

Designing Real Time Sense and Response Environments through UX Research

Kai Hansen¹, Thomas McLeish²

^{1,2}SapientNitro

^{1,2}{khansen|tmcleish}@sapient.com

Ubiquitous computing systems are changing the way retail environments are being designed. With increasing frequency, User Experience (UX) designers leveraging ubiquitous computing systems that observe and respond to user behaviors are assuming roles once held exclusively by architects. As these systems continue to spread, space designers will need to embrace UX research and design methods. We will discuss how ubiquitous computing is leveraged in our research, and our position on how these systems are impacting the design of retail environments, illustrated by several examples of UX research projects informing the design of retail environments.

Keywords: *ubiquitous_computing_systems, user_experience, retail_environments,*

UBIQUITOUS COMPUTING IN THE RETAIL SPACE

Mark Weiser, considered by most to be the father of ubiquitous computing, described it as "invisible, everywhere computing that does not live on a personal device of any sort, but is in the woodwork everywhere." (Weiser, 1995) He further explains, "[ubiquitous computing's] highest ideal is to make a computer so imbedded, so fitting, so natural, that we use it without even thinking about it" (Weiser, 1994). One can see that without good user experience design around products, interfaces, and digital environments, accomplishing such a feat would be impossible.

The goal of this paper, and our work in general, focuses on informing the design of digitally connected retail environments, so let's first take a look at some of the ways in which we may experience ubiq-

uitous computing in that space.

Ambient Information

This form includes digital signage for displaying prices, sales, way finding, etc. The content for these interfaces can be tailored for time of day, day of week, and data on who buys what during those periods. Content can be delivered onto digital displays or kiosks (see Figure 1). In some cases these interfaces are made interactive with a touch screen or some other type of human interface. We would still consider these to be mechanisms for the delivery of Ambient Information. However, some are capable of autonomously observing people that are interacting with them. For example, there may be an imaging device and computer capable of determining the age and gender of a viewer(s), and tailoring content based on that information. In these cases, the kiosk

would fall into the Observe and Respond category discussed below.



Observe and Respond

Ubiquitous computing systems that observe behavior and make decisions on how to respond based on that data, and perhaps other sources of data from within a network of supporting devices, are relatively straightforward in terms of the process by which they perform these actions. In many cases, it is an "if this, then that" relationship that drives the experience. For instance, if you bring your mobile smart device, that is running an in-store application capable of looking for one of Apple's iBeacons, near a product on a shelf and you pass inside of a predetermined proximity threshold, then you will receive a push notification (see Figure 2) about a special promotional offer for that product.



Figure 2
Receive product
specific deals based
on location or
proximity
Digital content
displayed on a mall
kiosk

Observe and Broker

Systems like Observe and Respond - such as when a mobile smart device interacts with a BLE beacon to support an "if this, then that" action - can also be driven by other bits of information and algorithmic analysis taken from multiple streams of synchronized data to derive insights and richer experiences .

Consumers might still receive personally tailored content via push notifications or other means of communication. However, the content that is being delivered can be based off of more than a simple bea-

con interaction. Data around online or mobile browsing history, purchase history, location based information, or customer loyalty programs can also be used to ensure that the appropriate content is provided to the user, providing a better chance that the user will make a purchase.

In addition to what the consumer experiences, retailers can receive data about a guest's browsing on their mobile app, procession through the store while the app is running during a visit (see Figure 3), and what the guest's level of interaction is with any push notifications they may have received (do they ignore it, click on it then navigate back to the previous task, proceed to purchase it online [a.k.a. show-rooming] or potentially in store). Retailers can use the insights gained from such user interactions to inform the designs of future in-store experiences.

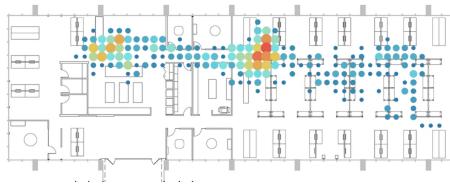


Figure 3
Aggregated indoor positioning data showing general procession and moments of engagement

UNDERSTANDING BEHAVIOR THROUGH UX RESEARCH AND UBIQUITOUS COMPUTING

Through the study of user behavior, ubiquitous computing systems in the built environment are changing the way retail spaces are being designed. UX researchers and designers now do work once performed almost exclusively by architects.

