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
Master of Architecture at the
Massachusetts Institute of Technology
February 2014

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Department of Architecture
January 15, 2014

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Takehiko Nagakura
Chair of the Department Committee on Graduate Students
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Submitted to the Department of Architecture on January 16, 2014 in Partial Fulfillment of the Requirements for the Degree of Master of Architecture

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 feedback 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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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.
Bibliography


Data visualization from Navigation game from Democratic Play <circulation path & photos taken>
TECHNOLOGY USED FOR DEMOCRATIC PLAY
PHOTOGRAMMETRY + GAME ENGINE

SAN GIORGIO, VENICE

Palladio museum, VICENZA

SAMPLED DATA in GAME ENGINE

TEATRO OLIMPICO, VICENZA

VILLA POIANA, VICENZA
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.
Q1: WHY PHOTOGRAMMETRY?
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 an exterior wall of Convento della Carita from Venice city, which was generated 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
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 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
exterior wall from Venice

Chest
Villa Foscari

wall fragment
Palladio Center

bench
Palladian Villa
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.
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

“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
CIRCULATION PATH
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

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.
PROGRAM RESEARCH

CAMPUS AS PRIVATE VS. PUBLIC
CREATE PUBLIC SPACE

PROGRAM
- studio
- laboratory
- common room
- gallery
- class
- office
- library
- lecture
- bathroom
- cafe
- cafeteria
- garden

SITE

Main Circulation

43% area
private vs public

40%

public

semi public

study

office

Lab

accessibility

4%

9%

5%

3%

43%

area

private vs public

semi public

study

office

Lab

accessibility

43% area
private vs public

40%

public

semi public

study

office

Lab

accessibility

4%

9%

5%

3%

43%

area

private vs public

semi public

study

office

Lab

accessibility

43% area
private vs public

40%

public

semi public

study

office

Lab

accessibility

4%
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.
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 an empty structural box, void box.

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

11 BOXES: press the button for a box to fall

- Restart the game
- Section cut
- Rotate to other section
- Finish & save user data
**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

LIKE PHOTO

DIS-LIKE PHOTO

player 1  player 2  player 3  player 4  player 5

49
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.

resulting DATA OF 20 PLAYERS

PLAYERS: Bum K. 1, Bum K. 2, Jay L, Jess L. 1, Jess L. 2, Kam R, Kyle B, Toshi I, Tyler P, Tamrat G

DATA

Example Data by Bumjin Kim

5 floor & 6 span grid

GROUND LVL
EXPLODED **DATA** INTO EACH PROGRAM

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<td>Li H.</td>
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<td>Duk C.</td>
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</tbody>
</table>

(Note: The table contains cells filled with various colors, indicating data points or interactions.)
SIMPLIFICATION OF EXPLODED **DATA** INTO THREE CATEGORIES

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Public</th>
<th>Semi-Private</th>
<th>Private</th>
</tr>
</thead>
<tbody>
<tr>
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<td><img src="image" alt="Garden Semi-Private" /></td>
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<td><img src="image" alt="Meeting Semi-Private" /></td>
<td><img src="image" alt="Meeting Private" /></td>
</tr>
<tr>
<td>Lab</td>
<td><img src="image" alt="Lab Public" /></td>
<td><img src="image" alt="Lab Semi-Private" /></td>
<td><img src="image" alt="Lab Private" /></td>
</tr>
</tbody>
</table>
### COLAPSING SIMPLIED DATA INTO EACH CATEGORY

<PUBLIC VS. PRIVATE>

<table>
<thead>
<tr>
<th>PUBLIC</th>
<th>PRIVATE</th>
<th>SEMI-PRIVATE</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Public Data" /></td>
<td><img src="image2" alt="Private Data" /></td>
<td><img src="image3" alt="Semi-Private Data" /></td>
</tr>
</tbody>
</table>

**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.

PHOTOS TAKEN
1 : LIKE

2 : LIKE

3 : DIS-LIKE

4 : DIS-LIKE
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]
Seven people have participated in Navigation game. Sampled data is circulation path and photos taken by players.

**PHOTOS TAKEN**

1: LIKE

2: LIKE

3: DIS-LIKE

4: DIS-LIKE
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

The gallery space on the ground level was most popular view by participants.
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.
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.
ARE WE A DESIGNER OF A SPACE?
OR
A CREATOR
OF THE SYSTEM
THAT CONTROLS
DESIGN PROCESS?