Conveying Interactivity at an Interactive Public Information Display

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ABSTRACT

Successfully conveying the interactivity of a Public Information Display (PID) can be the difference between a display that is used or not used by its audience. In this paper, we present an interactive PID called 'Cruiser Ribbon' that targets pedestrian traffic. We outline our interactive PID installation, the visual cues used to alert people of the display's interactivity, the interaction mechanisms with which people can interact with the display, and our approach to presenting rich content that is hierarchical in nature and thus navigable along multiple dimensions. This is followed by a field study on the effectiveness of different mechanisms to convey display interactivity.

Results from this work show that users are significantly more likely to notice an interactive display when a dynamic skeletal representation of the user is combined with a visual spotlight effect (+8% more users) or a follow-me effect (+7% more users), compared to just the dynamic skeletal representation. Observation also suggests that - at least for interactive PIDs - the dynamic skeletal representation may be distracting users away from interacting with a display's actual content, and that individual interactivity cues are affected by group size.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*Graphical user interfaces, input devices and strategies, interaction styles, screen design, user-centered design.*

General Terms

Design, Experimentation, Human Factors.

Keywords

Interactive public information displays, interactivity cues, gestural interaction, user centered design and user studies, pervasive computing.

1. INTRODUCTION

A commonly encountered challenge for interactive PIDs is that their passers-by are unaware of their interactive capabilities, which usually leads to such displays being largely unused [7]. This challenge is magnified by the historic nature of public displays, which have traditionally taken the form of static billboards that provide no interactive capabilities and quite often have no relevance to the user. Milgram [10] shows how information overload leads to the need for users to become highly selective in the information that they consume, and Müller et al. [13] explore this concept further using the term 'display blindness', which they define as occurring when users who expect uninteresting display content ignore the display entirely.

Interactive PIDs need to overcome a number of challenges in order to be used successfully. They need to alert users of their presence, and of their interactive capabilities. They need to entice users to actually engage with them; they need to convey to users how to interact with them; and finally, they need to fulfil whatever purpose it is for which they were deployed in the first place. For PIDs, this purpose is commonly the comprehension of content, such as a timetable of flight departures in an airport [14], or a listing of events at a theatre.

In this paper, we present the interactive PID installation that we have recently deployed within an Australian University. One contribution of this work is the user interface (UI), which we have designed to present rich content that is hierarchical in nature, and thus representative of a very wide range of applications from simple slideshows to complex navigable datasets. Accompanying the UI, we also describe the gestural interaction mechanisms that we have implemented and the interactivity cues we employ to alert passers-by of the PID's interactive capabilities. This is followed with a field study based on a total of 2,312 skeletal arrivals that were detected by the installation throughout the testing period.

2. RELATED WORK

Müller et al. [11] outline how the vast majority of displays are still not interactive. Alt et al. [1] further outline how real-world experiments in public display research are rare, due to the lack of coherent theories that exist for public displays, and also due to the high cost and time consuming nature of real-world experiment setups with public displays.

This section outlines some of the past work that has been conducted on interactive PIDs and the studies on conveying the interactivity of such systems to their end users.

2.1 Interactive PIDs

Public displays and digital signage in general have been used in many different application contexts including public information (e.g. showing news, weather, or flight information [14]), entertainment [3], advertising [17, 12], and even architecture [5]. Some of these works have also incorporated the notion of interactivity into their design. Some, such as [8, 15] are based on touch interaction, while other work has focused on vision and gestural-based interaction, such as the Proxemic Peddler [17] and Looking Glass [12].

Public Information Displays (PIDs) differ from other types of public display in that their purpose is to provide (often location-specific) information to their public users. Also in contrast to other public displays - which may have as their objective to increase sales of a particular product - the objective of PIDs is to convey relevant information to their users. This requires not only that users actively engage with the display, but also that they depart from the display more knowledgeable about a particular topic than when they arrived. It is this fusion of PIDs and interactivity that our work centres on.

2.2 Studies into conveying public display interactivity

In [9, 11], the concept of an 'audience funnel' is introduced. This is essentially an interaction paradigm for gesture-based public display systems that describes the phases of a user passing by a public display. The phases are outlined to be: 1. passing by; 2. viewing and reacting; 3. subtle interaction; 4. direct interaction; 5. multiple interactions; and 6. follow-up actions. Müller et al. [12] further outline how little is known about understanding the interactivity of interactive public displays, and in particular the important task of conveying public display interactivity across to passers-by. This process of conveying interactivity is particularly important to phase 2 of the audience funnel, i.e. the point that a user views and reacts to the display.

The study in this paper extends on the work outlined in the Looking Glass project [12], in which the effectiveness on noticing display interactivity was studied for four separate conditions, namely that of: a mirror image of the user, a silhouette of the user, a 2D avatar, and an abstract representation of the user. That project found that the mirrored user silhouettes and images were more effective than avatar-like representations in conveying display interactivity (in terms of both time and accuracy). The work also showed that significantly more passers-by interacted when immediately shown the mirrored user image or silhouette compared to a traditional attract sequence with visual call-to-action such as a banner with the text 'Step Close to Play' [12]. Interestingly, it was also outlined how image representations were disliked by some passers-by because of the lack of anonymity and dislike of being observed by cameras, and concluded that systems could - for the purpose of effectively conveying interactivity - use a dynamic array of point lights (e.g. skeletal joints) to represent passers-by.