We might consider the growth and evolution of mobile smart devices as the key technology that ushered in the new era of mass computing, and in fact act as user interfaces (UI's) for many ubiquitous computing systems. Between 1988 and 1994, the PARC team at Xerox (led by Mark Weiser) developed several working prototypes of ubiquitous computing interfaces known as "tabs, pads, and boards" [1], which are, perhaps not so surprisingly, very similar to the

devices we use to interface with ubiquitous computing today. These devices that handle our day-to-day goals and needs while also helping us to do more while doing less (McCullough, 2005), are capable of interacting simultaneously with other devices, both local and remote. Simultaneously interacting with the physical and digital environments augments how we experience our world, and the quality of these experiences is driven by the thoughtfulness of their design.

In the coming years, interest in merging digital and physical experiences will likely encourage the use of UX research and design principals in other types of built environments where ubiquitous computing systems exist. This shift in methods and approach should serve as notice to architects that the technological changes we are experiencing elicit a fresh set of skills tailored to treating the digital environment with the same considerations given to the physical when designing space. We believe this necessitates not only equal consideration of both, but also careful scrutiny of the experiential conditions that are created when physical and digital environments meet. One of the most exciting things about the architectural profession is that it has always been a multi-disciplinary practice. Just as architects have learned to utilize other emergent technologies (e.g. electricity, steel structures, the PC), so to must it learn how to handle the inclusion of ubiquitous computing systems into the built environment.

WHY UX METHODS FOR DESIGNING RETAIL SPACES MATTERS

Retail environments may not always be the most glamorous of examples from an architect's point of view. However, because their architectural 'language' is well defined (meaning, that their programming is mature and well-understood) they serve as a good launching pad for discussing how ambient computing systems can be of value for understanding how occupants experience a space, as well as informing how it should be designed or reconfigured at any point throughout its lifespan.

There are several reasons for claiming that retail environments should be considered well defined. First, the design problem statement is well understood and widely applied. Retailers need a physical location for consumers to visit, experience first hand their inventory, and hopefully make a purchase. It is the intention of the retailer to encourage as much spending as possible. Secondly, the hierarchical programmatic language is well defined across specific types of retail spaces. When you walk into a grocery store you understand where the produce, deli, or frozen sections should be relative to one another and the point at which you entered the store. You know how to navigate based on signage that indicates what is kept in each aisle, familiar departmental configurations, or that the primary point of sale (cash register) is generally at the end of the intended procession.

Physical instances of retail environments are public spaces, and as such the UX methods for designing them should be considered relevant to the design of other environments that are also public in nature.

While the design of space through UX methods that employ ubiquitous computing systems can certainly inform the design of un-built iterations of a similar space, it is important to understand that much of the work happening in the retail space is used to inform the reconfiguration of a given space, as well as other pre-existing spaces like it. This also relates to other non-retail types of space, in that many of them are already built but may have experienced changes in how they are used over time.

John Habraken developed the Open Building approach, which is rooted in the way an ordinary built environment grows, regenerates, and achieves wholeness over its lifespan [2]. Habraken suggests that certain changes correspond to certain time frames. For example, how the furniture is arranged in a space may change every two to five years, technological/mechanical infrastructure may change every 25 years, a façade may be replaced every 50 years, a building's structure lasts for 100 years, and so on (see

Figure 4).

Subscribing to the whole building approach means that one understands:

- That occupants may make design decisions as well as professionals
- That designing space is a process with multiple participants also including different kinds of professionals
- That the built environment is in constant transformation and change must be recognized and understood
- That built environments are the product of an ongoing, never ending design process, in which environment transforms part by part

Ubiquitous computing systems deployed to observe behavior, respond and broker insights that inform design decisions are capable of facilitating each one of the above understandings by autonomously gathering information about how occupants experience a space differently over time, and converting that information into understanding how a space could be improved.

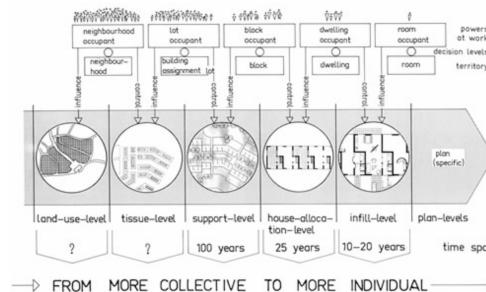


Figure 4
John Habraken's
Diagram of the
Principle of
Environmental
Levels [2]

THE IOT LAB

The IoT Lab is an innovation team within Sapient-Nitro, a global digital agency. We support internal market research, including a specialized "Instrumented Intelligence" team that extends traditional

ethnographic research methods with sensors and non-traditional data gathering techniques. The data from this research allows us to broker actionable insights that are then translated into design decisions for the retail environment.

