Group Behaviours around Public Displays

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Alec Azad, Jaime Ruiz, Mark Hancock, Edward Lank

Cheriton School of Computer Science, University of Waterloo

a2azad@cs.uwaterloo.ca, jgruiz@cs.uwaterloo.ca, mark.hancock@uwaterloo.ca, lank@uwaterloo.ca

ABSTRACT

Information kiosks often decorate large public areas to provide basic information to inquisitive patrons. This paper presents an observational study examining groups interacting with public kiosks. We identify fundamental issues regarding patterns in user orientation and layout, group identification, and behaviour both within and between social groups during the entire period of interaction. Based on observations from our study, we present a foundation of guidelines and principles that informs the design of public (vertical) large-screen surfaces.

INTRODUCTION

In shopping malls, amusement parks, airports, and other public spaces, large digital displays are replacing traditional signs as the medium of choice for communicating information to the general public. A digital sign can display generic, long-term information, e.g. a directory or map. Furthermore, this persistent information can be augmented with information that is timelier for passers-by. For example, a map of a mall or amusement park can be augmented with information on promotions or events that are occurring nearby. Digital displays are thus able to provide information more tailored to viewers' contexts. Larger interactive displays can support both multi-group interactions while preserving persistent ambient information for less-engaged passers-by as demonstrated in Figure 1.

This drive to develop tailored public information displays has spurred on-going research into large, public surfaces that nearby people can interact with. For example, Vogel and Balakrishnan [15] separate the environment in front of a digital display into four regions of interaction based on proximity to the display: *ambient* for more distant passers-by, *implicit* for peripheral awareness of passers-by, *subtle* for passers-by who focus on the display, and *personal* for passers-by who approach and interact with the display. Greenberg et al. [4] also demonstrate how proxemics can be used as a mechanism for managing input and information display for surfaces, i.e. depending on the location of users and their focus of attention, displays can support different information and different modalities for control.

While these systems clearly demonstrate that proximity can be used to effectively control an interface, little work has been done to explore the dynamics of group interaction with interactive public displays. There remain many open questions about the expectation a group walking up to a display might have about the influence of their position and orientation relative to the device. For instance, when a group of three approaches a display how would they normally position themselves? Should the device only consider interaction from those who are facing and close to the display, or are people in ambient or attentive zone simultaneously making use of the same information? Are strangers sharing a device identifiable by their orientation, so that the system can reasonably respond separately to these people?

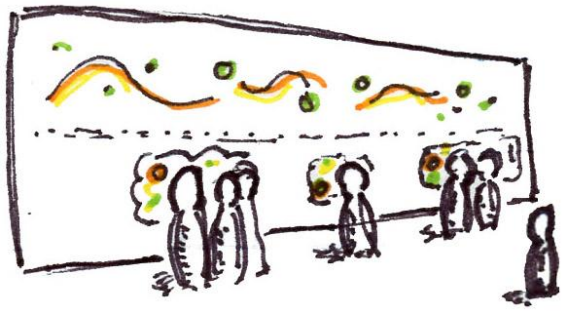

Figure 1: An artist's depiction of user groups engaging a large publicly-shared vertical display in parallel.

In order to inform design of these public, multi-user, multi-zone displays (envisioned in Figure 1), we explore how groups of users act at mall signs and at interactive kiosks. We present the results of observations of group intra- and inter-actions at shopping mall directories, movie theatre ticketing kiosks and photo kiosks. Patterns in user orientation and layout, group identification, and behaviour both within and between groups are explored over the entire period of interaction with these public displays. Intra-group behaviours were broken down into three phases: approach, access and interaction, and departure. Inter-group behaviours, including territory assertion, space-making, and orientation are also analyzed.

Our results outline the various dynamics in multi-group parallel use and how this can effectively be used to help manage territoriality and group identification. We provide evidence that territoriality *is* dynamic in nature and so must be extremely flexible in real-time. We also provide methods of reliable group identification; however, claim that this, too, should be dynamic and allow self-correction.

We first summarize the related work and then describe the environments in which the observations were. Subsequently, we present both similarities and differences of intra- and inter-group behaviors across public kiosks in users' entire interaction sessions. We conclude the paper with a discussion and interpretation of these behaviours and their ultimate design implications.

RELATED WORK

Research related to our work can be grouped into two main areas. First, studies of the design of large-screen single-display groupware provide the groundwork for understanding both synergies and differences between our work and past results. Second, studies of public kiosk systems can be used to inform the design of interactive displays in open, public environments. In this section, we provide an overview of the related work in each of these areas.

Large-Screen Displays

In their overview of large-screen research, Czerwinski et al. [3] summarize the cognitive benefits of using larger displays. They note that larger displays tend to improve information recognition and peripheral awareness making them well-suited to navigation tasks. Other researchers have noted productivity gains [17] and improved collaborative interactions [18] around large screens.

While researchers have demonstrated the cognitive benefits of large screen displays, deployments of interactive displays in open public environments are rare [3, 12, 18]. Many large screen systems (e.g. LiveBoard [23], BlueBoard [18], Flatland [24], Plasma Posters [19]) have been deployed, instead, in workplace environments. While workplaces have multi-person spaces like meeting rooms and hallways, the environment is restricted to employees. It is not clear that group behaviours in semi-public spaces like the workplace are similar to behaviours in public spaces such as malls, airports, or amusement parks [1]. In particular, the role of large displays in workplace environments is different than their role in open, public spaces. For example, in workplace environments the act of taking control of an entire display and customizing it for one's own or a group's use is acceptable, assuming that display co-opting is done to support work [18]. In public spaces, any personalization of a display must still be mindful of other users need to access generic content.

