180 x 120: Designing Alternate Location Systems

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Abstract
Using 180 RFID tags to track and plot locations over time, guests to an event at the San Francisco Museum of Modern Art (SFMOMA) collectively constructed a public visualization of the individual and group activities by building a history of movement throughout the space over 120 minutes. The projected histogram builds over time, revealing crowd intelligence, patterns of group distribution, zones of intensity, and preferred locations. The real-time data is projected atop a geometrically constructed, three-dimensional tessellated screen whose texture and shape have been previously calculated using a model of expected user clustering and activity. The juxtaposition of real and expected data manifest itself in this group created visual artifact. This paper presents a structured design approach to location systems that ignores quality and reliability, celebrates the loss of privacy, integrates physical architecture into the output, and explores crowd generation of public digest artifacts. A resulting deployed system is described.

Keywords
RFID, location tracking, tessellation, crowds, design

Introduction
Where are we? Locative media, GPS in car navigation, and the barrage of emerging location technologies are upon us? Somehow more than ever we find ourselves lost in the sea of longitudes and latitudes. A new wireless numerology? We envision a space where

"Any new technology, any extension or amplification of human faculties when given material embodiment, tends to create a new environment."

- Marshall McLuhan [1]

mobs, crowds, tuples, and even the wallflower are active participants in an interactive architecture of interwoven patterns. RFID tags and tessellated surfaces thrust themselves into a feedback system generously lubricated by social interactions.

Figure 1. 180x120 visualization of individual participant tracings projected atop the tessellated surface during a public event. In this example, person number 42 has just been logged as entering the green zone which happens to be the bar.

Alternate Location Tracking Design Spaces

Location tracking concepts, technologies, and projects are numerous within the HCI/UbiComp communities [2-5], and the goal of 180x120 is not to duplicate these efforts. Rather, our goal is to set forth a series of alternate design principles, several directly opposed to much of the *status quo* discussion about location tracking. Using these as design constraints, we explore this alternate design space to uncover what we hope to be a new family of location system applications. We see each of the four constraints outlined below as fruitful new design directions within the research space of location tracking technologies. Finally, we implemented an example of one such system – 180x120 (Figure 1).

The first two design constrains are radical inversions of the two primary issues often positioned at the forefront of discussions concerning location systems while the later two introduce new physical design directions. We describe these four design vectors in the subsections that follow.

Ignore Quality and Reliability

A tremendous amount of effort is often spent on refining, debugging, and insuring that acceptable levels of a system's tracking hardware and software approach 100% tracking reliability. There is indeed a valid justification for these points in that many of the applications and usage models built atop today's location tracking systems depend on highly reliable location tracking data to be delivered from the underlying system. However, the 180x120 system was intentionally designed to operate with noisy, invalid, and missing data with absolutely no guarantees on any reliability metrics for tracking individuals. Clearly, this is a poor design criteria for some set of tracking applications. However, there is also a design space of applications that function, perhaps even flourish, under these relaxed location tracking constrains. More importantly, in our rush to optimize around location data reliability, we have lost a broader discussion surrounding the space of noisy, error prone yet useful and meaningful location systems. Our challenge was to discover and embrace this design space.

Celebrate the Loss of Privacy
The concept of location tracking inevitably brings up issues of privacy, security, and anonymity. And with good reason, who archives the data? Who shares the data? What exactly is contained in the location data, etc? Privacy issues are seen by many as one of the major barriers to adoption of location based technologies [6]. However, in the spirit of the design noir [7, 8] we need to realize that there is a design space within location tracking where there are no privacy guarantees and no one is anonymous that still yields useful and meaningful applications. What types of location tracking applications will emerge if we invert the concern about privacy and anonymity and instead celebrate the exposure of everyone? Similarly, the tracking technology is often hidden into the background of an environment. What if we overtly expose all of the elements of the tracking system?

Integrate Physical Architecture into the Output
There are countless systems that project a visualization onto a screen or flat surface. Similarly, there are projects that use the physical architecture as an output mechanism [9, 10]. We wanted to elevate the role of the physical architectural surface used for the projection. How could the three-dimensional shape and texture of the projection surface reference the live data feed and *vise versa*?