We have worked with retail clients to deploy ubiquitous computing systems for observing customer and sales associate behavior. Findings from this research translate into new views of in-context behavior and inform design decisions for the retail environment. Because our research often extends beyond the shell of the building - to understand the larger context for a user's behavior - we work across the various stages and roles a physical environment plays. Our work has immediate impact as well as longer term implications on the design and planning of retail spaces.

We typically categorize physical environments into a taxonomy of spaces. Categories that we're currently using to track our projects are:

- Retail
- Home
- Institutional
- Workplace
- Entertainment
- Travel (includes mode of transport and supporting spaces)

Within this framework we typically employ 14 types of observation techniques:

- Atmospheric observation
- Motion tracking
- Video analytics
- BLE beacon tracking

- Wi-Fi "sniffing" or tracking
- Geomagnetic field mapping
- Geofencing
- Geolocation tracking (GPS)
- Social data analysis
- Large interactive displays
- Digital activity logging
- Augmented/Virtual reality
- NFC payments
- RFID tagging

Many of the technologies we use could be considered "off the shelf" products or services, and the data they produce can be accessed through public APIs. This data, along with any captured through our bespoke sensors, is stored in our backend. Once uploaded (or while streaming in real time), data is processed through a series of custom analytics algorithms to reduce its footprint. We then explore the processed data through various visualization techniques that allow us to glean new insights about what we are observing through the lens of our sensors.

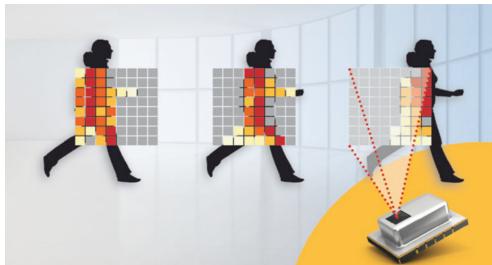
Below, we present four case studies that employ some of these technologies for use in retail environments.

Grideye Indoor Tracking. The Grid-EYE is an 8x8 pixel (low resolution) thermal imaging camera - it differentiates between body heat / ambient temperature to detect movement of people (see Figure 5). It's 'always on' and can collect data over very long periods of time (months, years).

The Grid-EYE is completely anonymous, low-impact technology we've developed to measure indoor traffic. It can be used to calculate dwell times and hot spots in a defined area, measure flow in and out of a space, and trigger a responsive environment.

Retailers typically rely on observation (shop-alongs, manually watching security camera footage) to study how people move through their stores. Grid-EYES can support or replace this technique; data from these devices is processed in real time to reveal paths, speed and direction of movement, dwell times, and dwell location (see Figure 6). This technology is also passive in nature, meaning it does not require people to "opt-in" to use it. Additionally, the ability to look at space over a long period of time without having to significantly modify the technology makes conducting longitudinal or A/B tests (of fixtures, floor plans, merchandising, etc.) very easy.

We installed 60 grid-EYES in a big-box retailer to measure the impact new mannequin displays and shelving fixtures were having on shopper traffic along the store's main aisle. We collected data for over 3 months, and found that dwell time, aisle conversions, and movement patterns at new fixtures was significantly different than at standard / non-innovation fixtures throughout the store.



Office Tour. The Office Tour is designed to illustrate the customer experience of hyper-local content delivery via Bluetooth beacons, and the kind of data you can collect from this type of interactive experience. The tour is composed of a custom mobile application

run on a mobile smart device (in this case an iPod Touch) and Bluetooth beacons (see Figure 7). Additional data (e.g. motion and ambient audio levels) can also be collected by the mobile smart device's sensors. There are two types of Bluetooth beacons installed throughout several floors of our Toronto and Chicago offices. 150 Kontakt BLE beacons were placed on a rough 15 ft x 15 ft grid; the tour app listens for their signals and triangulates the location of your mobile smart device based on which it hears and their known location within the space. Swirl beacons are placed at each of the five tour stops and activate specific content relevant to their location. Only devices with the "office tour" app are tracked, and only when the app is open and "beacon tracking" is enabled.