One exception to this lack of public deployment of interactive shared displays is CityWall [12], a public, large-screen (2.5m wide), multi-touch display that enables participants at large public events to upload and share photos. Researchers studied collaborative behaviours, and found CityWall provided as sense of "active spectatorship" as participants felt much more engaged in the event(s) knowing they could be photo content submitters (via a smart phone). In a follow-up study, Peltonen et al. [11] examined the social interactions that occurred while users interacted with the display. Their work presented several social concepts around large shared displays including, social learning (teamwork), conflict management and turn-taking protocols. Using a revised version of CityWall, named Worlds of Information, Jacucci et al. [9] extended the concept of social learning and more formally enumerated all the observed behaviours as users assisted each other.

Figure 2: An array of four movie theater ticket kiosks separated by stanchions.

One reason for limited deployment of interactive large displays may be user reluctance to engage with these devices in public venues. Brignull et al. [1] considered the early stages of interaction with public large-screen displays. They identified root causes of both users' reluctance (e.g. fear of embarrassment) and attraction (e.g. "honey pot" effect) to use large-screen displays in public areas.

Another challenge associated with public deployments of large-screen interactive displays is interaction design. Many single-display groupware systems support direct manipulation via a single-touch or multi-touch interface [7, 8, 9, 14, 15, 18], but there are exceptions. Dynamo [7] supports group collaboration in a semi-public environment (e.g. a meeting) using a WIMP-based interface in order to address sharing and privacy concerns. Body-centric interaction techniques [14, 20], where the interface is controlled by actions of the entire body or eye gaze have been developed and evaluated.

To aid in the design of interaction with shared public displays, researchers have explored proximity to a display to characterize interaction [15, 21, 22]. Both Vogel and Balakrishnan [15] and Ju et al. [21], in contrast, focus on adapting the display behaviour based on participants' range. For example, in their whiteboard system, ink clustering is performed in real time, but the results of computation are displayed to the user only when she steps back from the intimate zone to the personal zone during interaction. In this way, the system does not interrupt the user with recognition results during the writing task. Ballendat et al. [22] introduce the term *proxemic interactions* to describe how an awareness of position, movement and orientation can be used to control interactions in multi-device environments.

A final concern with single-display groupware systems is territoriality. Territoriality must address the psychological and sociological behaviours portrayed by users if a natural fluid interaction is to take place on public large-screen surfaces. In single-display groupware, researchers have made use of proxemics zones identified by researchers in anthropology and psychology. In anthropological research, four proxemic zones have been identified: intimate (less than 1.5 feet), personal (1.5 – 4 feet), social (4 – 12 feet), and public (12 – 25 feet) [4, 21]. For group interactions, neuropsychologists identify three basic zones of inter-personal space: the personal, peripersonal and extrapersonal [6]. During design studies for single-display groupware, Scott et al. [13] observed these same three zones of inter-personal space during group collaborations using a (non-digital) tabletop surface.

Public Kiosk Systems

In comparison to large-screen display research, relatively little research has been done on public kiosk systems. Maguire [10] established a verbose set of heuristics and design guidelines for building public information kiosks. The guidelines describe user requirements, placement constraints, interface design, and privacy issues. The digital Smart Kiosk project [2] implemented a public kiosk which used computer vision to track the movement of passers-by. An animated face on a portion of the display would rotate to orient itself towards people in close proximity which gave the system a degree of awareness. Hagen et al. [5] investigated smart interfaces on kiosks. They experimented with dynamically placing content on screen and changing text size based on the user's height and distance from the screen.

Interestingly, informal observations of public kiosk system in many environments illustrated a contradiction between research and design of these systems and use of these systems. While kiosks were primarily designed around the single-user experience, our observations indicated that groups of users would cluster around these single-user displays. However, surveying related work in public kiosks, we saw no research on the phenomenon of group use of single-user kiosks.

EXPLORING GROUP BEHAVIOURS AROUND PUBLIC DISPLAYS

The goal of this paper is to explore intra-group and inter-group behaviours around displays located in open, public environments. Displays exist in these environments. Some are passive repositories of information (for example, the classic shopping mall directory). Others allow interaction for specific tasks (grocery store check-outs, movie theatre kiosks, photo kiosks, etc.). The question then becomes how group behaviour around these existing artifacts can influence the display of information, the allocation of territory, and the design of interactive widgets.

More specifically, we explore the following questions related to group use of displays in open, public environments: 1) How do groups approach large displays? 2) How do groups orient and re-orient themselves over the course of interaction? 3) How does presence or arrival of other unrelated groups influence orientation? 4) How do groups assert and release control of portions of the display? Is territoriality fixed or variable during interaction? 5) How do individual users interact with the display and with other group members? 6) How does the presence of other groups influence intra-group behaviours? 7) Do unrelated groups ever interact? If so, how and why?

