"Measuring Display Interaction in Presence of Context Information"

by

Kah Yuen Lin
Donald J. Patterson

Technical Report LUCI-2009-002
http://luci.ics.uci.edu

The Laboratory for Ubiquitous Computing and Interaction

Department of Informatics

Donald Bren School of Information and Computer Sciences

University of California at Irvine

UNIVERSITY OF CALIFORNIA,

IRVINE

Measuring Display Interaction in Presence of Context Information

THESIS

Submitted in partial satisfaction of the requirements

for the degree of

MASTER OF SCIENCE

in Information and Computer Science

by

Kah Yuen Liu

Thesis Committee:

Professor Donald Jay Patterson, Chair

Professor Gillian Hayes

Professor Chen Li

The thesis of Kah Yuen Liu is approved:

TABLE OF CONTENTS

Contents

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENT

I would like to thank my committee members, Professor Donald Jay Patterson, Professor Chen Li, and Professor Gillian Hayes and for helping me realize this study and helping me through each step. I would especially like to thank Professor Donald Jay Patterson for his invaluable assistance, support and guidance.

I would also like to thank my friends and family, I could have not done this study without their support and their patience. I would like to especially thank my parents, Alan Liu and Audrey Wo, my sister, Stephanie Liu, and my friends, Jeff Bautista and Christina Kuo for their help and unconditional support.

ABSTRACT OF THE THESIS

Measuring Display Interaction in Presence of Context Information

By

Kah Yuen Liu

Master of Science in Information and Computer Science

University of California, Irvine, 2009

Professor Donald Jay Patterson, Chair

Traditional directory kiosk presents users with common facilities information that may be difficult to understand because it is out of the context of the user. Our study implements contextual information onto a kiosk display and studies the user interaction with context information.

Our study is separated into four phases to precisely measure the interactions of the traditional kiosk display system and compare the results to the interactions on a contextual kiosk system. Phase One was designed to establish a baseline for the interactions with the traditional display. Phase Two determined the effects of moving the display in location with a higher amount of traffic. Phase Three studied the interactions with a contextual display with search and compared the quantitative data with the previous phases. Phase four is exit interviews to gather qualitative data on the contextual kiosk display.

Our results show that contextual data is welcomed by patrons of the display. However, there are many concerns surrounding the validity, generalization, and subjectivity of the information. Many felt uncomfortable using the context due to their unfamiliarity with the system. Even with concerns, patrons used context more when it was available and interviewees rated a contextual display higher than a display with traditional facilities information.

Introduction

Traditional information directory displays present users with common facilities management information. This method of presentation may be difficult for users to comprehend because the information is not within the user's context, whereas context information may be more intuitive. The display created for this study bridges traditional facilities management information with context information to enhance the ease of usage. The study includes information on how individuals interact with the map display to determine the effectiveness of using context information (such as informal names for locations, class names, etc) in place of traditional facilities management information (building number, room number, etc).

Usage of Context

In this study, the term context is defined as the collective users' place and activity. We use Patterson's collected context from Nomatic*IM (Patterson, Xianghua, & Noack, 2006), a research project that broadcasts user's context (location and activity) through instant messaging clients, to populate the context in the interactive kiosk directory. As a result, context in this paper is used similarly to the usage in Nomatic*IM. However, there are some key differences between the definitions:

- Place – According to Nomatic*IM, place is a subjective label based on the user's situation in time, i.e. "In the lab". However, place in this study is the aggregation of users' places extracted from Nomatic*IM and only exists if it is used by one or more users. In this scenario, if both User A and B tagged "Technology Garden" as a location, then "Technology Garden" will appear in the study's kiosk display.

However, if only one user has tagged a location, then it will not appear in the study. The difference between Nomatic*IM and this study is that a place has a one-to-one relation between a user's context and physical location (this will be described in further details in the Methodology section).

- Activity - Nomatic*IM indicates activity as a subjective description of what the user is currently doing, which is the same for this study.

In this paper, we will first compare related work that has influenced this research, followed by a methodology section to discuss methods of study, as well as software and hardware architectures. Finally, the results section will examine the results from the four phases of this study, propose ideas for future further research, and conclude with final remarks.

Related Work

Our study of context on kiosk displays is influenced by past and present research in ubiquitous computing and human-computer interface. However, certain research projects stand out as related work in the field:

NomaticBubbles (Xianghua & Patterson, 2008)explores system location awareness displays. It is a prototype system designed to investigate location awareness issues in a community. This study used information from Nomatic*IM and was demonstrated in a large display within the Informatics department of UC Irvine. Using this information, the display showed current status in a layout that is dynamically generated by users' collective interactions with the WiFi infrastructure. NomaticBubbles benefited the user by focusing mainly on displaying information of Nomatic*IM users for patrons of NomaticBubbles.

ActiveMap (McCarthy & Meidel, 1999) helps increase awareness of workplace situations and locations. This system achieves this by placing a photograph of the person near their actual map locations. The tool has a range of features to help increase awareness of other users around them, from analyzing the "freshness" of information to the effectiveness of groupings within a kiosk. During the research, ActiveMap was placed on a kiosk in a heavily trafficked hallway within the research campus. The kiosk placement was successful in enabling users to use the system to form awareness of location without the commitment of installing and using the application on their own computers.

Huang's research (Huang, 2007) studies how people use and react to large ambient displays in public settings. She examined the state of the technology, the positioning of the display, and the brevity of glances at the display. She then discusses the benefit of certain placements and types of display that are most effective in delivering information to the users. She found that a display placed at eye level in a position that is easy to see receives the highest amount of interactions.

Gathering varying information from these related works, our study on context aims to tailor the display to best fit the users of Donald Bren Hall. Our study touches upon related works while adding our own research on contextual data on a large kiosk display.

Methodology

In this study, the context-informative kiosk display used context information from a concurrent research project called Nomatic*IM. Nomatic*IM is a research project directed by Dr. Donald Patterson at University of California, Irvine. Patterson's research uses a software application that gathers users' location and activity by either prompting for user entry or context suggestions based on previous entries. Their context is then broadcasted through instant message clients (AIM, Aduim, etc) and micro-blogging platforms (Twitter). In practical usage, a student with a mobile device running Nomatic*IM may have context information showing that they are at home studying. However, when the student leaves the location, Nomatic*IM will prompt the student to update their new location with context suggestions. The student may select the entry of their location and activity (e.g. "At school listening to a lecture") which sends the context information to Nomatic*IM servers to be anonymously stored in a secure database with data collected from other users. The information retrieved from Nomatic*IM by the kiosk display is kept anonymous and any information that can identify a user will not be used. Only aggregated information from users that have agreed opting-in to sharing anonymous data is shown.

