Democratic Play

Crowd-Sourcing through Digital Games for Architectural Design

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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?

Keywords: Gamification, Video game, Democratic design, Participatory design, Photogrammetry, Game engine

INTRODUCTION
This thesis explores an alternative methodology of an architectural design process using game as a crowd-sourcing tool for collecting architecturally relevant data. The game, titled Democratic Play, invites non-architect users to participate in a design thinking process for developing architectural awareness to help create a more genuinely public space. Set in the backdrop of one of empty courtyards on MIT campus, the game is constructed based on architectural knowledge, and designed to collect direct responses to various architectural elements of the surrounding space from participants. Such democratic data collecting process enables architects to share their design power with the general public in a manner free of hierarchical constraints; in turn, this process enables a more genuinely intimate participation from the actual users of the space, resulting in the true
The motivation for this thesis was the desire to think critically about the current state of architectural design process. As the field of architecture requires highly specialized knowledge and skill sets, the design process at times ends up being hierarchical. Users of spaces are often excluded from the intimate design process that creates the spaces, sometimes resulting in architecture that produces unexpected responses for and from the users (Negroponte, 1970). Regardless of the theoretical or pragmatic success of the end result, the final structure ends up including a latent threat of authoritarianism. Thus, this thesis suggests an alternative methodology that combines architectural motivation and advanced technology such as game engine, photogrammetry, and crowdsourced data analysis to achieve a greater level of equal participation from all users of the space.
The origin of participatory design traces its roots back to Scandinavian countries in the 1970s. Participatory design focuses not only on the style of a design, but also on the design development process. Including both the original creator and the final user in the design process, participatory design facilitates democratic design process that aims to produce design that is more responsive and suitable for the future users due to genuine consideration of users' behaviors and preferences. Participatory design is desirable for enabling people to develop realistic expectations, reducing resistance to change, and increasing workplace democracy by providing the right to be involved in the decision making process for future users (Gregory 2003). Democracy, in this sense, is referring to the mode of interaction that provides equal participatory capacity for all the interest groups involved in the design process, and should be distinguished from its political connotations.

The expansion of this thesis involves two methodologies: crowd-sourcing and game-playing. Both are utilized in a complimentary way to facilitate participatory data collection. Crowd-sourcing enables data collection in a hierarchy free capacity; game-playing ensures that the crowd being invited to engage with the data collection process will participate efficiently and voluntarily.

1. Crowdsourcing
The term crowdsourcing is the combination of the words "crowd" and "outsourcing" (Howe, 2006; [3]). It is a method of distributing tasks to people, usually through on-line platforms, then to collect data from them in order to accomplish a particular task. Oxman and Gu argue that "crowdsourcing is a new concept for breaking with the traditional hierarchical model of collaborative design" (2012). Crowd-sourcing, especially through on-line platform, enables the direct sharing of opinions and ideas, which decentralizes the hierarchy of the design process. Online crowdsourcing platform appears to be "powerful democratic and socializing forces of communications" which potentially have a strong impact on the design decision making process (Oxman and Gu, 2012).

Arcbazar is an example which has applied the logic of crowdsourcing to architecture in a disruptive way. In this platform, designs are collected through form of competitions and clients have an access to those design services. Creators of Arcbazar argue that through participation of masses, they can "even assist in developing a new product or service, refine a design, compute or derive various algorithms, or assist in providing, arranging, or evaluating significant quantities of information into viable data" (As and Angelico, 2012). Democratic Play proposes the unique way of collecting big data, which is through game-playing. In this particular system, the main role of architects is to prepare the platform for public's involvements to crowd-source feedback, and then to analyze the data in meaningful ways in which the final result is more expected and preferable by the public.

2. Game-Playing
In addition to crowdsourcing is game-play for another method of participatory design process.

But what is a game? Perhaps more easily defined in contrast to work, an activity primarily characterized by productivity and efficiency, no single exhaustive definition exists for what a game is. But it is possible to posit a few basic premises: game refers to an unproductive activity that is undertaken purely for its entertainment value. Important basic components of game are goals, rules, challenges, and interaction between the participant and the other components in ways that maximize the participant's experience of fun.

