Interactive Public Display

- Mobile and Pervasive Computing

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1. INTRODUCTION

Public displays are ubiquitous. They can be seen in many public locations including malls, schools, and coffee shops. Public displays share these characteristics:

- They appear in public places (as mentioned above)
- Their locations are usually fixed (not portable)
- They are usually large in size
- People pass by or gather around the display
- There are limited interfaces. Keyboards, touch screens are usually not provided
- No internal memory available (it is just a screen)

With those characteristics, public displays are often being used as a screen to display content. It could be static content like posters, images and Ads; or it could be dynamics content like news channels, trends or music videos. However, public displays are not necessarily aware of its surroundings. Most importantly, displays don't respond to the presence of people. In other words, public displays are not interactive. For instance, a public display in a mall could show music videos of Justin Bieber all day long, even though none of the people in the mall is a Belieber[1].

2. OBJECTIVES

The objectives of this project are to make public displays interactive. The scenario determines the type of interaction. We narrow down to a scenario, that is cocktail parties where people mostly mingle with other as per requested by our sponsor. Specifically, we hope to achieve two goals. First, we would like to encourage interaction between people and display, and also to make displays and people aware of each other's presence. Second, we would like to foster interaction between people and encourage discussion.

In order to engage people, we started with designing an application that attracts people's attention. Many ideas were emerged, such as developing games or tools that will allow people to participate in activities. We believe that game is an efficient way to gather people's attention in a short period of time, hopefully in a pleasant way also.

The objectives of the game are very simple. It allows people to interact with display and promote interaction between people quickly. Since we set up our game in scenarios like cocktail parties and coffee shops, where people are usually occupied, we want to make sure that players can join the game anytime. Moreover, players shall not feel obligated to stay in the game; he/she should be able to leave the game anytime without the impact to other players.

3. GAME IDEAS

We conducted a series of brainstorming and came up with several game ideas, such as action game (e.g., darts, basketball), gambling game (e.g., roulette), word puzzle game and trivia game. We later realized that action requires too much commitment to the game and space for movement, which doesn't suit our scenarios; puzzle game involves too much intelligence and it is time consuming; whereas gambling game is basically random guess. As a result, developing trivia game(s) was a favorable idea.

To ensure an abundant question pool for the trivia game, we utilized Google APIs which provide ample useful information.

3.1 Battle of Cities

Google radar search (part of Google Places API) provides number of a certain type of places (e.g., restaurant, bakery) in a given area. With this information we can develop a trivia game that is based on numbers of places in different cities. Here is a sample question: Which city has more bars, New York City or Shanghai?

We select more than 10 high-profile cities in both the eastern and western atmosphere and 80 place types to generate questions.

3.2 Translator's Dilemma

Translator's Dilemma was emerged when browsing a website called Translation-Telephone[2], which is similar as the traditional "Telephone" game where people pass a message around a circle and see how it turns out at the end. In

*This author will be graduating soon.
†This author will be graduating soon.
‡This author still has to "suffer" to lot.
[1]A huge fan of Justin Bieber.