Crowd Generation of Public Digest Artifacts
We are interested in a larger research question of how groups and crowds of strangers that temporarily share a space or activity can dynamically form a public record of that event or action. Clearly the raw location data and feeds from nearby sensors already constitute an archive of activity, often unique to that moment in time. However, can the passive actions of a crowd collective generate a time and space specific artifact such as a sound (*i.e.* a ringtone specific to that event [11]), an image, animation, *etc*? Individuals already use the diversity of stickers on their laptop, their collection of music concert t-shirts, the size of their email inbox, the number of entries in their address book, their iTunes' playlists, or the number of hits from egogoogling[1] as public and private indicators of personal experiences, interests, and values. How can events and activities generate unique artifacts such as images, audio, animations, *etc* that serve as specific markers of shared experiences and events (*i.e.* "see I was at Burning Man in 1996, Woodstock in 1969, the Uptown bar last Tuesday, *etc*"). The idea being that the collection of people at the event become passive participants in generating a unique artifact that can be digitally represented and individually copied and taken away as a record of each person's participation. We are also interested in this design vector for applications of anonymous crowds of strangers in public urban spaces.

Figure 2. One of 180 numbered RFID tags and another shown attached by an individual to themselves at an event

[1] Egogoogling, also called egosurfing, autogoogling or self-googling, is the practice of searching for one's own given name, surname, full name, pseudonym, or screen name on a popular search engine, to see what results appear.

180 X 120 SYSTEM

Recalling the four design constraints outlined in the previous section, we constructed and debuted the 180x120 system at an indoor public event at SFMOMA. We outline the system architecture, user experience and technical details in the following subsections.

System Overview

Using 180 RFID tags (Figure 2) and a set of four RFID antennae, each corresponding to one of four particular behavioral zones (bar, dance floor, lounge area, and main entrance), the group and individual behavior of participants at the event were tracked and event statistics logged such as an individual's duration of stay, time of entry, and favored geographic locations (near the bar, the lounge, etc). Each behavioral zone was color coded (bar=green, dance floor=red, lounge=yellow, and entrance=blue) and a colored light attached to each RFID reader (Figure 3).

User Experience

Upon arrival at the public evening event at SFMOMA, each of the 180 individuals received a numbered, visible RFID tag sticker (see Figure 2) along with instructions on how to attach it to their exterior clothing. When a person passed through a behavioral zone (*i.e.* bar, dance floor, lounge, *etc*) and came into range of the corresponding RFID reader (Figure 3), their ID tag would be read. Their number would be briefly displayed atop the main visualization and color coded according to the zone they were within (Figure 1).

Figure 3. Blue behavioral zone RFID reader

Interactive Visualization

The visualization was comprised of people (horizontal) and time (vertical). The result was that each numbered tag (*i.e.* person) was represented as a whole column. Time moves downward for 120 minutes in total with an event horizon line clearly shown at all times. Recall that each of the four regions was color-coded. Each time an individual was detected in a specific region, their ID number flashed on the screen and the corresponding color filled in their column at the current time (denoted by the event horizon line). A horizontal line indicates the current time and advances downward every minute.

After being undetected by an RFID reader for 10 minutes, individuals fade in color until they turned black. Entering a new region generated a new color in the user's column at the current time. The result was a visualization where each person was represented by a column with their actions and activities, including the time the arrived and left indicated by reading the column's color coding downward.

Since the ID tags were handed out in numerical order, you can see people first arriving at the event. Later you can see them change color as they move around and eventually turn black when they leave. The image represents a unique view of the social dynamics at play over the course of the 120 minute event (Figures 1 and 6).

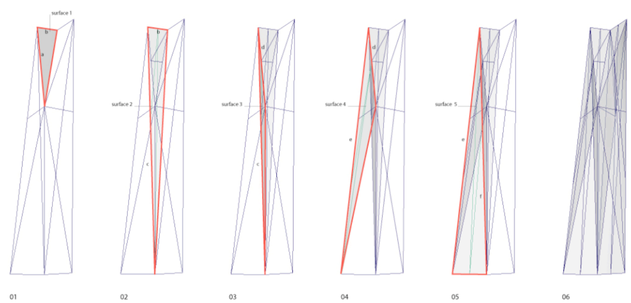

Figure 4. The four distinct folded cutouts that form the language for building the overall tessellated surface. Deeper tessellated patches are used in regions of unexpected behavior

Tessellate - To form into a mosaic pattern with interlocking shapes or patterns such as by using small squares of stone or glass.

Tessellated Surface

A corresponding event specific set of forecast data was used to geometrically construct a tessellated paper screen that indicates where average behaviors should occur. A modeling system was used to pre-calculate the expected activities during the event, rendering flat tile surfaces on the screen in regions of forecast activity, while increasing both the scale and three-dimensional depth of the tessellations in regions with fewer forecast activity (Figure 5). The result is clear, smooth projections of the live data in regions where it is expected and rough, deeply shadowed projections of the outliers and unexpected event behavior (Figure 6). The entire calculated tessellated screen was cut using a laser cutter, hand folded, and assembled. The projected data and hence folds were generated using a clustering social dynamic simulation system.