DATA ACQUISITION AND ENVIRONMENTS

We passively observed people's interactions at three public environments that offered different degrees of interaction with different tasks and goals in mind: movie theatre kiosks, photo-developing kiosks, and a mall directory.

Observations were recorded on two separate visits at each of the three locations and lasted approximately two hours each, resulting in 12 hours of observations (3 locations × 2 visits × 2 hours/visit). In each session, detailed observations were manually noted and coupled with hand-drawn figures depicting the motions and positions of the active users. Data was supplemented with still photographs depicting orientations and actions of groups. Qualitative coding was then performed on this data.

Scene 1 – Movie Theater Ticket Kiosk

As patrons enter the movie theater, they are presented with the option of lining up at cashiers or using one of four kiosks separated by stanchions (rope barriers) as shown in Figure 2. The width allocated to each line was approximately one meter which influenced users' behaviours as will be seen in the Analysis section. The kiosks include a single-touch small-screen display (~15" diagonal).

The viewing sessions contributed observations on a total of 26 groups containing a total of 59 participants. The breakdown is as follows: twenty-one pairs, three groups of three and two groups of four. Individuals and patrons who chose to line up at cashiers were omitted.

Scene 2 – Photo-Developing Kiosk

Photo-developing kiosks enable customers to order prints of photos brought in on any number of types of media (CDs, memory cards, etc.). Housing a small-screen single-touch display (~15" diagonal), users can scan through the photo collection on the media and select, manipulate and/or crop images for printing. Each kiosk also had a scanner located just below the display.

Observations were recorded for 9 different cases consisting of a total of 21 participants (8 males and 13 females). The average duration of use was 29 minutes ($\sigma = 17$) with the shortest case lasting 5 minutes and the longest being 55 minutes (to the nearest minute). There were six groups of two and three groups of three. No groups of four were encountered and singles were again omitted, except when interacting with groups.

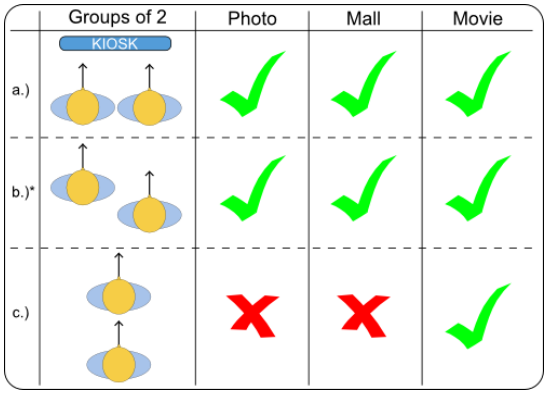

Figure 3: Approach patterns observed for groups of two at the three scenes. (*) indicates that the mirrored layout is also valid.

Scene 3 – Shopping Mall Directory

Mall directories contain an index to all the merchants in the mall (lower half of display) along with colourized maps outlining the floor plans for each level indicating the locations of stores and resources such as elevators, washrooms, and exits (upper half). To facilitate searching the map, a standard grid system adopted from cartography is used. The observed directory was a static large-screen display (~100" diagonal) which did not support interaction.

Twelve cases of interaction were observed which incorporated 18 distinct social groups and individuals. Specifically, there were six individuals, eight pairs, and four groups of three which totaled 34 participants (15 males and 19 females). In this scene, individuals were considered only if they experienced inter-group interactions (individual-individual interactions included). Interactions were all very brief: less than a minute, on average.

ANALYSIS

The next two sections present our analysis of user behaviours. In the first section, we focus on behaviours of individual groups of users, i.e. *intra-group behaviours*. Once we have analyzed these, we then examine the influences groups seem to exert on one another and the interactions we observed, either implicit or explicit, between unrelated groups of users, i.e. *inter-group behaviours*.

INTRA-GROUP BEHAVIOURS

Intra-group behaviours can be decomposed into three elementary phases, or, stages: *Approach*, *Interaction*, and *Departure*. Approach addresses the various ways in which users physically approach the display with the intent of engaging it. Specifically, we define approach as the period of time from when a group of users notice the kiosk until the time they reach and establish their initial position at the kiosk. Interaction concerns itself with the behavioural patterns observed whilst users are engaged with the kiosk, i.e. positioning, roles, and actions. Departure encompasses behaviours exhibited as users complete their interaction with