However, all games are not just about fun. They are also capable of providing "creative expression, instruments for conceptual thinking, or tools for social change" (Flanagan 2009). Within the field of game there exists something called "serious" game. Abt describes serious game as "an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement" (1970).
A good example for a 'serious' game that applies crowdsourcing is 'Fold-It,' an online game created by University of Washington that doubles as an experimental research tool for protein folding (Figure 3). Recently, an AIDS-related protein problem that went unresolved for fifteen years was solved in just three weeks of gameplay, suggesting that participatory input can be more powerful than sophisticated computational algorithms. Fold-it shows how crowdsourcing through game-playing is an ideal model for distributed problem-solving and production that has potential for not only solving scientific problems but also generating creative ideas (Brabham, 2008).

Despite such nontraditional development in both form and content of game, the foundational concept of game remains unchanged for the serious games: having fun. This fun factor is the key attraction point for generating crowd-sourced data used in this thesis. Game-play engages people in their most intimate emotional and intellectual capacity, and is thus able to generate highly personalized responses, which serves as data input for future design process. To achieve this end, it is crucial that the game is easy to understand for anyone who wishes to participate while including accurate architectural knowledge for the players to provide useful data.

Oxman and Gu points out the difficulty in adopting crowdsourcing in design due to lack of technological understanding. They argue that "what is required is the clear definition of the principles of operative and technological requirements of online environments that can support design activities suitable for crowdsourcing and provide design environments enabling crowd participation. Only through the establishment of such enabling conditions will we be able to foster, motivate and exploit crowd wisdom in design" (2012). Coupled with photogrammetry (explained below), game engine can help solve the technological barrier by enabling architects to create a realistic environment for crowdsourcing. Game engine can easily simulate navigational system, environment recreation such as weather, wind, and sound, human density, and physics for structures in comparison to having only the conventional architectural drawing on the two-dimensional paper. Also, game engine enables easy computation for recording and collecting participants' behavior data. Moreover, photogrammetry, an emerging technology, can help creating visually realistic digital environment for more intuitive interaction and engaging experience.

3. Photogrammetry

Further contributing to the goal of creating an accurate interactive platform is the technology of photogrammetry. In order to control the quality of people’s input during the game play, the game should contain accurate and abundant architectural information. Photogrammetry is a science of extracting three dimensional information from an object with its photographic texture. Examples of photogrammetry are the Google map’s three dimensional landscapes and buildings which are 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 recreated using 3D modeling tool, which makes the existing condition simplified without textures. Of-
ten times, architectural renderings shows site condition in white boxes for adjacent buildings on the flat ground without actual topographical information, leaving blank much potentially important information for the client.

The main reason this omission is the lack of time for manually re-creating real site condition. Photogrammetry provides quick and easy solution for this issue as it can help architects to capture 3D models of existing condition with photographic textures. With photo-realistic setting, participants have better experience involving in the design process helping them provide better data. This idea is well expressed by Lynch, who writes in 'The Image of the City,' "nothing is experienced by itself, but always in relation to its surroundings" (1960). The way people truly understand the city or the design component within the city has to relate to the surrounding environment. Thus, photogrammetry plays a crucial role in creating the most realistic digital environment for participants to understand the design in order to provide their honest feedback.

A captured photogrammetric model such as Figure 4 is a simple mesh with photographic texture covering it. By carefully adjusting each mesh to represent an architectural component, it is possible to reassemble multiple models into a new spatial design just like making a 3D collage (Nagakura, Tsai and Choi 2015, see esp. Fig. 4 on p. 687). With such photo-realistic setting, participants have better experience involving in the design process helping them provide better data.

**EXPERIMENT BEGINS...**

Ideally the game-playing platform for this thesis should be on-line with hundreds of participants. However, this experiment was done with around 20 people (I thank for all the participants), which I believe works as a proof of concept in demonstrating the new methodology, Democratic Play.

There are three steps to creating 'Democratic Play': research, construction, and distribution. In the first step, professional architects prepare the necessary architectural information for setting up the game by doing intense site research, which includes capturing significant architectural objects using photogrammetry. For step two, using collected data from step one as a building block, architects create games with user-friendly interface. For step three, architects distribute the game to the public for generating crowd-sourced feedback. After an adequate amount of data is gathered, architects analyze the data for future design development. Step three can be repeated multiple times for further design development with updated games.
**STEP ONE: Research**

Step-One has two phases, secondary research and field research. Secondary research or desk research helps prepare appropriate programs for the given site. For this portion of the experiment, I chose the empty courtyard within the MIT campus shown in Figure 5.