We created a kiosk that is used to display context information and placed it on the first floor of Donald Bren Hall near the entrance hallway at University of California, Irvine. This kiosk is a touch screen LCD that provides directory information about Donald Bren Hall building, including room numbers, faculty location, rest rooms, etc. Using existing software, we added motion sensing hardware and augmented the software to fit our study. The motion sensing hardware is an infrared motion sensor (Phidgets Motion Sensor (Motion Sensor, 2008)) that does not capture any visual elements, keeping the anonymity users. The sensor gives a number value when the surrounding infrared field is interrupted and is mounted on the bottom of the kiosk display to detect ground movements.

Figure 1 – Mockup of the touch-screen LCD with motion sensor mounted on the bottom

Our study took into consideration multiple methods of implementing the front-end of the kiosk display. Prior to our current application, we decided to use the original application that was running on the kiosk because it provided a more accurate baseline by not showing any change to the users. We then redesigned the system by adapting concepts from Weiser's original paper on Ubiquitous computing (Weiser, 1991), the Context Toolkit (Salber, Dey, & Abowd, 1999), and Software Engineering Issues for Ubiquitous Computing (Abowd, 1999). Specifically, we focused on the core foundations of ubiquitous computing by providing a transparent motivating application that can be used by anyone anytime a directory display is needed.

Our study took place in four phases. The first phase measured the usage amount of the existing display and gauged how users' interaction with the system. The second phase moved the kiosk display to another location with different amount of traffic to measure the usage in the new location. The third phase used contextual information in the new kiosk display location. The last phase was an exit interview to gauge the impact of the Phase Three design.

Phase 1

The first phase gathered baseline data for motion in front of the kiosk display and also recorded all interactions with the display. During this phase, the display was not moved nor was the software's user interface augmented, revealing an interface that is identical to the display prior to our study. The recorded information includes users manipulating the display to find facilities, room numbers, faculties, or staff. For example, User A, trying to find a faculty member, presses on 'Floor Five' then selects Dr. John Smith from the menu to locate his office. The system records the floor number he pressed on as well as faculty member 'John Smith'.

We also modified the original Flash application to track user interaction by recording the location where the user touches on the screen and the motion in front of the display detected by the motion sensor. Measuring the interactions and motion allows us to determine the actual usage of the system along with its effectiveness.

The motion sensor was controlled by a custom built Flash application, simply named Tracker, which ran concurrently with the kiosk display software. The user interactions were then recorded securely and anonymously into the application's server hosting the kiosk display. Tracker controlled the sensitivity of the motion sensor and reported only motions that resemble human movement in front of the display. When motion is detected Tracker wrote to a local XML file. This motion file contains only time-stamp of motion occurrence. The previous kiosk display software was augmented to track user interaction by recording specific information pertaining to users' manipulation of the display. The location (x, y), element, and timestamp of each touch of all users are recorded in XML files stored in the kiosk server.

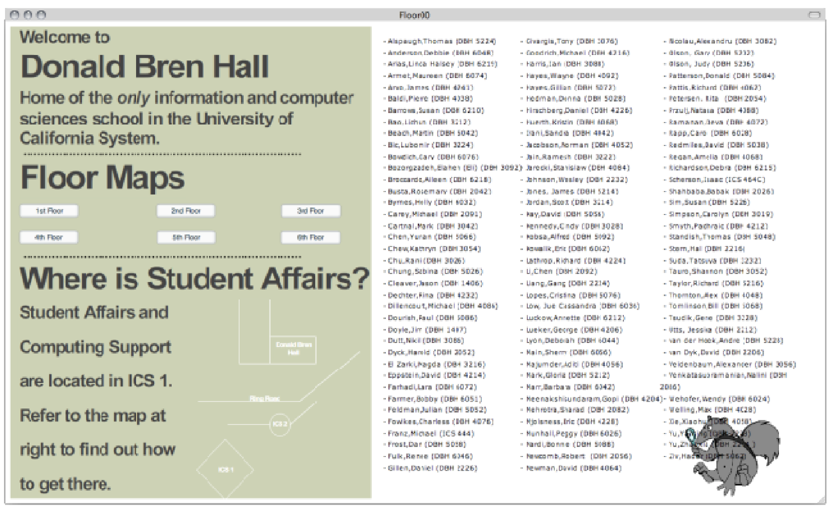

Figure 2 – Main screen of original kiosk display

After the system had been augmented, it was left to collect data for three weeks. During this time, we developed an administrative web interface to help visualize the data. This web interface includes a graph that represents the amount of motion per hour and another to represent the amount of interaction per hour. The interactions were also mapped by the hour of the interaction to allow access to the data for a specific timeframe.

Phase 2

For the second phase of the study, the display was moved. We hypothesize that the new location will produce a higher amount of foot traffic due its exposure to the main entry way. We also hypothesize that this increase in traffic will result in a higher amount of interaction with the display. The figure below shows the location of the move from Phase One to Phase two.

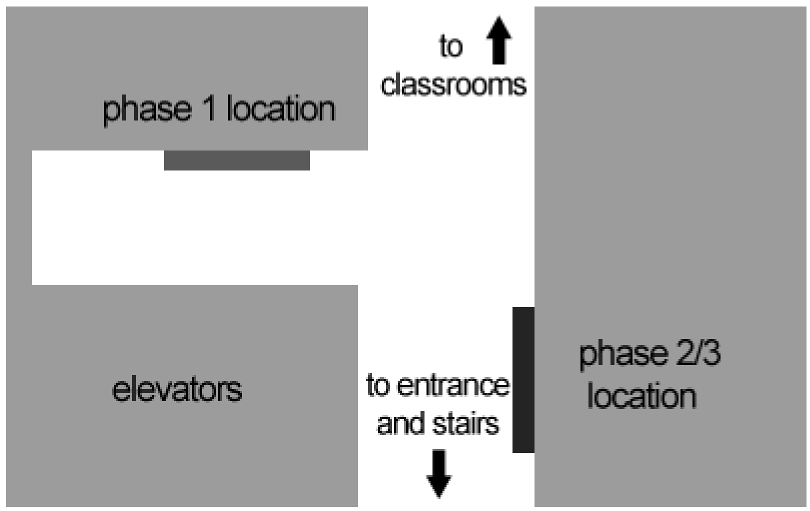

Figure 3 – Placement of displays in Phase 1/2/3

Aside from the change of location, there were no other differences between Phase One and Phase two. Phase Two was also left to track user motion and interactions for three weeks.

Phase 3

Phase 3 differs from the previous phases with the addition of contextual information and pSearch. pSearch is a fuzzy search algorithm that we used to search contextual information. During this phase, most of the user interface, tracking, and information from the previous phases were kept.