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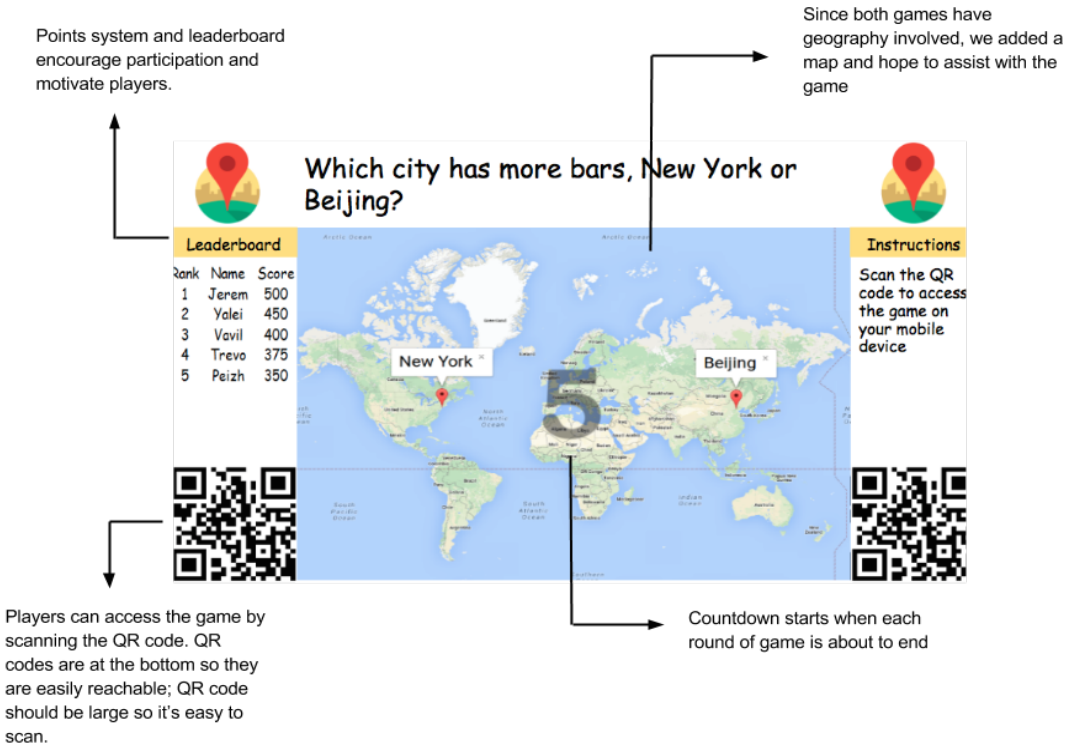

Figure 1: Preliminary Design

translation-telephone, a message gets translated to random languages and back to the original language.

We thought it was an interesting idea and wanted to develop a game based on it. Google Translate is one of the most widely used translate engine, and it is a great tool to use in this game. In the same way as translation-telephone, we randomly select collections of languages and use Google translate API to generate translations. In addition, we have two collections (paths) of languages and provide one final translation. In the end, players will get to choose which path the final translation is generated from.

4. PRELIMINARY DESIGN

Our goal is to design games that are easy for user to understand; it should be straightforward and easy on the eye. To that end, we came up with a user interface prototype (Figure 1) that is to be used by both Battle of Cities and Translator's Dilemma.

5. USER STUDY

In order to evaluate the effectiveness of the games we developed and iterate the design, we conducted user studies. User studies were conducted in a student common on Carnegie Mellon University, Silicon Valley campus. The students common is the hub of the building and there were hundreds of people passing by each day. We deployed there to attract more students to play and therefore obtain more feedback. The game was deployed on 65 inch Sharp display. A Macbook Pro was connected to the display to render the view in a web browser. A backend end server backed by Node.js, along with a CouchDB, was deployed at an EC2

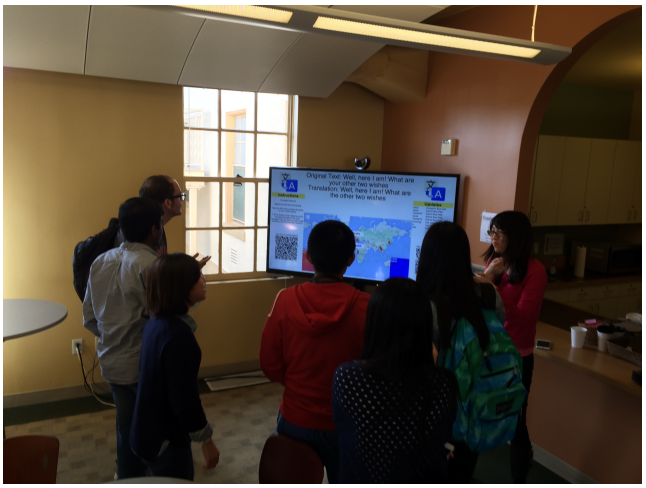

Figure 2: Deployment of Translator's Dilemma

instance on Amazon Web Service. The web page was loaded from the backend server to the web browser. Figure 2 is a capture of the deployment.

We invited some students to play the game and there were some unsolicited involvement. After they played the game, we asked them to fill out a survey. The survey focused on the game design, participants' behavior and interaction during the game.