The site is surrounded by the Architecture department, Mechanical Engineering department, and Lobby 7, which serves as one of the most public and touristic spot on MIT campus. The site condition provides an interestingly dynamic mixture of multidisciplinary groups and visitors, yet it does not serve any useful functions to those groups of people.

I studied floor plans of buildings around the site to find spatial hierarchy and relationship between existing academic programs. As predicted, science labs and offices were dominant programs at MIT. There were very few public spaces other than Lobby 7 for visitors and students alike to enjoy: a small gallery for Environmental Engineering on the first floor and even smaller architecture gallery on the fourth floor; two commons for each engineering and architecture department; small cafeteria with around 12 seating tables. The calculation for area ratio for public spaces are only about 3% for students, faculties, and visitors, and 7% for students and faculty. There were not enough public spaces for visitors, students and faculties to relax, study or do events and exhibitions.

At the end of the secondary research, I prepared ten suitable programs with proper dimension found on the site for participants to choose from during the later stage of this democratic process. During the game play, participants will be able to use these ten programs as design components (Figure 6) to provide their preferences; ten programs are architecture studio, labs, common room, gallery, class, office, lecture room, meeting room, garden and café.

For the field research, I went to the site to capture more 500 photographs to process photogrammetry to create a photo-realistic digital site environment for the game system. I took around 80 photos per façade, and processed each façade separately to minimize the computational power requirement, then assembled facades in 3D modeling tool. The trees in front of the façades were challenging; digital models ended up missing large portions of meshes that were behind the trees, which had to be fixed manually with 3D modeling tool. After fixing façades and removing unwanted meshes such as trees, digital trees were planted to regenerate the site condition as realistic as possible (Figure 7). Now, I am ready to make games.

**STEP TWO: Creating Games**

Using the photogrammetric model and ten programs from Step One, two games are created for this experiment: Section Game and Navigation Game. Section Game collects data regarding sectional program diagram that each player can designs according to her preference. Navigation Game collects two types of data: circulation paths and screenshots. Every game created for Democratic Play should be designed care-
Figure 6
ten programs
prepared from the
research in the
order of cafe,
common room,
architecture studio,
lecture room, class,
meeting, office,
gallery, lab, and
garden

Figure 8
the third iteration
of Section Game

fully regarding the implementation of all the nec-
essary rules and constraints so that the game helps
participants to intuitively express their architectural
preferences without being required to have special-
ized architectural training.

Figure 9
the first iteration of
Section Game

The first iteration of Section Game shown in Fig-
ure 9 tested how players can drag and move colored box onto a section drawing for them to create
a simple public vs. private diagrams. This allows
them to express their preference for public v. pri-
vate spaces. White represents public, black repres-
sents private, and grey represents semi-private. For
the second iteration, I implemented the photogram-
metric model and inserted ten program components
instead of colored boxes from the first iteration; ten
program boxes have general furniture layout in order
to guide players visually.

As the sample size of participants available for
the experiment was limited, this iteration was not ade-
quate for generating sufficient data. There was too
much freedom for the ways in which boxes could be
moved, which resulted in lack of sufficient patterns
for proper data analysis.

For the third iterations (Figure 8), I implemented
gravity to provide greater reality simulation. If you
drag a program box into the air, it drops to the
ground level. This feature introduced certain design
constraints for the player; if a player prefers the gar-
den on the second floor, then he needs to put a struc-
tural box or other programs on the first floor first.
Since there is a gravity acting on each box, players
need to start creating a pattern from the ground to
top. Contrast to the second iteration, the third iter-
ation with this element was useful in organizing the
outcome to be more recognizable with patterns for
the analysis.

Navigation Game records individual participant's
circulation path and also allow players to note their
preferences by taking photos of their likes and dis-
likes. This is for the future step, but the overall con-
text for using these two types of data to analyze
player's experience can be achieved with machine
learning algorithm. The general flow of implement-
ing machine learning is following.

1. The machine learning algorithm, or super-
vised learning, will use 'like' and 'dislike' photo
as a training data. Training data is example
data that has desired output (Guttag 2013). In
this case, 'like' photo represents positive expe-
rience while 'dis-like' photo represents nega-
tive experience of a specific location.
2. Based on the training data, the computer will
learn how players experience the virtual space to predict how they experience in all other locations even if they have not taken any photos.