Our study uses Nomatic*IM's database of contextual information to place contextual tags on the map. Unfortunately, the entries in the Nomatic*IM database did not contain any signal strength information. In order to determine the location of a label, we need to use wireless signal strength information to run with Spearman's ranking correlation coefficient.

Originally, we analyzed various WiFi localization methods, which were narrowed down to three WiFi localization techniques; Locadio (Krumm & Horvitz, 2004), ActiveCampus (Griswold, Shanahan, Brown, Ratto, Shapiro, & Truong, Oct. 2004), and Spearman's ranking correlation coefficient (Cheng, Chawathe, LaMarca, & Krumm, 2005). Locadio's algorithm uses wireless signal strength from existing access points and hidden Markov models to infer states of "stillness" and "movement". After analyzing the paper it was decided that our study does not need to collect data from Nomatic*IM while a user is moving, hence rendering Locadio unfit for our study.

ActiveCampus and Spearman's ranking correlation coefficient both locate users using WiFi access points in a similar method that supports the study. The main difference is that ActiveCampus uses distances of wireless access points' to determine the location of a user, whereas Spearman ranking correlation coefficient uses signal strength of wireless access points as seen by a user. We tested both methods to determine which would best fit the study, in terms of accuracy. The test was run on five locations, all with multiple WiFi access points and in a close range (approximately 10 feet apart).

ActiveCampus' method allowed us to estimate distances from a list of access points and helped to determine the location by comparing the distances of the seen access points to a database of historical access points found during fingerprinting. For the test itself, we scanned signal strengths of all visible access points a total of 25 times using Mac OS X's built-in Airport scanning tool. These signal strength results were averaged and used in the ActiveCampus equation to determine the distance of each access point that were stored as historical access point data in the database. Each of the five locations was scanned one more time to mimic a user and compared to the historical database. Due to the close proximity of the test area, this method failed to mark the correct location for the majority of the tests. Our study required a method that can discern access points ~10 feet apart.

We did a similar test using Spearman ranking correlation. We scanned for all WiFi access points seen to mark the location and the signal strength of each access point is then stored in a historical database. Signal strength from users is compared to the historical signal strength to determine the location of the users. For our test, we scanned signal strengths of all visible access points 25 times using Mac OS X's built-in Airport scanning tool. The signal strength results were averaged and stored in a database along with their MAC addresses. A sample of one wireless access point scan was also taken at each location, similar to that of a Nomatic*IM user. Using the Spearman ranking correlation coefficient, the one sample scan is compared to all historical scans to determine the closest match (a more detail description of the Spearman ranking correlation coefficient is given further in the paper). The results of this test were successful in determining a user's location from wireless access points that were relatively close together. We also observed that using the raw signal strength gave us results that were more flexible than the other methods where a loss of an access point does not affect the sensing of one's location, whereas, it may be detrimental in the other methods.

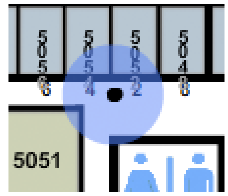

Figure 4 – Context spans 10-15 feet, covering two offices.

In order to use the Spearman ranking correlation coefficient, it was necessary to fingerprint Donald Bren Hall to gather historical data. Since the display shows context tags tied to a location, the fingerprints would have to be in close proximity of each other to ensure a specific location for the context information. We decided to make each fingerprint marker to be ~10-15 feet apart. At this distance, the diameter of one fingerprint mark covers one medium-sized classroom or two offices.

However, we had limited access to most of the offices and labs for fingerprinting and were restricted to fingerprints from the hallways outside the offices. Under these conditions, we collected approximately 30 fingerprints per floor. We used Mac OS X's built in Airport software with a custom shell script to scan and record surrounding access points information such as MAC address and their related signal strength. We found that scanning a location 30 times seems to be slightly above the minimum amount required to get an accurate reading. This was reached by completing a set of tests to determine when the averaged data was stabilized.

The fingerprints of each location were then stored into a database to be used with Nomatic*IM user's wireless signal. When Nomatic*IM users submit their context, their wireless information is attached, so that both context and wireless information is stored in the Nomatic*IM database. Twice a day, the display server queries the Nomatic*IM database to obtain new context labels and compile them for the display. The retrieval of new context is done by a SQL query to Nomatic*IM servers. Each new context is put through the Spearman ranking correlation algorithm to locate the user's context. To calculate the coefficient, we sort both the fingerprinted locations and the user's submitted locations in order of value, strongest first. An instance where the fingerprinted signal strengths (SS_A, SS_B, SS_C) = (-30, -90, -60) would be ranked as (1, 3, 2) and the user's signal strengths (SS'_A, SS'_B, SS'_C) = (-90, -10, -50) would be (3, 1, 2). Afterwards we used the Spearman ranking correlation coefficient to find the closest match:

$$\rho = \frac{n(\sum x_i y_i) - (\sum x_i)(\sum y_i)}{\sqrt{n(\sum x_i^2) - (\sum x_i)^2}\ \sqrt{n(\sum y_i^2) - (\sum y_i)^2}}.$$

In this equation, n is the number of access points that were found, while x_i and y_i represent the rankings on the sorted fingerprinted signal strengths and user's signal strength, respectively. The fingerprint that has the highest correlation is taken as the location of the context. Only data that are detected within the building are used.

The kiosk display application was also modified to display the context data and add searching capabilities. The study kept the design of the kiosk display similar to the original application, but with contextual information added. We planned for the most popular context tags to appear on the right side of the display to match the floor the context refers to. Context on the display was seeded (by using Nomatic*IM's database and manually adding them to kiosk's display database) until Nomatic*IM began to generate data that could be compared to our fingerprint calibration. The original information was kept but moved elsewhere on the display. The context locations were added to the display according to where the fingerprints were located. These locations were represented as a dot surrounded by a transparent circle to show the error rate of the location. Each location was given that identification to match with the identification of the fingerprinted location in the database. pSearch was added to provide a method to search for information on the display. The primary focus on search will be to determining the importance of search within the display.