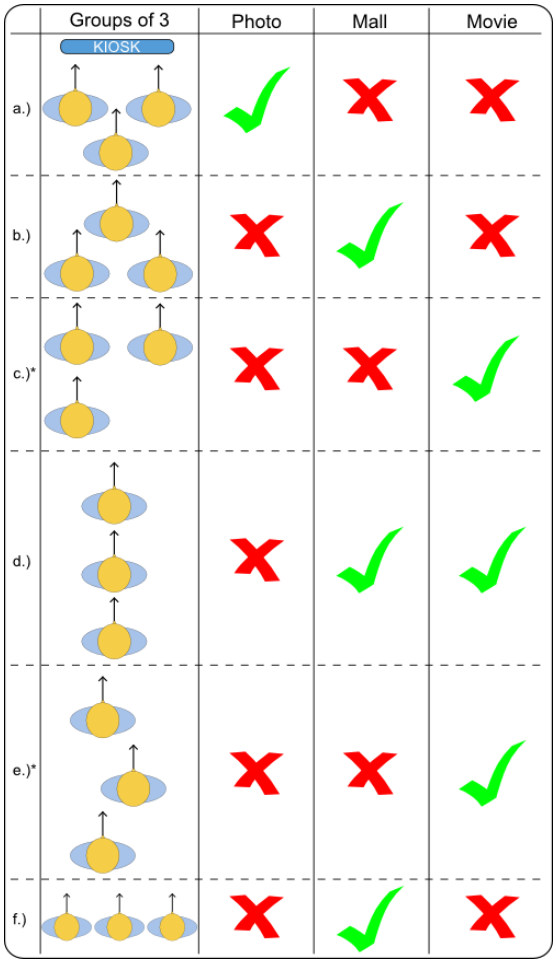

Figure 4: Approach patterns observed for groups of three at the three scenes. (*) indicates that the mirrored layout is also valid.

the display and physically move away from the device, thus completing their experience.

Approach

We identify three broad scenarios that accounted for approaches of all observed cases: *simultaneous approach* (or near-simultaneous), *delayed approach*, and *led approach*. In the instances of a simultaneous approach, the group, whether consisting of two or three people, casually walked to the kiosk as an ensemble, maintaining a shoulder-to-shoulder arrangement. Their approach is depicted in Figure 3a for groups of two and Figure 4f for groups of three. Other instances demonstrated a delayed approach where a portion of the social group would initiate interaction only to be later joined by rest of the group well into the interaction. The approach pattern observed is simply the same as that of the subset. A variation of a delayed approach was most frequently observed where one member of a social group would take the initial step and lead the group to the display, voiding a shoulder-to-shoulder assembly. To help differentiate this subtlety, we define this stricter version as a led

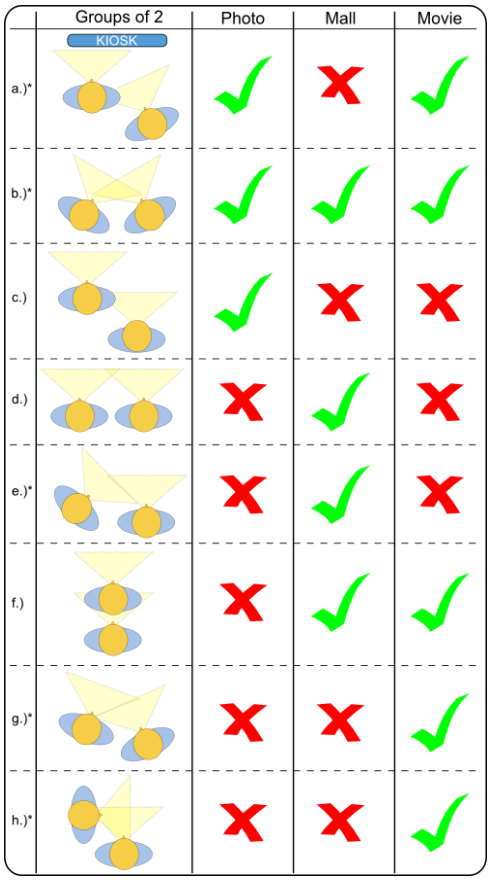

Figure 5: Orientations and layouts observed for groups of two at the three scenes. (*) indicates that mirrored layouts are also valid.

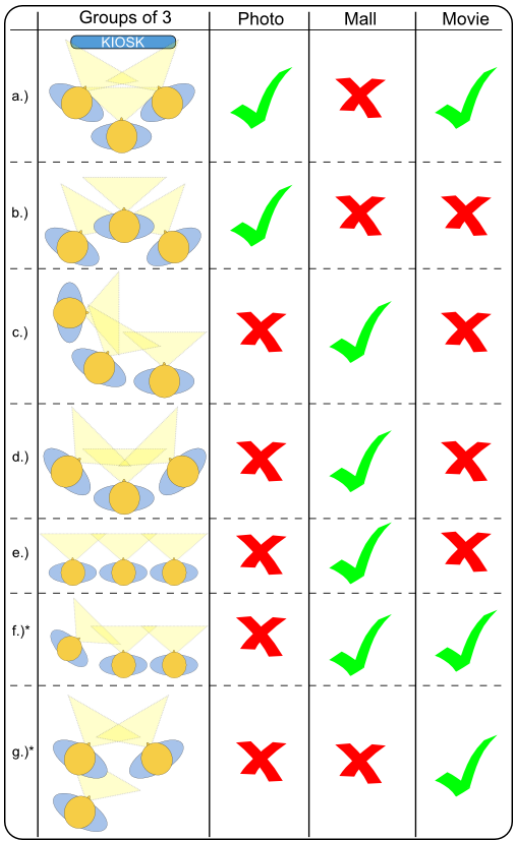

Figure 6: Orientations and layouts observed for groups of three at the three scenes. (*) indicates that mirrored layouts are also valid.

approach. The remaining figures in Figure 3 (b - c) and 4 (a - e) depict this style of approach.

Groups of two approached the large-screen display similar to how they approached the small-screen kiosks with the exception of the movie ticket kiosk which exhibited one addition form (Figure 3c). Groups of three showed much more variance across venues and no single approach was common amongst all three.