The two types of beacons we deployed perform do two different jobs. Kontakt beacons are simple to deploy and manage because the batteries (long lasting!) are easy to change. Swirl beacons work with a separate SDK and platform that are designed to deliver content, and have a good dashboard interface for managing and updating content. Having separate beacons for content delivery also makes relocating, modifying signal range, or adding/removing content-delivery beacons easy - without disturbing the underlying path tracking / way-finding infrastructure.

This system can also be easily reversed - where beacons move around and receivers (in this example, iPods) are stationary throughout the space.

SapientNitro has deployed beacons in a European airport to provide a turn-by-turn way-finding experience. We have also deployed Swirl beacons in a grocery retailer to provide in-aisle coupons and encourage cross-category shopping, and to track high-value products.

Figure 5
How the Grid-EYE detects people and movement

Figure 6
Examples of passive traffic analysis used to develop coefficients for measuring retail fixture success

Figure 7
Office tour app with location driven content delivery

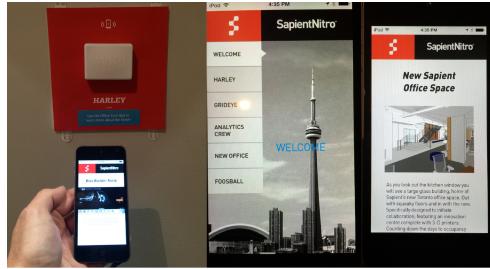


Figure 8
Path and motion data produced by the Office Tour App capturing BLE beacon data

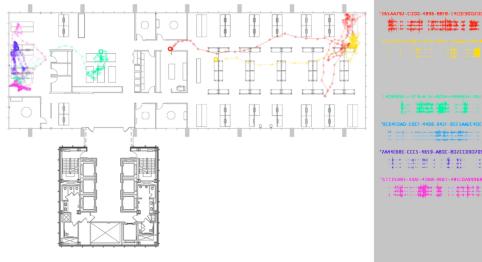


Figure 9
Foosball table interface running on iPad web-app



Figure 10
International SapienNitro foosball Twitter feed



International SapienNitro Foosball League. This is the smartest foosball you've ever seen. It automatically counts goals, logs player stats, tweets a photo of the winning shot and the score (@Snofoos), and monitors occupancy of the room. It has the ability to lure game players by tweeting directly to people or calling out when people are in the room but not playing.

This is a demonstration of blending physical and digital in non-obvious ways, and to tell stories about activity beyond the immediate (see Figures 9 and 10). Because it tracks individual players, and because it's capturing data about its context, we can know something about office culture and happiness. Because there are similar tables in other offices, we can begin to measure or compare these characteristics across installations, or to measure success of the installation based on context.

The table uses our backend to collect real time goals, calculate player stats, and snap photos - and share them immediately with the world through our data streaming API. We've built proprietary models of room occupancy based on simple environmental data points - CO2 and noise level - gathered from an

off-the-shelf "internet of things" device (NetAtmo).

This project isn't about the foosball table or the specific sensors used, but the idea that many kinds of measurement tools can be combined to tell a story of something abstract, like social-ness of a space.

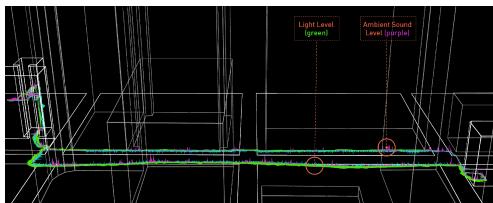
Measuring abstract topics or complex interactions takes a good chunk of "discovery" phase - experimentation to identify the key performance indicators and it always helps to start with a theory or hypothesis.

We instrumented several office spaces to understand similarly abstract concepts: modes of occupancy and when collaboration happens. Using a simple set of discreet instruments, we built models of collaboration and provided measurement platform for evaluating the success of furniture configurations. This became the foundation for a new product offering.

Measuring Engagement. This was an internal effort to develop more reliable means of measuring the nebulous concept of engagement - the positive experience of being engaged with a product, service, place, or brand. Engagement is a central mechanism of everyday life.