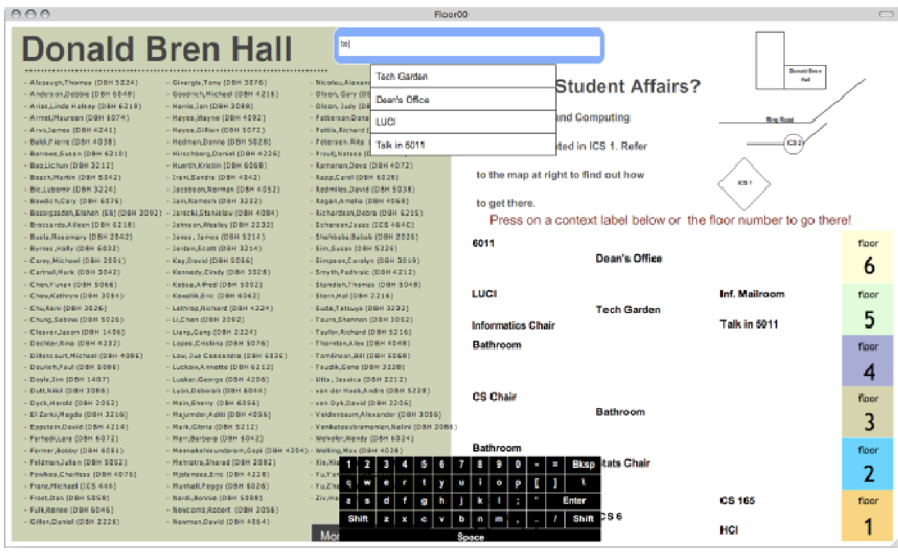

Figure 5 - Main screen with pSearch and context tags

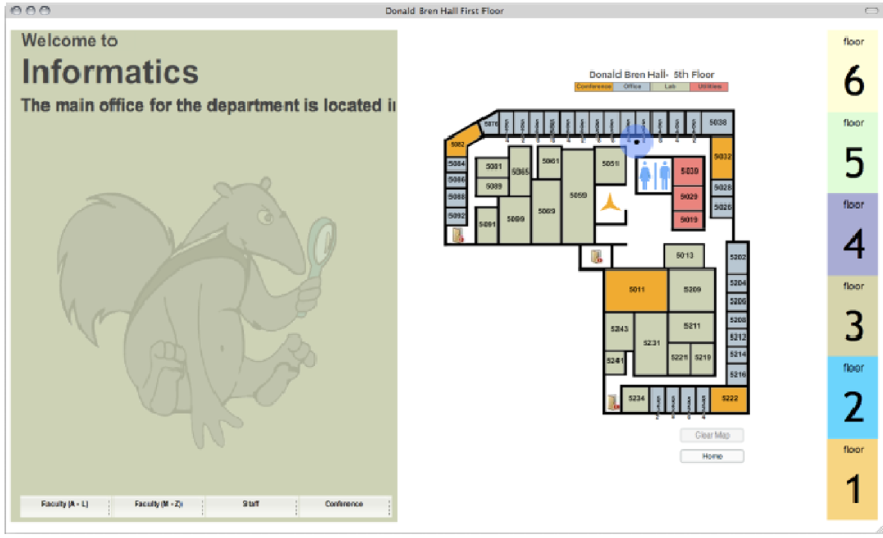

Figure 6 - Map screen with context location marker

Small scripts were developed and installed on the server to retrieve, process, and send data to and from the kiosk display application. The study uses PHP web language to process all business logic for the study, including calculating Spearman ranking correlation coefficient and sending context data to the kiosk display server. The architecture can be found in the figure below.

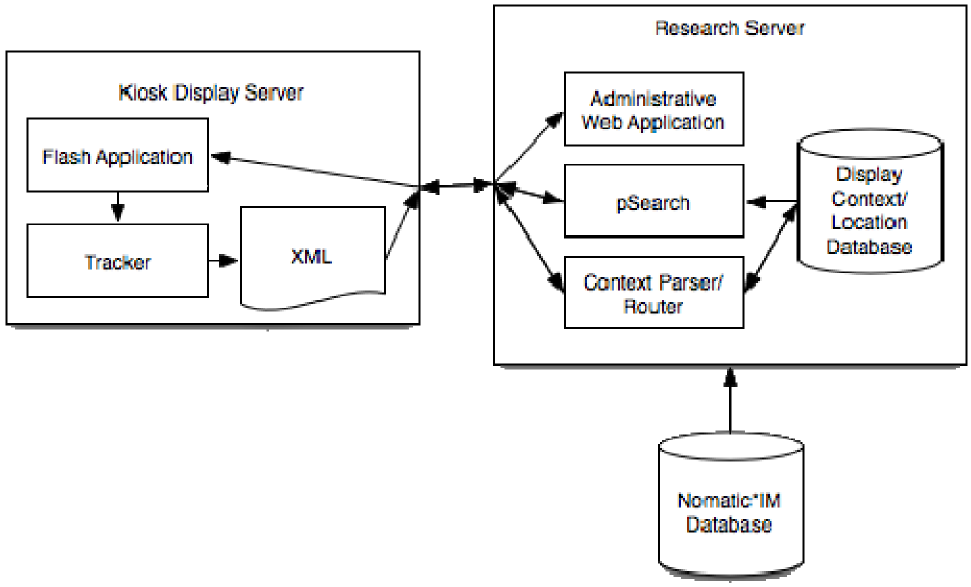

Figure 7 – High level system architecture of the kiosk display and research server

Phase 4

A group of 15 people was asked to perform an exit interview. This interview asked seven questions about context within a kiosk display. The interviewees were asked not to comment on the design of the system, but rather to focus on the functions that the system provides. Most of the questions asked are related to contextual data within a kiosk display in comparison to traditional kiosk display with the exception of a few demographics questions. Questions were left open-ended to allow the participants to spawn a discussion of their views on contextual displays, expressing their preferences and concerns. The range of participants consists of people from various backgrounds, ages, and directory kiosks usage. The only requirement of this interview is that participants must have used a directory in their past.

Results

Phase 1

The results in Phase One allow us to approximate and measure the amount of traffic that passed by the kiosk display each day. This phase also helped us measure the number of interactions users have had with the display. For a period of three weeks this phase was ran and the collected results were used to establish the baseline for the study.

During this phase, Donald Bren Hall had a total of 13 trafficked school days. 1318 minutes of motion were detected and recorded in front of the kiosk display. During the other 8 days, which were weekends or holidays, the study only recorded a couple minutes of traffic per day. These results can be calculated (minutes of motion/number of school days) to show us that Donald Bren Hall receives approximately 101.4 minutes of traffic per school day. The data also shows that the highest traffic coincides with the beginning and ending of each class time and peaked at around 3-4 PM each school day.

Within the three weeks, there were 655 interactions with the kiosk display. On low traffic days, there were no interactions, except for one or two interactions on rare occasions. Although there were 655 interactions, 335 of them were "one-touch interactions". One-touch interactions happens when a user touches the display to wake it from its sleep state showing the main screen but does not interact with it further. For example, User A touches the display to start and is shown the main screen with technical facilities information, room numbers and a welcome message. After that initial touch, the user makes no other interactions with the display. These one-touch interactions could mean a user was looking at the directory located on the main screen for a person, looking for information about the building, or pressed it while waiting for an elevator simply for fun.