In the cases of a led approach, if the lead was sufficiently small (up to a couple steps), the leader would take position (no particular preference was observed) using foresight that their companion(s) would soon join in and would ultimately create a layout and orientation in the respective figures. If the lead was larger than a few steps, the lead would arrange themselves as an individual initially, and then re-arrange accordingly when companions eventually reach the display.

When kiosks were first noticed by those whom eventually decided to use them, users' trajectories would quickly curve towards the display. Users generally did not change their walking speed as they approached the display with the exception of young children who would often run after being led by parents.

For the large-screen mall directory, groups we observed were more likely to approach the display simultaneously as opposed to being led by an individual. The inverse relation held for the small-screen kiosks. In the case of movie ticket kiosks, the stanchions may have influenced approach. However, the photo kiosks also adhered to the led approach – even with opposite-sex pairs.

In our data, a delayed-type approach was exclusive to the photo-developing kiosk and was not observed elsewhere. In the case of pairs, one user would begin interaction, always approaching the display at the center of the small-screen console (as any single user did), and his/her acquaintance would join later. This time delay ranged anywhere from one to 10 minutes. More often than not, the initiator would adjust his/her position at least slightly to accommodate the late-joiner as seen in Figure 5b; however, multiple instances were seen where the late-joiner was forced to peek over a shoulder, typically from the right side as depicted in Figures 5a and 5c. This was consistent for both crowded and open environments; however, crowded environments preferred Figure 5c. In the cases where group size was three, two patterns were observed: one user initiated the interaction and was later joined by two acquaintances or two users initiated interaction and had a third member join in well into

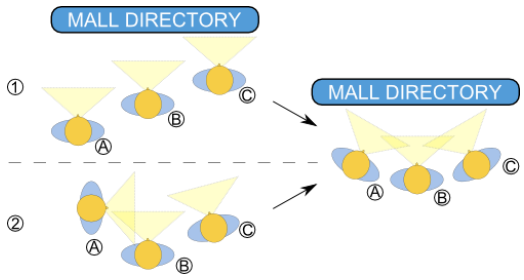

Figure 7: Asymmetric group layouts would typically morph as initially uninterested users gradually engaged in interaction.

the interaction phase. In the former scenario, the two late-joiners would shuffle the user layout to mimic those shown in Figure 6 (left-column). In the latter case, with two users already positioned at the kiosk (Figure 5), his/her choice was limited to standing behind (in the center) and as a result was forced to overlook over shoulders and between two heads as shown in Figure 6a: shuffling was not performed. No instance was seen of a group of three approaching the display one at a time: the third possibility.

No approach patterns for groups of four are shown even though they were encountered in the movie theater. In both cases, the group divided into two subgroups of pairs and entered different lines. In one instance, one subgroup entered the cashier line while the other went for a kiosk line: subgroups were not bound to the same methods. The decision of temporarily breaking up was also often observed with pairs of friends, but never with groups of three. If traffic at the kiosks was light, pairs of friends would often separate and perform two transaction concurrently using two kiosks (not necessarily adjacent). They would then either regroup in an open area immediately behind the kiosks or the quicker user would regroup with their friend until they finished their own transaction.

A few additional observations were noted about late-joiners to the photo-developing kiosk. Firstly, their introduction to the group was not always acknowledged with eye-contact or even verbal communication. In other words, it was quite often the case that engaged users did *not* distract from the task at hand to greet the newcomer. Secondly, late-joiners were more likely to become wanderers, users who would briefly leave and return to the group on one or more occasions.

The conclusion of the approach stage is marked by the initial layout taken by the users. The initial orientations and layout of the groups are shown in Figure 5 for groups of two and Figure 6 for groups of three. Maintaining the strict shoulder-to-shoulder layout in Figure 5d was predominant amongst opposite-sex pairs viewing the mall directory. The unusual layout in Figure 6f, where one user stood directly behind another, occurred twice. In one instance, a mother stood behind her daughter while reviewing the mall directory. The child's shorter height did not obstruct the mother's view of the display. The other example involved a young couple, where the young man was embracing his girlfriend from behind while she was using the kiosk.

Users stood very close to small screen kiosks. The large-screen and non-interactive nature of the mall directory did not have this restriction and allowed for some more interesting behaviours. Groups of two stood at about arms' length from the display, whereas individuals and groups of three stood slightly further: just outside of arm's reach. Individuals never exercised pointing and/or touching of the display and preferred to stand further back than pairs. We hypothesize that this increased individuals' field of view, thus requiring less neck movements to look at the bottom (store index) and top (map) halves of the display. Larger groups also stood slightly back. We believe this allowed larger groups to slightly increase inter-personal space while still remaining within each others' visual range.

Interaction

We define the primary user of an interactive system as the *driver* [16]. In all observed photo-developing kiosk cases, the first user to arrive at the kiosk assumed the driver role leaving the others to be observers – at least initially. This was not the case with the movie ticket kiosk. Occasionally, the first user to arrive at this kiosk did *not* become the driver. In simultaneous approaches, this role was chosen at random: there was no predisposed position (i.e. user on the left versus the right taking lead). It was noted that in the vast majority of cases, there was one driver at any given time. This generalization was violated in only one case where a pair of users at the photo-developing kiosk would constantly alternate touching the display and sometimes reach for the display concurrently.

