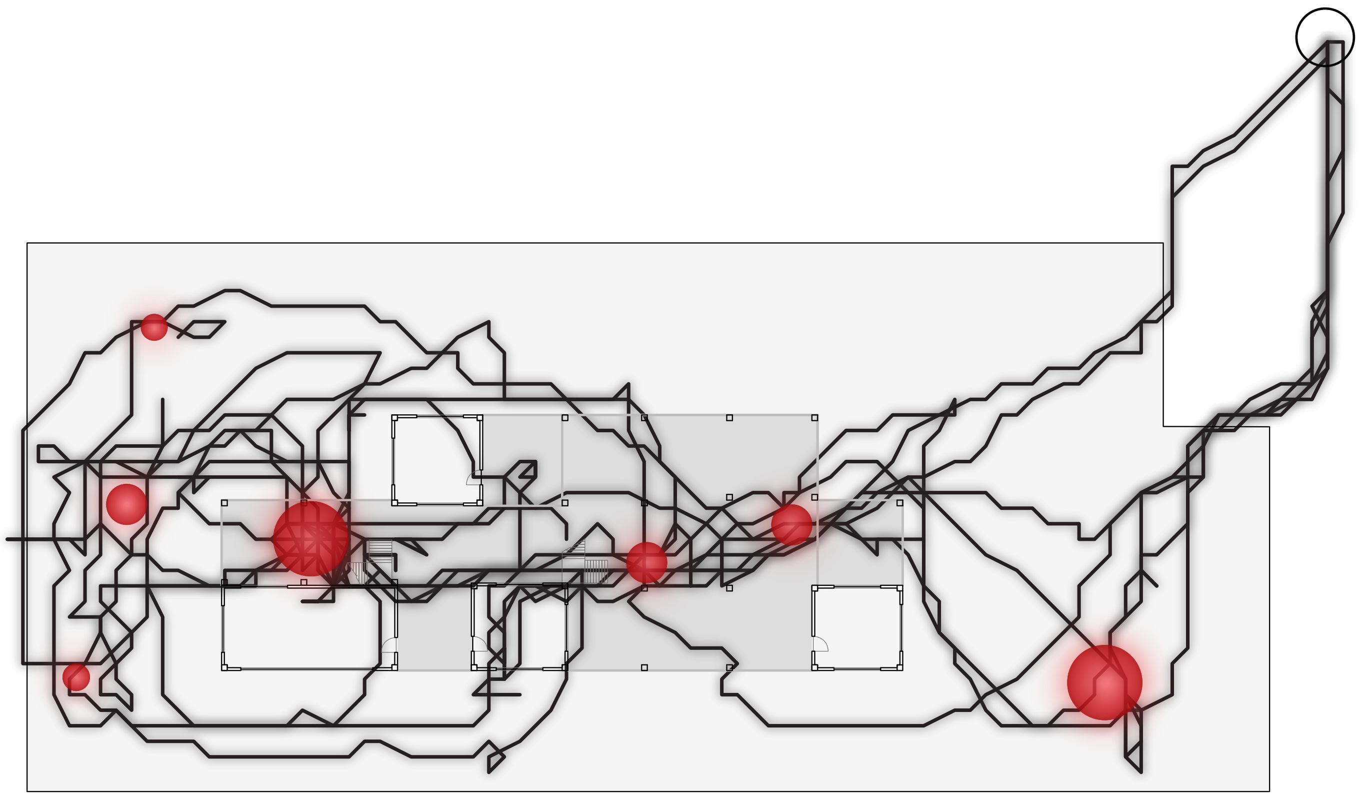

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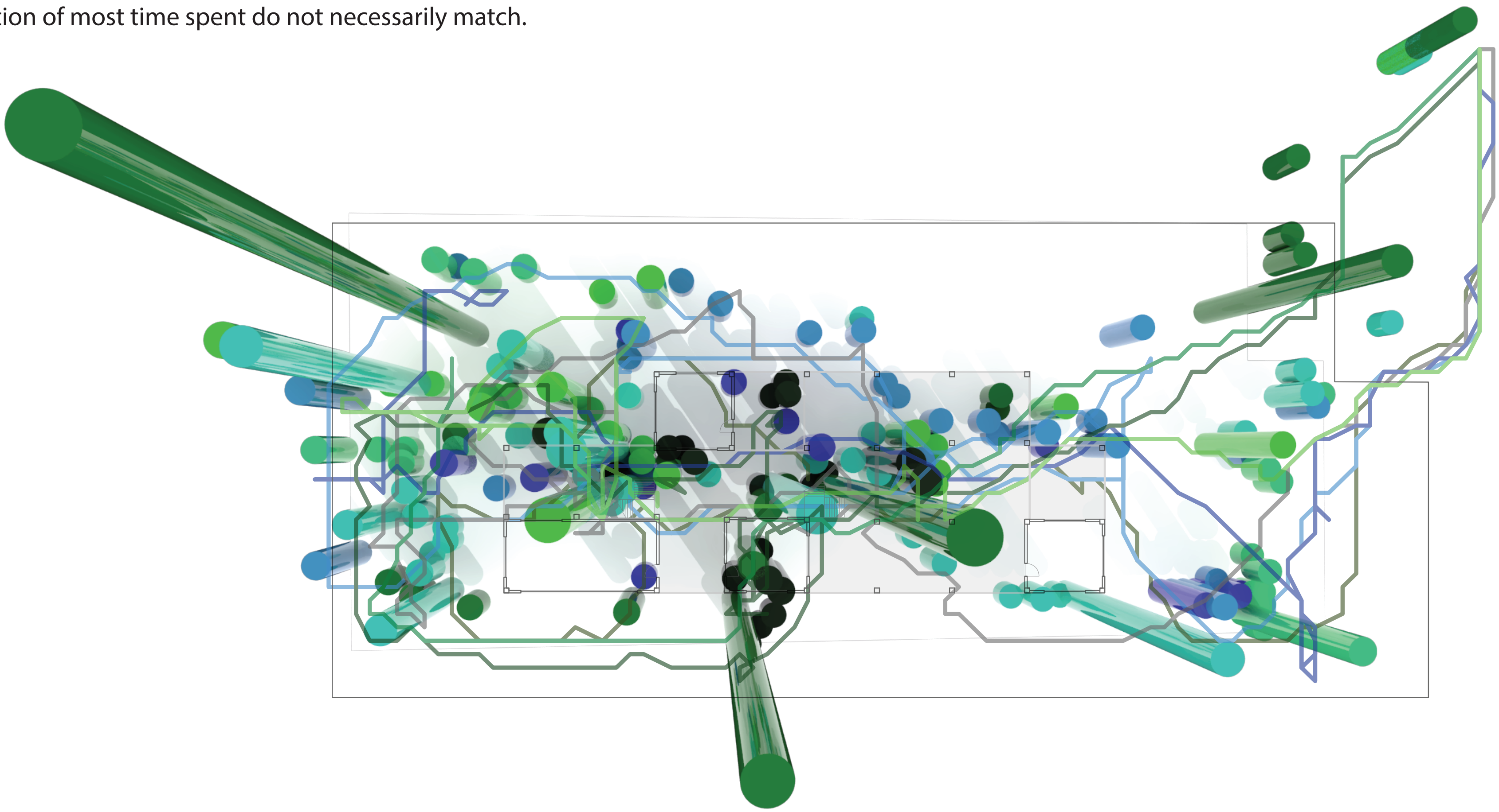

NEXT STEP FOR **DESIGN [B] & DESIGN [C] ?**

Data above from Navigation game will be analyzed for design development.

Democratic design process through games can generate design iterations through game plays. Those iterations can be averaged or selected through people's involvements. Architects do not select designs; they merely create and update games for people to play and make design decisions.
This democratization of design process allows the public to express their preferences. Thus, the final design is a friendly space created by the public.

with thesis advisor, Takehiko Nagakura

final presentation

ARE WE A DESIGNER OF A SPACE?

OR
A CREATOR
OF THE SYSTEM
THAT CONTROLS
DESIGN PROCESS?