There were 320 more substantial interactions that included at least two actions, i.e. showing information about a specific floor or finding a location. We categorized these interactions into five categories based on what the users were looking for. The categories include floors, staff, classrooms, labs, and others (facilities, etc). The floor category includes a map of the floor along with all the other categories' information. We analyzed these interactions to reveal the primary usage of the kiosk display.

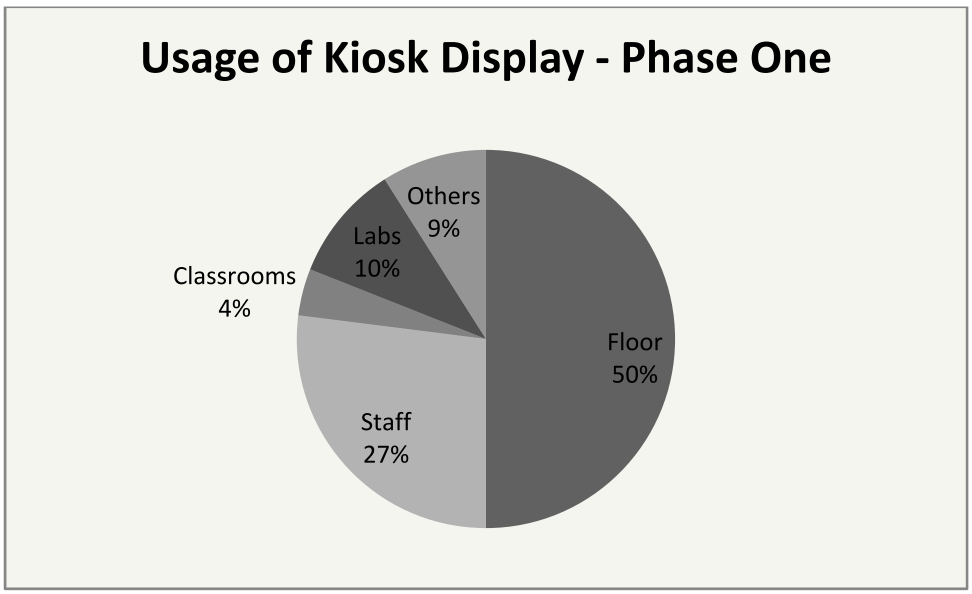

Figure 8 – Usage percentages in Phase One

The low percentage of classrooms searched may be due to the interaction design of the kiosk display. The kiosk display was designed for users to view the floors first before determining classrooms, faculty, and others from a sub-menu on the floor of the map. Users knowledgeable of the room number may find the location without further interactions with the display.

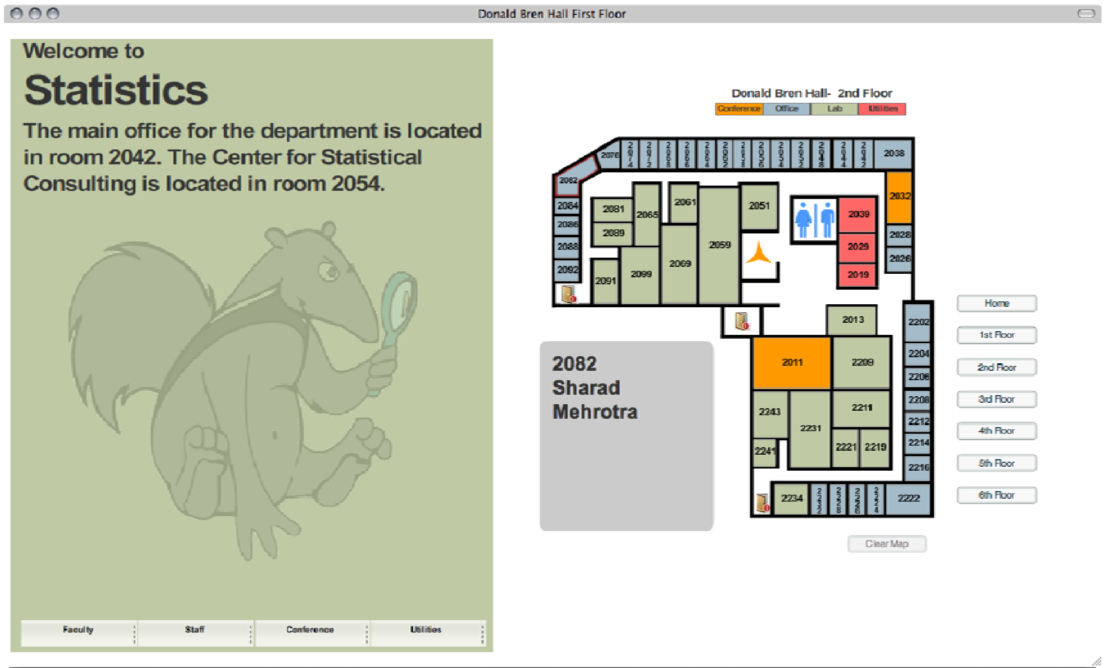

Figure 9 – Example of 'Floor' map category

The figure below shows a portion of the administrative web application developed to analyze the raw data of the recordings. The top graph shows the number of motion (in seconds) recorded in Donald Bren Hall over a period of three weeks. Each point on the graphs represents an hour of time. The bottom graph shows the number of interactions over three weeks. These results show the correlation between the motion and interactions. The days with little motion and no interactions were weekends and holidays. This correlation is reflected throughout the entire study.