Although observers of interactive kiosks did not directly interact with the device, more often than not, at least one of the observers (typically nearest to the display) would frequently point at options on screen and guide the driver. We define these observers as *active observers* because they contribute their opinions and assist in the decision making process. In contrast, there were also *passive observers*, whom would simply overlook the entire process without any intrusion or contribution to the task. It was noticed that passive observers would, with good likelihood, become wanderers. This was particularly true given a layout in Figure 5c. It was clear that drivers knew which of their companions, if any, were passive observers. Drivers typically would not adjust their positioning as they wandered, holding the pattern shown in Figure 5a,c and Figure 6a for groups of two and three, respectively.

An asymmetric group layout generally implied a lack of interest by one or more members of the group. For example, in Figure 6c – the most extreme example – a group member positioned himself perpendicular to the mall display; he completely disregarded the display's contents and maintained face-to-face contact with his two peers. Many of these cases lead to a morphing of the group's layout that ap-

proached a more symmetric distribution shown in Figure 7. The initially uninterested members gradually became more aware of the display and began to engage it.

Interaction with Interactive Displays. Users understood that the systems would respond to only one touch at a time, so two simultaneous pokes were never seen – even for (seemingly) novice users. There were a few cases where the participants would take turns touching the screen; however, a significant bias was always seen to one user who was responsible for the majority of the touching. Passive and active observers were both encountered with roughly the same proportionality. Pointing was a commonly used gesture by active observers to assist the driver in the navigation of the menus.

While users placed very strong preference in using their dominant hand to interact and/or point, several examples revealed users switching to their non-dominant hands. This switch would always be temporary before they resorted back to using their dominant-hand. Furthermore, the relative positioning of a user is *not* a good predictor of which hand they would use. For example, taking the positioning shown in Figure 5a the user on the right could use either hand.

In nearly half of the cases, the role of driver was not immutable and underwent a *role rotation*. Throughout the session, these cases experienced a role change at least once and in the extreme, over a dozen times. This was no surprise considering the lengthy duration of many of the sessions on the photo-developing kiosk. The duration and complexity of the task appeared to influence whether a role rotation was performed and how frequently. The longer the process took, the more rotations seemed to take place. In one case at the photo-developing kiosk, the original driver became fatigued after 25 minutes of usage and left to purchase a drink leaving his wife to inherit his duty in his absence. He then re-assumed the driver role upon his return (five minutes later) resting his newly purchased drink on the kiosk. This particular session took the longest – 55 minutes – and experienced the highest role rotation count and it occurred between three people (i.e. all three members were drivers at least once). Role rotations in groups of two did not change positioning; however, one group of three literally rotated positions with the driver relinquishing control and position to the individual in the back. In most cases, the layout and orientation was dramatically affected by a role rotation, especially for groups of three. This is undoubtedly a result of the small-screen nature of these kiosks. For example, two women initiated a layout in Figure 5a. As the first driver obtained her movie ticket, a fairly dramatic morphing took place to get Figure 5h which required a dance of multiple small steps to accomplish.

It seemed that initial observers of the movie theater ticket kiosks were much more focused on the display's contents than their surroundings, but after a role rotation, the new observer, who was recently a driver, is much less interested in watching the screen and more in wandering, looking around and/or maintaining eye contact with peers.

Wanderers were most frequently seen with the interactive kiosks, especially at the movie theater. In particular, it was observed that pairs would exhibit wandering whereas groups of three did not. Furthermore, wandering was more likely in light traffic conditions (just as with the photo-developing scene).

Interaction with Non-Interactive Displays. In the base case of individuals, no actual pointing and/or touching (physical contact being made with the mall directory) was done. The vast majority of groups *did* perform some form of interaction with the display. In addition to verbal communication, pointing and touching were methods employed to communicate ideas.

Pointing was more common method than touching. It was understood by users that to prevent miscommunications through pointing, fingers had to be sufficiently close to the display to prevent parallax. This played an important role for when groups of three interacted with the display. As it was mentioned, groups of three generally stood just outside of arm's reach, thus, to enable pointing/touching, they would often lean slightly towards the display.

There was typically one member of a group that performed the gestures, although it was not uncommon for members to take turns. There could be multiple users pointing simultaneously; however, it was noted that if a user was touching the display, others would cease gesturing. Even in a multi-group setting, only one user would touch the display at a time. Since there is only one (large) shared copy of the map on the display, people would wait their turn to touch the display. It seemed that touching the display would instantly gain others' attentions (a metaphor for "grabbing control"). In one observed case involving two women, bimanual gestures were used by one member: her left index pinned the destination on the map while using her right index to trace out the intended path. Furthermore, some users gestured in the physical environment the direction of travel.

Socializing. The amount of verbal communication across venues and within social groups varied dramatically. Two groups at the photo-developing kiosk remained fairly silent throughout their session exchanging nothing more than a handful of sentences. Their common layout is shown in Figure 5a. On the other hand, one group of three, also at the photo-developing kiosk, was so talkative that they would frequently take breaks from using the machine, turn towards each other (still in the same isosceles triangle formation shown in Figure 6a), socialize and laugh for a couple minutes before continuing with the activity. The remaining cases fell comfortably in-between these extremes. Our observations suggest that when the photo-developing kiosk is used by a group, it *generally* becomes a social event and is engaging for potentially all those involved. This held true also for the movie theater ticket kiosk to a lesser extent.