6. DESIGN GUIDELINES

Table 6 summarizes the design guidelines that we hope will

Aspect	Lesson
Content	The questions should be intuitive or easy to understand The answers should be correct or logical They are usually large in size People pass by or gather around the display
Player Perception	Attention span of users is limited. The timing between rounds of games has to be reasonable Make sure the player knows the status of the game at all times Players should be motivated

Table 1: Design Guidelines Summary

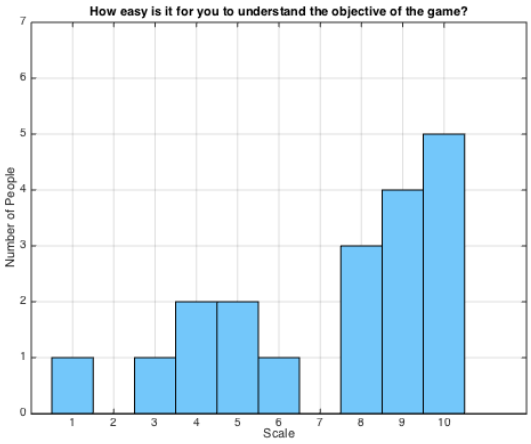

Figure 3: Battle of Cities - How easy is it for you to understand the objective of the game?

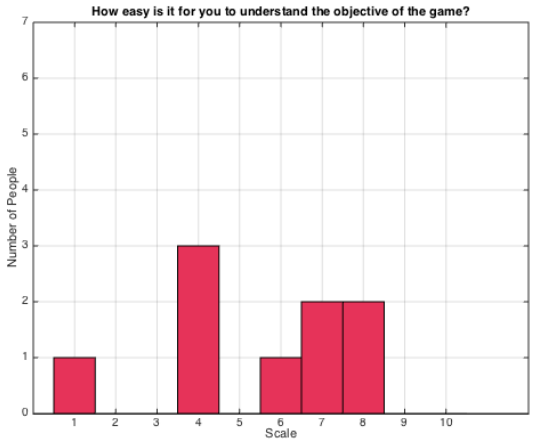

Figure 4: Translator's Dilemma - How easy is it for you to understand the objective of the game?

assist the design of games for interactive public displays.

The design guidelines were formulated based on user feedback and results from user studies conducted as part of the live deployment. We also used the results of user studies to evaluate whether we met the objectives of the game. The study responses were scaled from 1 to 10. We normalized the scaled responses to standard[3]. In simple terms, the percentage calculated from the z-score represents the percentage of responses that are greater than or equal to the benchmark selected during the z-score calculation. We have selected a benchmark of 8 for the scale from 1 to 10.

In the following subsections, we discuss each design guideline and the user study related to the guideline.

Guideline 1: The questions should be intuitive or easy to understand.

Guideline 2: The answers should be correct or logical.

The first question we asked participants was, "How easy is it for you to understand the objective of the game?". Figure 3 shows the the responses for the game Battle of Cities and Figure 4 is the responses for Translator's Dilemma.

37.98% of the participants felt that the Battle of Cities game was easy to understand. This was primarily because the question was quick to read and easy to understand. There was higher participation in the game as a consequence.

Compared to Battle of Cities, only 13.85% of the participants felt that Translator's Dilemma game was easy to understand. As mentioned before, Translator's Dilemma game is based on the "Telephone" game. During the user study we noticed that it was very hard for participants to understand the objective of the game; most of them had not played the "Telephone" game before, or they could not relate Translator's Dilemma to the "Telephone" game. The question text was also long and complex in this case.

The following question we asked participants was, "Did you discuss with others during the game?". Figure 5 shows the the responses for the game Battle of Cities and Figure 6 is the responses for Translator's Dilemma.

27.30% of participants discussed with others during the Battle of Cities game and 22.93% of the participants discussed with others during Translator's Dilemma game. Knowledge of popular cities is common and the interaction was on how the population, culture or geographical location of a place may affect the answer. Whereas in Translator's Dilemma game, knowing all languages in the list is highly unlikely. The question is also long and complex so much of the interaction is focussed on understanding the objective of the game.