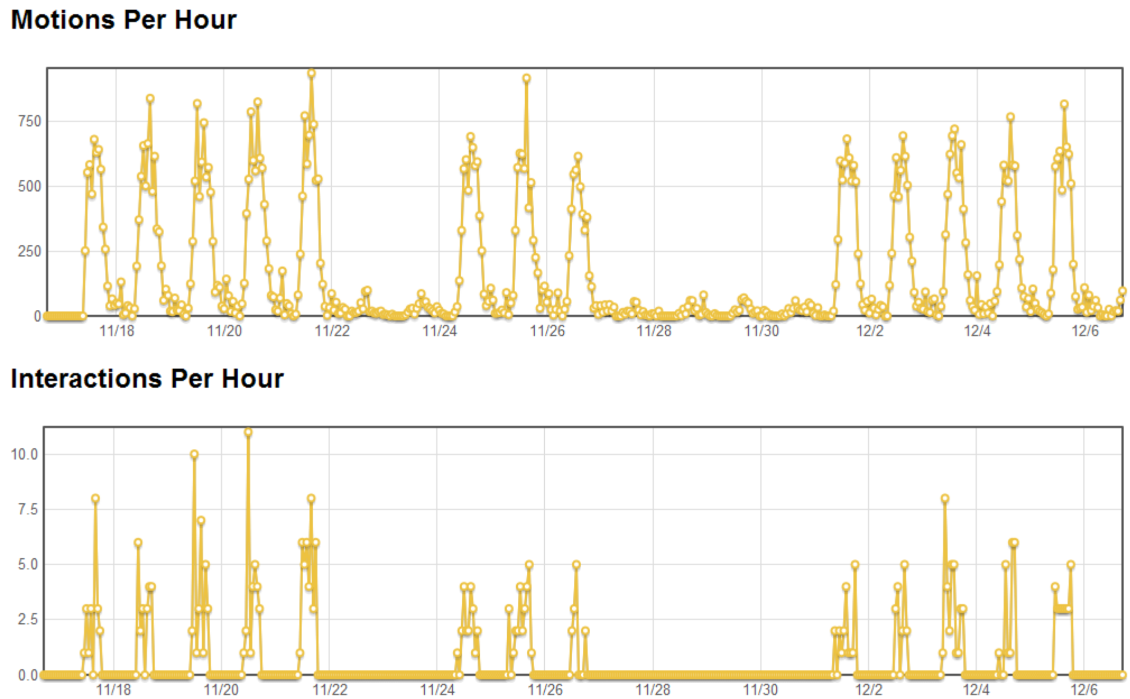

Figure 10 – Phase One motion/interaction over time.

Phase 2

Phase Two moved the display from a position in front of an elevator set to a hallway that leads to the elevators and classrooms. Although this position was hypothesized to have more traffic, the results for Phase Two actually show a more complicated result.

During this phase, only 1019 minutes of motion was recorded by the kiosk display versus 1318 minutes of motion in Phase One. Over the three weeks of Phase Two, Donald Bren hall had a full 15 school/work days. Similar to Phase One, the weekends did not show much motion inside the building. The amount of motion per school day is around 68 minutes, a large decrease compared to the motion in the first phase of 101.4 minutes per school day. However, we noticed an increase in both one-touch and the more substantial interactions with the display. The one-touch interactions rose to a total of 736 from 335 from Phase One and the more substantial interactions rose to a total of 520 from 320 from Phase One. In Phase Two, the average time of user interaction with the display was 13.18 seconds (excluding one-touch interactions).

The higher amount of motion in Phase One may be explained by the kiosk display's placement in front of the elevators. Instead of recording only the traffic that passed by the display, people waiting for the elevators may have also been recorded by the motion sensor. This hypothesis is supported through analysis of the raw motion data results. The motion sensor inserts an entry every second a motion is detected, resulting in motions grouped by time. A person interacting with the display would have a larger group of entries (ranging from 10-60 entries) than that of a person passing by (ranges from 1-2 entries). During Phase One, there were more groups of entries ranging between 5-30 entries meaning that motion was detected in front of the display. However, as Phase Two shows, the entries do not indicate more substantial interactions with the display.

Analyzing individual interactions show an increase of usage in the floor category. Since the kiosk display did not change, the interaction design still encourages patrons to view floor maps first before allowing the selection of classrooms, faculty and facilities from the submenu. From these results, we can conclude that viewing the floor is still the primary usage of the display. However, the number of patrons searching for staff had decreased by 15% and the search for classrooms had increased by 300%. These results may reflect the time of the phases. Phase One was active during the ending of the Fall academic quarter and Phase Two was launched shortly after the beginning of Winter academic quarter.

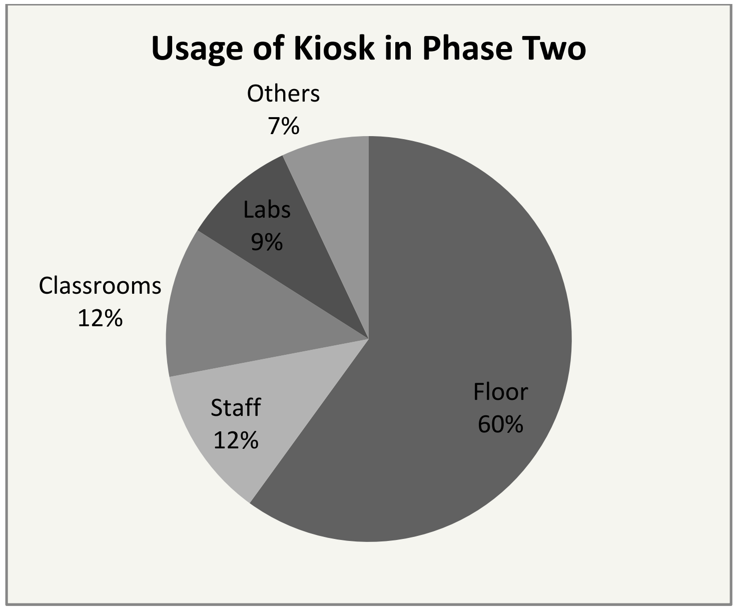

Figure 11 - Usage percentages in Phase Two

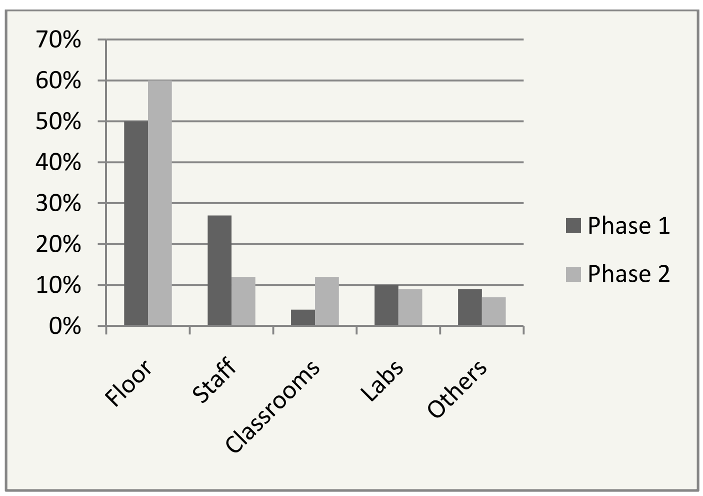

Figure 12 - Usage comparison of Phase One and Phase Two

Phase 3

Phase Three added Nomatic*IM context information and pSearch to the kiosk display. This phase was ran for three weeks yielding twelve days school days worth of data at the middle of the academic quarter.

This phase recorded 686 minutes of motion in front of the kiosk display, with an average of approximately 57 minutes per school day. Similar to the other two phases, there was little activity on weekends (less than 10 minutes of motion throughout the entire weekend with a small amount of interactions). Analyzing the motions reveals the amount of motion had decreased from 69 minutes per day to 57 minutes per day. We noticed a drop in motion per day when comparing daily motion data of Phase Two and Phase Three. We did not notice any factors that would have affected the results from Phase Two to Phase Three, except for the timing of Phase Three during the middle of the academia quarter.