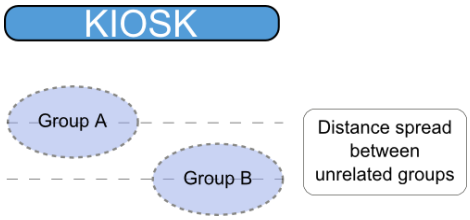

Figure 8: Multi-group interaction at a large-screen display. Unrelated groups of any size tend to stand at different depths from the display.

The mall directory, more often than not, generally involved minimal amounts of verbal communication, although this is not surprising from the rather short session times. A greater degree of interactivity and complexity lead to a greater need for socialization and collaboration.

Departure

Analogous to Approach, we define two (instead of three) broad categories in which users left the kiosk: *simultaneous departure* and *led departure*. Simultaneous departures consider cases where all members of the group leave together at the same moment (or nearly) within one full stride. In contrast, led departures represent the set of social groups who were lead away from the kiosk by one or more members leaving at least one other behind to catch up by at least two full steps. An action as subtle as a user turning away from the display would trigger the others to follow suit. Through communication, either through speech and/or gestures, it was obvious if the goal had been accomplished and from that point, users were receptive to this trigger which would result in the group parting from the display.

There was no obvious pattern observed in who lead the exit. It was just as likely for an observer to lead away from the kiosk as it was the driver. Similarly, in cases were a led approach was taken to approach the kiosk, it was just as likely for the initiator to lead away as it was any other member of the group. The type of departure was not exclusive to any group size or scene, but it was discovered that pairs were generally more likely to exhibit a led departure than groups of three, especially at small-screen kiosks. This difference was emphasized at the movie ticket kiosks and minimal at the mall (nearly equal).

At the movie theater, an observer would more often than not trigger departure from the kiosk. From having witnessed the (final) driver complete payment and reach below to pick up the printed ticket, an observer would slowly turn his attention away from the kiosk and companion and take the initial step away from the kiosk. The vast majority of users would leave the kiosk and proceed forward towards the theater screens and/or concession located directly behind the kiosks. Rare occasions revealed that some users would turn around and head back out with their backs towards the kiosk. This was only observed only in light traffic conditions.

As drivers completed their transactions on the photo-developing kiosk, a common practice before leaving was to take one step back whilst maintaining eye gaze with the display to re-verify that the process was indeed complete and successful. In several instances between the mall directory and movie theater kiosk, the fashion in which groups left was in a single file line until at least a couple (or so) steps had been put between the last member of the group and the display. At that point, the trailing member(s) would accelerate to quickly restore a should-to-shoulder arrangement as they initially held.

There was only one instance where a *lagger*, a user who is temporarily left behind his pack, was observed. In this case, consisting of a father and his young son, the boy quickly found the target on the mall directory map and gestured it to his father. He immediately turned and began walking away while the father still remained focused on the display for an additional five-six seconds before leaving.

INTER-GROUP BEHAVIOURS

Multi-Group Positioning

In our observations, we saw variations in behavior influenced by different amounts of traffic. Apart from it forcing people closer together (e.g. morphing Figure 5a to c), it seemed the likelihood of an observer role rotating into a wanderer decreased as traffic density increased (inverse relation). If traffic was very low such that adjacent kiosks are vacant, two photo-developing cases showed that observers would leave the driver temporarily to engage other kiosks. In one example, a woman left her husband to experiment with an idea on another kiosk. She returned to her original position after about three minutes of "playing around". The idea demonstrated here is how groups would submit to resource constraints.

When adjacent kiosks were occupied (a crowded environment), groups were forced to squeeze together. Rather than pairs being forced next to each other, the less-driven user typically preferred taking stance just behind the other, peering over their shoulder (typically the right) – Figure 5c. Groups of three simply accepted squeezing tightly together: they did not have an alternate positioning when there was no crowd (Figure 6).

The mall directory's large size provided rich insight into multi-group dynamics. An observation worth strong emphasis is the effect multi-groups had on distance (depth from display). As Figure 8 indicates, groups of any observed size (particularly of one), would take position at slightly different distances from the display. Specifically, the joining group would stand slightly further back. They would not stand closer, both out of respect and to not risk occluding their view, nor beside as to not violate personal space. This follows from anthropological studies in personal spaces [4]. This is a critical observation if group identification is the goal of a technology. This, in conjunction with orientation and facial cues, could together create very reliable group identifiers. Young children were an exception. On one ac-

count, a young girl ran to the display and took a stance right next to an existing couple already at the display. This could easily be misinterpreted as the girl being related to the couple when in reality her parents were casually catching up to her a few meters away.

Technical Support

There were two instances with the photo-developing kiosk where progress was blocked and assistance was required. In the first example, a couple of older women had been using the kiosks without any problems for roughly 15 minutes before hitting a roadblock. The confused driver seemed frustrated and wandered for approximately five seconds before returning to the kiosk. Although there was another group adjacent to them, the driver requested that the active observer seek assistance from an employee at the establishment. The employee took the place of the observer and the three of them formed the triangle pattern in Figure 6a. In another scenario, a single user became blocked early into her session. A neighbouring group of three all turned their attention to assist the older women in using the scanner at the kiosk, playing the role of tech support. This disturbed their initial layout in Figure 6b as they turned to face the troubled user. Once resolved, the helpers very briefly assembled into a layout shown in Figure 6a before restoring their original layout (Figure 6b) and continuing.