During the user study we also noticed that all participants were surprised with answers that they thought were fairly obvious. The discrepancy happens as Google radar search does not have enough data to return answers that match user expectations. This causes participants to lose interest in the game. The above observations logically lead us to the guideline 1 and guideline 2.

Guideline 3: Strike a balance between guess work and logical thinking. We asked the participants, "How did you choose your answer". Scale 1 denotes completely

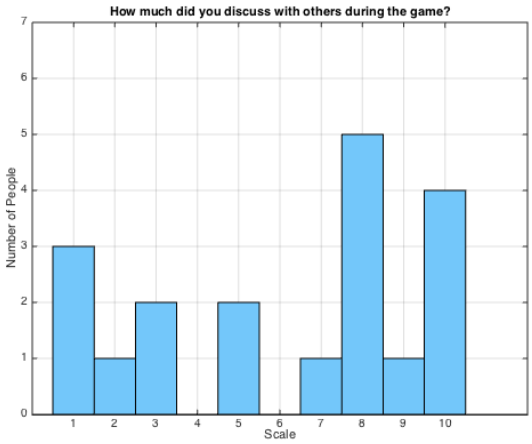

Figure 5: Battle of Cities - Did you discuss with others during the game?

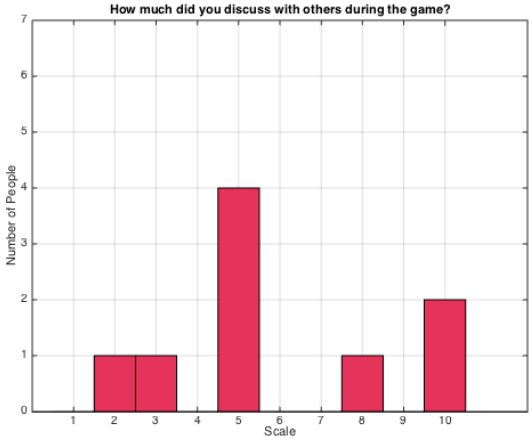

Figure 6: Translator's Dilemma - Did you discuss with others during the game?

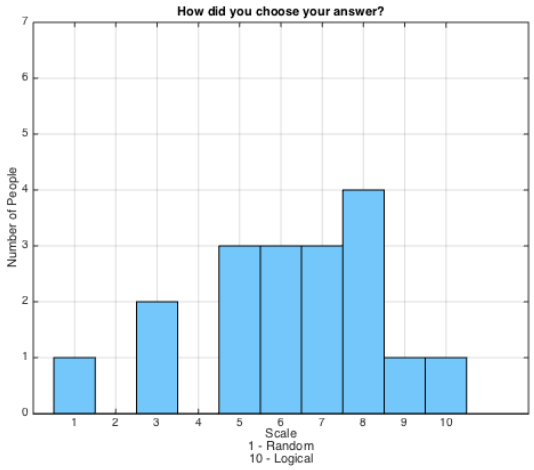

Figure 7: Battle of Cities - How did you choose your answer?

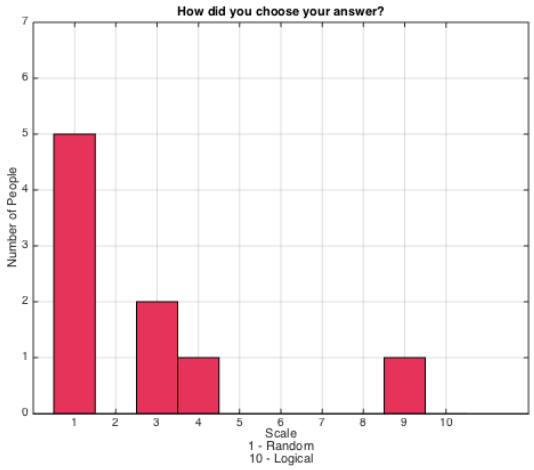

Figure 8: Translator's Dilemma - How did you choose your answer?

random answer and 10 for logical answer. Figure 7 shows the the responses for the game Battle of Cities and Figure 8 is the responses for Translator's Dilemma.

21.54% of the participants in the Battle of Cities game felt that they chose the answer logically. This is mainly because the game itself has cultural and geographical hints that help users logically infer the number of places of a type in the given location but it is not possible to know the exact answer with confidence. This adds to the guess work component to come up with an answer.