Our hypothesis is that we'll be able to more effectively look at engagement as an outcome by having first figured out how to see something measurable in moments we agree are engaging. Having those measures, we can look carefully at the conditions and outcomes around those moments. We believe there are ways of being inside a moment, ways that don't involve self-recall, self-report, or multi-million dollar fMRI machines. We've tested a wide range of inexpensive technologies (mostly "wearables") that provide a more or less continuous readout of different behavior indicators. We settled on a handful of metrics that measure or are proxies for time, attention, and effort.

We decided to study what seemed to be a well-bounded activity - leaving the office for an afternoon coffee with a co-worker - as an instance in which we could delve into the usefulness of this instrumentation and our definitions of what might mark engagement in everyday occurrences. Smartphone GPS data provides the first layer; the participant's path from office to coffee shop, as well as time and date stamping the start and end of the trip. Accelerometer data provides a count of steps - in this instance, just under 1300 of them. Physical exertion is a component of effort, which can be used to measure engagement. Other experience related variables we tracked include light level and ambient sound (see Figure 11).



We also captured continuous head orientation

through the multi-axis accelerometer in Google Glass. In the rendering below you can see the participant's gaze direction (green) as he is leaving the building and crossing the street on the way to the coffee shop (see Figure 12).

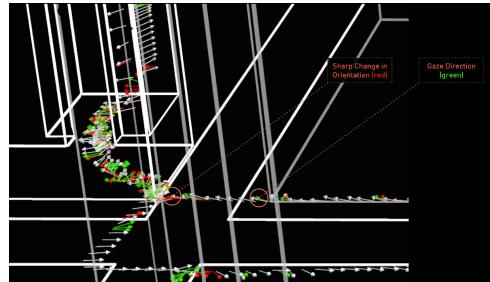


Figure 12
Vectors representing head orientation and rate of movement

Combining the indicators (including analysis of the 1st person point of view still frames) led us to focus on three possible moments that the participant was actively engaged with something; focusing time and attention on it (see Figure 13).

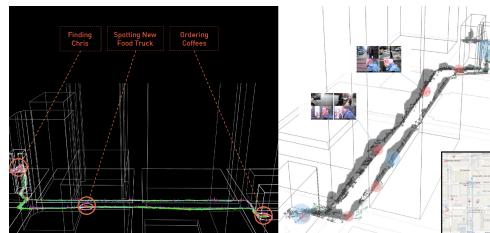


Figure 13
Moments of engagement along path: locating a coworker, noticing a new food truck on the street, ordering coffee

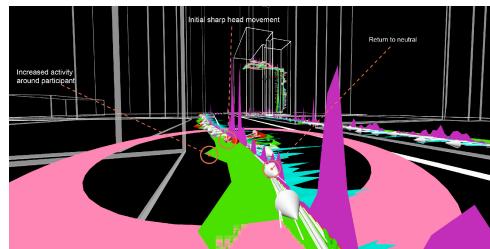


Figure 14
1st person POV of the first detected moment of engagement. Study participant's path, accelerometer, local light level, and ambient sound data

Even a 23-minute walk to a local coffee shop generates several million data points. The down-in-the-weeds level of data that tell us when a head turn

starts, or the degree of movement, or even the length of time looking at a payment app or a text message. And that's for one person.

Constructs like "engaged" become useful when we can build models of them "in the wild". By carefully aligning data streams across types, we can eventually zero in on a configuration of event information that let's us say, confidently, "THAT was an engaging moment!" If we do that, we'll eventually get to understanding what the most conducive conditions are for engagement in all sorts of settings (not just coffee shops).

CONCLUSION

User experience researchers have begun to employ ubiquitous computing to observe behavior, respond in real time, and broker insights that lead to changes in retail building. It is a priority for all designers of space to undertake the lessons required to understand how occupants experience space, and how to leverage tools like ubiquitous computing to understand experiences and develop new insights to inform design decisions.

REFERENCES

- McCullough, M 2005, *Digital Ground*, The MIT Press
- Weiser, M 1994 'Creating the invisible interface', *UIST '94 Proceedings of the 7th Annual ACM Symposium on User Interface Software and Technology*
- Weiser, M 1995 'The Computer for the 21st Century', *Readings in Human-Computer Interaction*
- [1] <http://www.ubiq.com/weiser/testbeddevices.htm>
- [2] <http://www.open-building.org/ob/concepts.html>