Morphing

In the multi-group situations encountered at the mall directory, departures of one group would affect the rest. The parting of one group would result in a (slight) reshuffling of the other(s) such that territoriality was redistributed fairly. The adjustments were minor one-step relocations: sufficient for a screen of this size. Most of the multi-group interactions seen consisted of two groups. One exiting would leave the other group alone to immediately shift closer (if initially arrived second, resulting in standing further back) and to the center as if they had just approached a vacant display.

DISCUSSION

Design Implications

The observations recorded and presented in this paper have led us to compile a short list of some design implications. Below are some things that designers of public vertical surfaces should consider.

Dynamic Territoriality. Users in groups may approach displays asynchronously. The longer and more complex the task, the more likely wandering and a delayed approach would occur (i.e. member(s) of a group joining well into the interaction). These delays can range from a couple seconds to several minutes, depending on the task. It would be required that any virtual workspaces on large-screen displays be dynamically sized if collaboration is to be supported. This would also address wandering behaviours.

An asymmetric group layout (Figure 6c,f,g) was a good indicator that one or more members of a group were unengaged with the display task. As an unengaged group member gradually became more engaged, we noted transitions in their layout in front of the display; an indication that intra-group parallel interaction was about to increase. If space allocation on large screens was dynamic, then changing orientations of groups could fluidly be supported. As more members focus on the display, more space could be allocated.

Inter-group behaviours also motivate the potential benefits of dynamic territoriality. At small screen kiosk, groups approach a free kiosk even if another group is infringing on the space in front of the free kiosk. Stepping up to a free kiosk asserts territoriality, and the group that was infringing on the workspace around the free kiosk naturally reorients themselves, both by compressing together and by repositioning members close to the free kiosk. This tacit negotiation or territory between groups was, however, poorly supported by the mall directory. When a second group approached the mall directory, there was no indication of their presence, so no space was made for concurrent use. Instead, later arrivals would wait until the current group moved before approaching the display.

Based on this tacit negation of territory, territory could be used to promote concurrent use by un-related groups. If displays were made aware of their environments, i.e. displays could recognize prospective moving from the implicit to subtle zones of interaction [15], and then the display could signal groups of users in the personal zone of interaction by shrinking and/or repositioning territory. This would support the natural dispersions and compressions that occur as additional groups arrive at shared screens. It seems reasonable to consider territory a resource that can be used to maximize concurrent use by and between groups.

Suspension versus Termination. An interesting result we observed was that of suspended interaction. In our observations, we noted that inter-group communication happened when a group went to assist another group struggling with a display. As a result, it would be presumptuous to mark the conclusion of a group's interaction solely based on a physical departure for a large-screen display. A method of censoring the display's contents would be advisable in the case of suspended interaction. Furthermore, if the system could recognize when users are interacting with other groups around the kiosk and may return and resume versus when users have left the kiosk entirely, this would allow elegant discrimination between situations where suspension versus termination of groups' sessions was most appropriate.

Group Identification. It was generally a trivial task to identify a group of two; however, as group size increased, the number of variations of approach quickly grew and made this task very unpredictable. In fact, with delayed approaches becoming introduced with groups of three on more complex tasks, group size is a very dynamic variable and must be accounted for continuously throughout the interaction phase.

Distinct social groups tend to position themselves at different depths from large-screen ambient displays to avoid intruding on personal spaces. This, in conjunction with orientation of members and facial cues may be used for group identification. This study cautions against the use of facial cues and eye contact alone to infer groups. While its existence can assist in group identification, its absence, which was repeatedly seen, does not imply unfamiliarity between members.

Pointing versus Touching. There is a semantic, profound difference between pointing and touching. Users who point are communicating ideas within a social group and may not want the technology to treat it as input. This is more of a cautionary note for hover detection.

Fragmentation and Recombination of Groups. It was immediately obvious that users, even within a social group, preferred to maintain a certain amount of buffer zone between each other. This was evident from the layouts in Figure 6c-e which occupied the largest surface areas and was exclusive to the large-screen mall display. The study showed that territoriality can be influenced by the system itself – to a small degree. Compression in the size of the screen real-estate would result in group members squeezing together; however, with the caveat that there was clearly a sensitive threshold where if the compactness of users became too demanding to maintain, wandering of group members can result. This study also showed that as tasks became more complex and real-estate was available (in the form of a vacant kiosk), individuals would break away from the group's work and explore independently. Because group members occasionally break away, interact alone, and return, shared public screens should be designed to support this fragmented collaborative style.

CONCLUSION

This paper organized detailed observations of users' sessions whilst engaging with both large- and small-screen public displays (digital and non-digital). We emphasized reoccurring patterns as well as unusual use cases so future designs of such technologies can consider and address them. User orientations, layout and movements were documented to help better understand natural social and human behaviour around these displays. Furthermore, issues concerning group dynamics such as group identification, mutual interactions, territoriality and practiced etiquette were identified.

To complete the study, basic design guidelines and principles were outlined that will assist in the designs of future public vertical surface technologies.

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