The number of interactions totaled to 891, where one-touch interactions were 557 and more substantial interactions were 334. Although there were a lower amount of interactions in the data, the interaction to motion percentage was higher at 2.15 percent. Analyzing individual interactions, we found that usage had become more diverse. The figure below shows the usage in percentages in Phase 3:

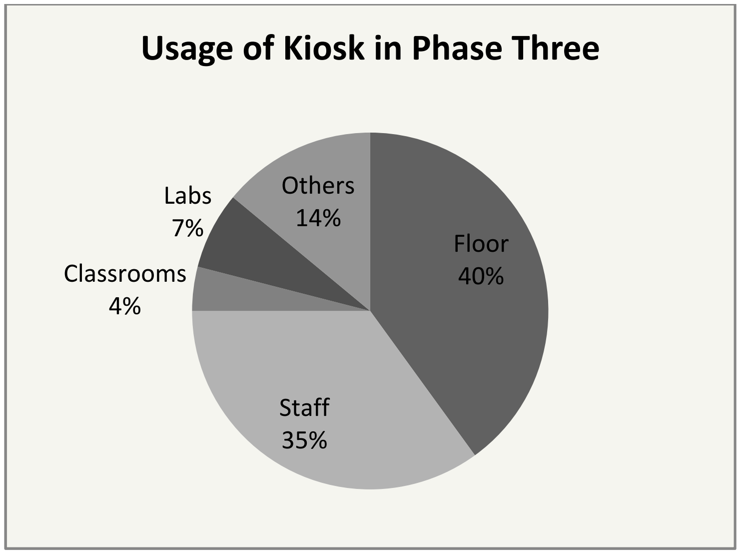

Figure 13 - Usage percentages in Phase Three

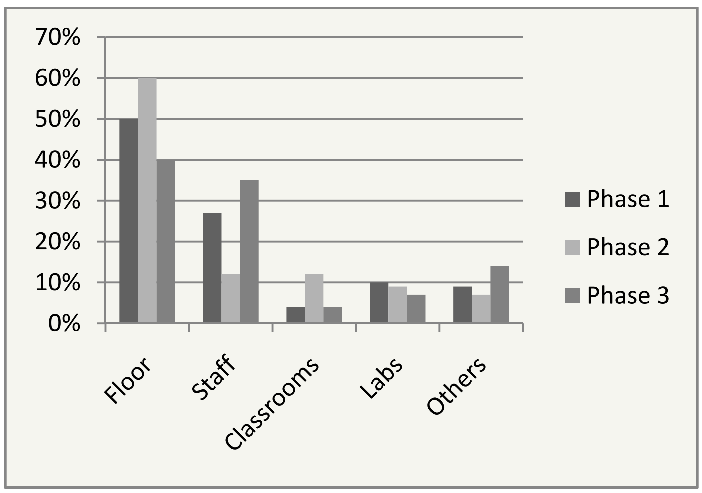

Figure 14 - Usage comparison of all three Phases

The figures show that more users were using the display to locate 'Staff' and 'Facilities' more than the previous phases. This may mean the new display allowed the users to find their destination directly rather than having the users search for their destination on a map with traditional facilities information. We suspect that the amount of floor usage will lower further if there were more direct method for users to find their destination, context or traditional. The individual results show that the increase in 'Staff' and 'Facilities' were largely due to context information provided on the display. We noticed an increase of searches for staff that were within the context system and the majority of facilities information searched was 'Bathroom' on various floors.

Approximately 56% of the interactions with the display were using context information, either using context tags or searching with pSearch. More specifically, 18% of all interaction attempted to search using pSearch and 38% used contextual tags. The result shows that the majority of contextual interactions were followed by users pressing surrounding rooms. This may show users wanting traditional information to locate themselves there due to the general area (+/- 10 feet radius) given by the contextual information. The majority of the interactions were towards 'Staff' and 'Facilities' and less towards 'Classes' and 'Labs', however, as explained in Phase Four, this could be due to the users not being aware of the names of classes or labs and such names are only applicable to a small subset of users.

In Phase Two, the average time of user interaction with the display was 13.18 seconds (excluding one-touch interactions).

In Phase Three, approximately 18% of users utilized pSearch during their interaction with the display. The average interaction time during those sessions was 20.34 seconds, compared to average time of interaction in Phase Two of 13.18 seconds. Approximately 50% of the pSearch interactions ended immediately after the search interaction, suggesting success. The other 50% of interactions was often characterized by additional searching to explore the map around the pSearch result, a behavior similar to that which occurred after clicking directly on the contextual tags. This is not surprising as our pSearch results only provided information on context tags and not on the full complement of directory information available elsewhere on the display. If we only average the times when users ended their interaction following the selection of a pSearch result, the average interaction time with the display is lowered to 10.80 seconds.

Phase Four gives more insight into user's views on pSearch and contextual information.

Phase 4

Phase Four represented the qualitative portion of our study. 15 participants were interviewed to gauge the overall feeling towards the new additions in the display, including pSearch and contextual data from Nomatic*IM. The participants were asked to focus on the features of the displays, rather than on its aesthetic design. The only aspect of design participants could comment on was the amount of information available on the display. The participants themselves came from various technical backgrounds, age, and profession. Half of the participants were students from UCI, although only a quarter of them have been in Donald Bren Hall. The other half were not UCI students and had either never been in or had very little interaction with Donald Bren hall. The age of the participants ranged from 18 to 30 years. Their professions varied from students to developers, and salesmen to office clerks. The only requirement we have of the participants was that they must have used a directory in their past. As we discovered, most of the participants have used directories only in unfamiliar locations, while a few others use them more than once a week. Only about a quarter of the participants have used the display located in Donald Bren Hall.

Table 1 - Demographic of Participants in Phase Four

Total	
Participants	15
Gender	
Male	10
Female	5
Age Group	
18-21	4
22-25	5
25-30	4
31-64	2
Directory Kiosk Usage	
Rarely (Less than once a month)	6
Occasionally (At least once a month)	5
Frequently (At least once a week)	4
Familiarity	
Familiar with Donald Bren Hall	4
Familiar with UCI but not Donald Bren Hall	5
Not familiar with UCI or Donald Bren Hall	6

Between the two displays, we found that familiarity is a key issue for users. The participants who were familiar with the building responded differently compared to the participants who were unfamiliar. Those who were familiar with the building did not feel the display was within their context, and as a result, did not believe the display would benefit them. On the other hand, participants who were not familiar with the building felt the context is at the right level of detail to find their target location. All participants were more familiar with traditional information than context information and have expressed they would resort to traditional information first before moving onto search and context.

Interviewing the participants also validated claims made in other phases of our study. The UC Irvine participants who often visit Donald Bren Hall tend to tap on the display for sake of entertainment. “It’s fun to touch the display and see something happen. I don’t do anything else, but I do walk by and touch it”.