Only 2.19% of the participants of Translator's Dilemma game felt that they chose the answers logically. It is highly unlikely that a participant knows all languages that are in the question. Furthermore, in order to come up with an answer, players need to analyze text rather than simply compare numbers like what they do in Battle of Cities. Hence, instead of inferring the answer, players tend to make a random guess.

The above study leads us to believe that there should be a good mix of logical thinking and guess work to encourage

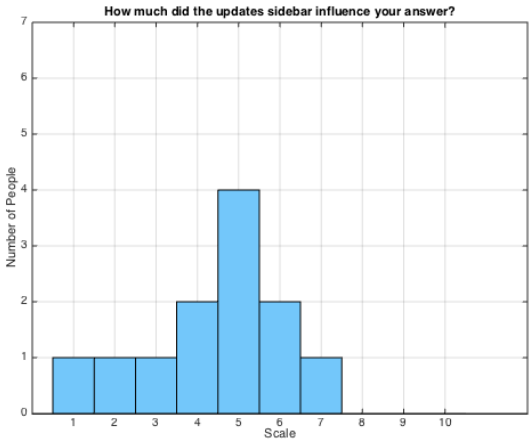

Figure 9: Battle of Cities - How much did the updates sidebar influence your answer?

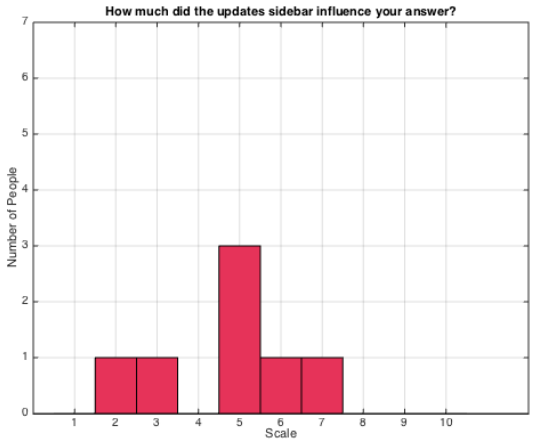

Figure 10: Translator's Dilemma - How much did the updates sidebar influence your answer?

interaction among participants.

Guideline 4: Attention span of users is limited. The timing between rounds of games has to be reasonable During the course of the user study we observed that the timing between rounds in the game is a very important factor to keep participants engaged to the game. If the time is too long, participants get distracted from the game. If the time is too short, participants do not get time to interact with each other.

The timing has to be adjusted based on the game too. There is no "one size fits all" solution. For instance, the time for the Translator's Dilemma game was 10 seconds more than that allotted for the Battle of Cities game due to the difficulty of the Translator's Dilemma game.

Guideline 5: Make sure the player knows the status of the game at all times We have a dynamic updates sidebar in the game that gets updated in real-time with messages about user activity including "player joined", "player submitted answer" and "player changed answer". We asked participants, "Did you look at the updates sidebar?". 68.42% of the participants of Battle of Cities game and 77.77% of the participants of Translator's Dilemma game noticed the updates. Both games have a high number which leads us to believe that it is an important feature for interactive displays.

The follow up question asked participants, "How much did the updates sidebar influence your answer?". Figure 9 shows the the responses for the game Battle of Cities and Figure 10 is the responses for Translator's Dilemma.

Surprisingly, only 1.47% and 2.69% of the participants in Battle of Cities and Translator's Dilemma game were influenced by the updates. This means that the updates bar primarily served as an activity monitor that provides feedback on user actions. The fact that a majority of the users noticed the updates but did not get influenced by it shows that it is very important to let the participant know the status of the game at all times.

In our prior design, we did not have a timer on the device that showed the time left in the current round. Lot of the participants were confused about what was happening after they selected their choice. The timer on the device helped alleviate this confusion.

Guideline 6: Players should be motivated During the first deployment we had a static leaderboard on the public display which showed mockup entries. We received feedback from participants that they would love to have the leaderboard implemented. We implemented the leaderboard feature for the subsequent deployment and found that it had a positive impact on participation.