3. The algorithm will be able to produce a visualization map of player’s experience from all circulation path data, which identifies specific locations that architects can develop.

4. Using those data output, architects can not only develop the design of the space but also update the game system for future crowdsourcing purposes.

An interesting observation was made during the test game play with a random space I designed. Resulting photos of 'like and dislike' showed a good sense of how players behaved: most of 'dislike' photos were spaces in shadow, unfinished, or unused spaces which could be developed. In contrast, 'like' photos were spaces under skylights or with trees and benches as seen in Figure 10. This observation was interesting because they were acting very close to the real world scenario, which hints the benefit of using game engine in simulation of a designed space. Also, it proves how a simple data such as 'like' and 'dislike' can start to help to identify specific design tasks architects can focus on developing; the potential future case is that with machine learning algorithm, the observation and analysis can cover more complex design spaces with more variables other than 'like' and 'dislike'.

**STEP THREE: Crowdsource Data**

Third step begins by distribution of two games for crowd-sourcing data. Future users of the space, visitors of MIT, mechanical and architecture students,
and staff were involved in this step to provide feedback. Initial data of Section Game is analyzed to create initial design iterations, then those iterations are put in Navigation Game for design developments. Step Three is repeated multiple times with synchronized updates on game systems based on people’s preferences.

A total of twenty participants played Section Game, resulting in twenty unique section diagrams shown in Figure 11. For this experiment, I decided to simplify the data in order to derive three design iterations.

First, each section data was exploded into ten sets of data representing ten program boxes. Then each program box is clustered into three categories, which are public, private, and semi-private. Lastly, the data is collapsed into those three categories (Figure 12). Using these resulting new set of section diagrams, I began to search for the pattern to generate design iterations.

The first pattern I found was that for every horizontal private space, there was public space underneath. The second pattern found was that the vertical public space was most of the time sandwiched by both private and semi-private space and visa-versa. Using these found patterns, I created three general massing models as a starting point for design developments shown in Figure 13.

With these three designs, I introduced a simple participatory system, voting. I distributed three designs to all the participants of future space users to rank their preferences. Consequently, Design A was least favored, and thus removed; people favored Design B for its big open plaza at the center, while Design C was favored for its relationship with existing exterior walls of MIT buildings which can create interesting contrast with new structure in future.

From this point on, assuming the role of a profes-
sional architect, I updated two separate Navigation Games with two design iterations for each game.

7 out of 20 participants in Section Game continued on for Navigation Game, which produced 7 data sets for each Design B and Design C. Each data sets include 'like and dislike' photos and a circulation path (Figure 14).

Figure 15 represents a visualization of data for Design B from Navigation Game. Left figure is collapsed circulation paths. The red dot represents the location of all the photos taken and the larger dot represents more photos taken. Right figure represents all the players' time spent on every position they circulated. The different color represents different player while the height of bars represents the amount of seconds they stayed in the position.

**FUTURE STEP**
The upcoming thesis will implement machine-learning algorithm to analyze crowd sourced data computationally. Those results will help identify what to design for architects for further development. However, there is more than computational challenge; there are still many different ways to develop design after identifying future users' feedback and design problem.

In order to study how architects can make design decision with identified design problem, I need to experiment with many different tools for the participants to use during the game in addition to 'like' and 'dislike' photo function. For example, in the future iteration, a player may potentially move around furniture, or even relocate a room so that at every end of the game, the design of the space can undergo a significant infrastructure transformation by different players. Tentatively titled as Transform Game, this stage can take place collaboratively at the same time, so that one can see other players changing the surrounding environment as one plays the game. In this way, architects can also study the interconnectivity of the participants design decision-making process.

**REFERENCES**


Nagakura, T, Tsai, D and Choi, J 2015 'Capturing History Bit by Bit', *Proceedings of eCAADe 2015 (Volume 1)*, Vienna, pp. 685-694


Oxman, RO and Gu, NG 2012 'Crowdsourcing: Theoretical framework, computational environments and design scenarios', *Proceedings of the 30th eCAADe Conference*, Czech Technical University in Prague, pp. 393-401