Recall that during the actual event, people could track themselves using their unique RFID number, with their location and time information projected onto the screen in real time, creating a cross referencing of real and forecast information, that is highly event and location specific. We wanted to highlight the juxtaposition of the fixed, pre-calculated model of expected data results with the actual live data from people at the event.

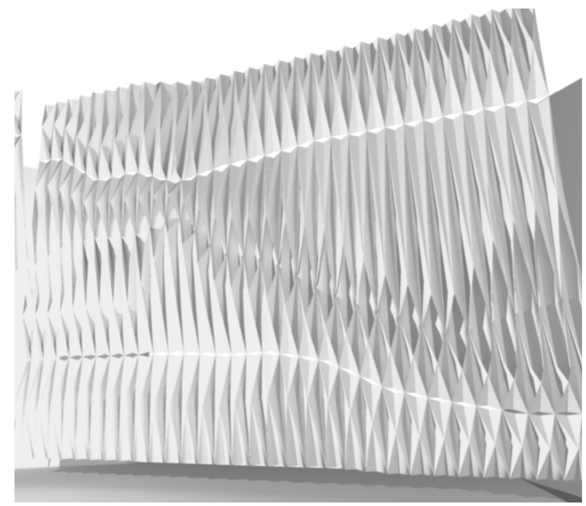

Figure 5. The full view of the calculated tessellation of projected group activity for the event.

Figure 6. Live visualization projected atop the calculated tessellated screen.

Technical Details and RFID Tracking

The overall system used four antennae attached to a single Alien ALR-9780 reader. Custom Java code was used to parse the data from the reader and generate the visualization. The tags distributed were the ALL-9350-02 I RFID Tags. Each of the four RFID readers were polled every 5 seconds to report all tags within range. The range was, as expected, highly variable as tags aligned on axis with the reader could be read at nearly 6 meters while those attached around a person's shoulder or curved surface below the reader's main envelope were often missed. People themselves also served to interfere with the RF signals, sharply deteriorating the effective range of the reader down to just a meter or two. In addition, often a single read cycle would yield 25 or more visible tags. While all of the individual ID colors were updated, we only selected a single tag from the set to be displayed using the large color numeric overlay. This was done primarily to make the display readable and allow individuals to find themselves ("Hey look there I am…number 22") and see the locations of others within the space ("Number 33, that's Jill, looks like she's at the bar again"). This technique allowed the individual ID number to be on screen for nearly 5 seconds as apposed to rapidly firing through 25 or more numerical ID tags in 5 seconds at 200ms each, which would be humanly unreadable.

Results

Adhering to our design constraints we developed a location system that fails to accurately read and record tags (*ignore quality and reliability*), publicly reveals and implicates each individual's actions and locations (*celebrate the loss of privacy*), juxtaposes anticipated actions with actual behavior using a live projected visualization atop a physically calculated fixed tessellated surface (*integrate physical architecture into the output*), and outputs a unique visual landscape incorporating every individuals actions into a single image digest (*crowd generation of public digest artifacts*).

This last design vector is a powerful one. In a world increasing layered with sensors and data collection mechanisms, it is vital that we have techniques to express and describe events in concise summarized (and in this example admittedly abstract) forms. While the image does not reveal who talked with whom it does capture who made a large number of trips to the bar, who appears to have spent the most time dancing, when was the dance floor most active, who left early, who stayed late. It also gives a sense of the scale of the crowd and an idea of the climax of the party (in our data there are two waves an early wave after 32 minutes and a second late night crowd after 96 minutes). The initial green coloring clearly indicates the bar as the universal first destination by nearly everyone.

We can imagine this imagery as metadata from the event with the individuals in attendance receiving the final digest image. "Hey look I left right before the party really got going" or "What was the party like last night? It was like this (pointing to the image). Yea but look at the one from last week!" Widening the discussion, the same basic system can be used for other contexts (using mobile phone Bluetooth IDs as tags): "Look at all this traffic we're stuck in from the suburb" (reader along highway in the suburb[2]), "So many people drove here tonight" (reader in parking lot), or "I've been waiting longer than anyone for this bus".

Figure 7. Live visualization before it is projected atop the calculated tessellated screen.

[2] Such systems currently exist such as FASTTRACK in several US metropolitan areas but are managed by municipal governments rather that providing an open source API for the public to generate these visualizations.

Conclusion

As location based systems and tracking tools become truly ubiquitous, we dream of exposing a wider application space for such systems by inverting several of the typical location tracking design constraints and watching a new set of experiences emerge. We have demonstrated one such location based system that has been deployed with 180 participants over 120 minutes. Particularly useful is the discussion of crowd generated, publicly shared and experienced digest artifacts of events and activities. *180x120* presents what we believe is an encouraging and simple approach towards expanding our range of choices as we adopt various location based technologies into our future lifestyles.

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