After adding leaderboard feature, many participants were motivated to play. One of them wanted to remain as the champion "forever" and played 35 rounds of games in a roll. Until now, she is still the best of all the players. We also came across many other motivated participants. For instance some participants asked us why they could not get on the leaderboard even though they had a high score. These observations lead us to believe that points system and leaderboard encourage participation and motivate players.

7. LESSONS

Deployment was an essential part of the project[1], and we learned valuable lessons. In this section, we discuss lessons learned in detail.

Lesson 1: Do not underestimate the efforts to implement web page on mobile devices
The challenge of making a fluid UI is to deal with different resolutions of screens. A basic solution is using relative units such as em or percentage(%) instead of pixels(px). However, in deployment we found out that since the dimensions of screens are different, the UI is not consistent across all screens. To handle this problem, we used viewport, which arranges elements by the actual size of the screen. Another problem we observed was users may hold the device in different orientations. Our initial web page on device was designed for vertical screen. When players held devices horizontally, the style didn't fit. We used CSS media query to detect the orientation of the devices and then display the elements on the screen. Even though we spent a lot efforts on device UI, the UI is not consistent on old devices.

Lesson 2: Public display should be self-configurable
Initially, the URL of the backend server was hard-coded to ensure users can connect to backend servers, and QR code

was static. Consequently, when the backend server was deployed in another location, all those static components need to be configured before deployment. A solution to ease deployment is to exploit that web browser is aware of where the page is loaded from.

Lesson 3: Long-duration deployment discloses bugs
Many potential bug weren't revealed until long-duration deployment. During deployment, problems may arise from unreliable dependencies, race conditions between multiple players operating at the same time and so on. Starting initial deployment as soon as possible is helpful to disclose bugs.

Lesson 4: Fault-tolerance at public display
In the deployment, we often don't have direct control of the public display. Display may lose connection to the server, in which situation the public display should be able to reconnect to backend server. If bugs are fixed, the display needs to reload the web page. A script which periodically reloads the web page is helpful in deployment.

Lesson 5: Backend server should be publicly addressable
A common mistake in deployment is to deploy the backend server with a private IP address. Due to the NAT problem, only the devices that are in the same network can access the game. Therefore, having a public addressable interface is essential to the backend server.

Lesson 6: Provide alternative way to allow players to access the game
In the deployment, we assumed that users will scan the QR code to access the game. It turned out that most of devices were not equipped with QR code scanner, and players are reluctant to install one. Alternative ways such as tiny URL are helpful.

Lesson 7: Carefully choose the place to conduct user study
The place of our deployment was in a student common. Students mostly were in a rush. Hence, unsolicited involvement was low. It is hard for us to measure whether an interactive game helps the interaction between people and the display. On the other hand, we need to measure the interaction among players. Therefore, we need a group of players playing the game at the same time. However, it is hard to have a group of players to play the same time as students showed up from time to time. To address this problem, we chose to do the user study when classes were over. At the same time, we also invited some of our classmates to play the game at the same time. In our case, an ideal place to deployment could be on a campus party.

8. CONCLUSIONS

With the Interactive Public Display project we have explored some game design ideas and features that will help improve interaction between players and the public display itself. We have learnt various design aspects during the course of the project that have been summarized in this report. We also learnt some valuable lessons from the deployment that are often underestimated and overlooked[1]. We hope that this report might serve as a guide to designers and developers who work with interactive public displays.

9. FUTURE WORK

One of the important aspects of our game was the points system and leaderboard. We also want players to be able to join and leave at any time. A player would expect his/her points to be retrieved when he/she re-joins the game. Currently, our game's backend does not maintain a Cookie for users and hence players' points are not maintained when they return the game. In the user study, we noticed that players often left the game to deal with some tasks and returned back to the game, however they lost their previous points. Developing this feature allows players to join and leave the game at any time without having to lose their points.

We would also like to use other technologies like mobile sensors and multiple networked screens to explore other game design ideas or foster other types of interaction between players.

10. REFERENCES

[1] Oliver Storz et al. Public ubiquitous computing systems: Lessons from the e-campus display deployments. *IEEE Pervasive Computing*, pages 1536–1268, July-September 2006.

[2] Pamela Fox. Translation telephone.

[3] Laerd Statistics. Standard score.