The traditional display scored lower overall than the contextual display with an average rating of 5.8. Although the majority of the participants felt more comfortable interacting with the traditional display, it does not appear to be as beneficial as that of the contextual. “It is easier to use the [traditional] display, but it doesn't seem as helpful as the [contextual]”. According to participants, those who preferred the traditional display expressed that it is more approachable and more familiar, “I don’t like standing at a display for too long, I get intimidated. I want the quickest way to get what I want to know, and I feel the quickest way is through the method I know best, which is the traditional information.”

The contextual display did rate overall higher than that of the traditional. We saw the average ratings (from 1 being the worst to 10 being the best) for the contextual display was 6.8. We noticed the participants who were familiar with Donald Bren Hall would score the contextual display slightly lower, with an average of 6 (n=4). The participants responded to the score in expressing that the display context was too generic and did not fit within their individual context. They did find the display useful when interacting with the kiosk display in an inquisitive manner, such as seeking for an event during breaks. Participants who were unfamiliar with Donald Bren Hall had a more positive response to the contextual display, with an average score of 7.2 (n=11). These participants expressed that the context information helped them determine the location faster without any previous knowledge of the building schematics. “I wouldn’t need to know the class number or room number, I could just search for the thing [I’m looking for]”. Many participants who favored the contextual display felt it was another set of information they could rely on if they could not find what they needed within the given traditional information. However, a small subset of the participants expressed discomfort with the context information due to their unfamiliarity with the system. All of the participants were more comfortable with a traditional system and, unless the context “pops-out” at them, would use the traditional system first before using context tags.

There were concerns on the contextual information involving validity, subjectivity, and general context. Six of the participants expressed their concern on the validity of the context information. “I’m not sure who is sending the information, it may be false even if multiple people tag it. I would trust one person that updates content more than an aggregated context”. The other users expressed the concern for the validity of the context location due to its dynamic behavior and user inputs. Subjective context was a concern brought up by 12 of the participants. Subjective context are those that were ambiguous, i.e. “In my office,” and cannot determine the actual location for the user. Three users mentioned that contextual data on the display may be become too general and lead to another form of technical information such as "Dr. Smith's Lab 147" together with "Dr. Doe's Lab 133". Two users did not foresee any issues with contextual information.

Search in the display is important for those who were not familiar with Donald Bren Hall. These participants felt that the search function was the most important feature of the display because it helped them find locations quickly without having to obtain any previous knowledge of the building. From these responses, we discovered that users' desired the display to include both traditional data and contextual data to complete the search. Most of the participants who felt strongly about the search function were using it for both general items, i.e. talks, events, general categories, and for specific purposes or locations, i.e. room number, personnel, etc. Five of the users commented about the fuzzy search feature within pSearch. One participant said, "It's nice when it auto-completes the text. It helps me if I am looking for a word that's the second word or in the middle of [many] words, ones I'd probably miss it if I was scanning [the traditional information]. It's faster for me to search."

The qualitative phase shows that many patrons welcome contextual tags and believe search is one of the most important features on the display. Although there are concerns on the contextual information, the context made the display more user-friendly by better catering to their needs.

Conclusion

In this study, we have created a contextual kiosk display to measure and study how context information can form a more personal user experience. In order to measure the interactions, we launched four phases to gather both quantitative and qualitative data for this study. This first three quantitative phases measured motion and interaction from multiple locations and added a search function with context information in the latter phase. The last qualitative phase involved individual interviews with 15 participants about their views on contextual information in a display setting.

Our goal in this study was to determine whether or not we can use context information in a large kiosk display setting. Our quantitative portion of the study shows that patrons enjoyed using the context tags for its quickness in locating their needs, but still heavily rely on the traditional facilities information due to their familiarity and the limitation of the building being labeled with facilities information. Some patrons felt that the contextual display is not within their context and did not see a benefit of using it. A few others thought the display is too complicated and confusing to use on a daily basis. In addition, participants in the exit interviews expressed concerns related to the validity, subjectivity, and generalization of context tags within the display. However, our results show that context within a kiosk display setting is generally welcomed. Most patrons felt that the display can provide information that would allow them to locate their destinations more effectively.

The concerns raised in this paper should be the primary focus of future work. From analyzing the responses from the patrons and participants, a more in-depth qualitative study on usage of contextual information is needed to determine the best method to provide the patrons a sense of comfortableness while using the display. In addition, a re-design of the system using user’s responses, we suspect, would benefit the user experience while interacting with the kiosk display.

References

Abowd, G. D. (1999). Software Engineering Issues for Ubiquitous Computing. *ICSE* (pp. 75-84). Los Angeles CA: ACM.

Cheng, Y.-C., Chawathe, Y., LaMarca, A., & Krumm, J. (2005). Accuracy characterization for metropolitan-scale Wi-Fi localization. *Proceedings MobiSys*, (pp. 233-245). Seattle.

Griswold, W., Shanahan, P., Brown, S. B., Ratto, M., Shapiro, R., & Truong, T. (Oct. 2004). ActiveCampus: experiments in community-oriented ubiquitous computing. *Computer* , 73- 81.

Huang, E. M. (2007). What Does the Public Look at Public Displays? *Companion Proceedings of Ubicomp 2007.* Innsbruck: Austria.

Ji, S., Li, G., Li, C., & Feng, J. (2009). Efficient Interactive. *WWW.*

Krumm, J., & Horvitz, E. (2004). LOCADIO: Inferring Motion and Location from Wi-FiSignal Strengths. *First Annual International Conference on Mobile and UbiquitousSystems: Networking and Services, Mobiquitous 2004.*

McCarthy, J. F., & Meidel, E. S. (1999). ActiveMap: A Visualization Tool For Location Awareness to Support Informal Interactions. *Handheld and Ubiquitous Computing* (pp. 158-170). Karlsruhe, Germany: Springer.

Motion Sensor. (2008). Retrieved from Phidgets Inc.: http://www.phidgets.com/products.php?category=2&product_id=1111

Patterson, D. J., Xianghua, D., & Noack, N. (2006). Nomatic: Location By, For, and Of Crowds. *LoCA* (pp. 186-203). Dublin, Ireland: Springer.

Salber, D., Dey, A. K., & Abowd, G. D. (1999). The Context Toolkit: Aiding the Development of Context-Enabled Applications. *CHI* (pp. 15-20). Pittsburgh: ACM.

Weiser, M. (1991). The Computer for the 21st Century. *Scientific American* , pp. 66-75.

Xianghua, D., & Patterson, D. J. (2008). NomaticBubbles: Visualizing Communal Whereabouts. *CHI.* Florence, Italy: ACM.