In the study described in Section 4, we extend the results of the Looking Glass project to show how the use of a dynamic array of point lights (i.e. skeletal joints) can be combined with additional visual effects to further improve the ability for a display to convey its interactivity. In particular, we show how both a 'follow-me' and 'spotlight' condition significantly increase the percentage of users who faced the display when passing through the interactive PID's Field Of View (FOV).

3. CRUISER RIBBON: AN INTERACTIVE PID FOR PEDESTRIAN TRAFFIC

Very little past research has focussed on gestural-based interfaces to navigate hierarchical datasets in large public display environments in which the users are not already familiar with the content dataset. This is the application context for our interactive PID, which is described below.

3.1 A ribbon model for browsing hierarchical content datasets

3.1.1 Hardware

The interactive PID installation described in this paper has been deployed and tested in a number of locations within the University, both inside of buildings (in two separate building foyers) and outside of buildings (i.e. on the outside wall of a building, as shown in Figure 1A). The I/O hardware components of the installation (as seen by end users) include the high-intensity projectors, projection screen/rear projection film overlay, and the Microsoft Kinect sensor. In addition, the setup as shown in Figure 1A also has a dedicated control room nearby, in which the display's current content is shown in addition to the depth, infra-red, and camera streams from the Kinect sensor. This allows for the logging and later analysis of captured screenshots and depth images simultaneously.

3.1.2 UI design and content creation

As shown in Figure 2, the main visual UI element of the interactive PID is the 'media ribbon', in which boxes representing media items are presented horizontally across the screen. The media items can be images or video clips, and these are intended to promote knowledge about a particular content dataset. The content datasets are created via a separately developed web application called Curator [16], and the underlying software framework for the interactive PID installation is based on the Cruiser platform [2]. This platform was originally developed for tabletop applications, but has since been extended to cater to surface computing applications in general. As shown in Figure 1B, the Curator web application acts as a Content Management System for the platform, and it is with this software that hierarchical content datasets (i.e. content that is contained within nested containers, similar to folders in a typical desktop interaction paradigm; see also [4]) can be developed from a desktop web-browser and then exported in a format suited to tabletop and/or interactive PID devices.

Figure 1B also shows the hierarchical list of datasets that can currently be viewed and interacted with on a display. Depending on the display's intended purpose and situational context, one or more of these datasets can be loaded onto the display at the same time. Media items in the 'Cruiser Ribbon' platform wrap around in an endless loop, meaning that when the last item in the ribbon is reached, the ribbon continues with the first item. Figure 2 also shows a number of other visual elements on the display, namely the upper hierarchical level of content (see the smaller images at the top of Figure 2B) and the visual interaction cues that alert the user of the available gestural interactions that the display

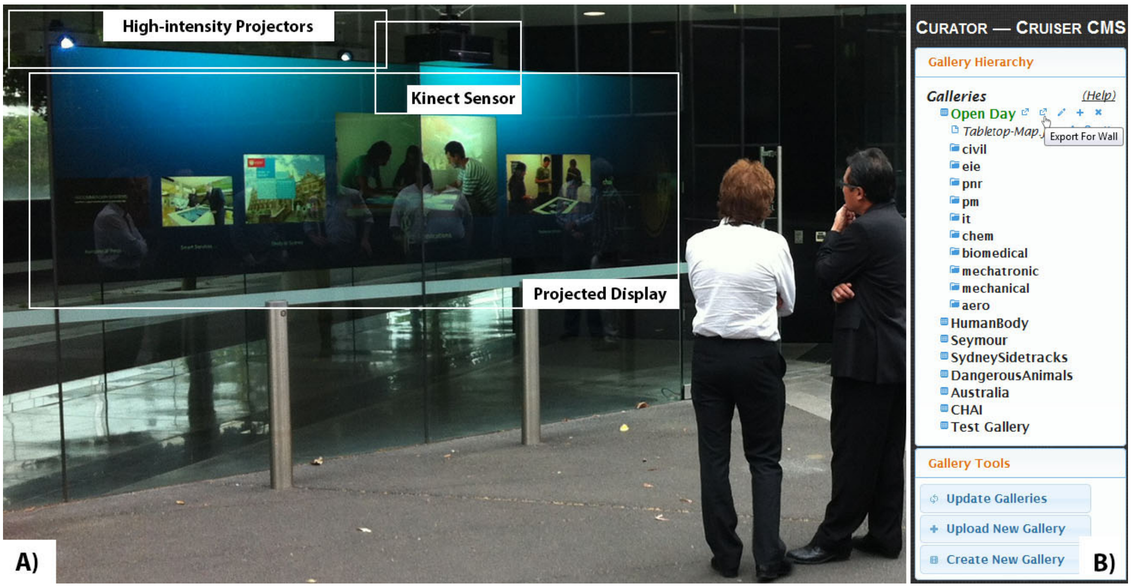

Figure 1: One of the Ribbon interactive PID installations at the University (A) and a range of content datasets that can be loaded onto the display (B).

can recognise (see the icons at the bottom of each of the Figure 2 images).

3.2 Gestural interactions with the interactive PID

Passers-by can interact with the display by entering into the Kinect sensor's field of view (i.e. 43 degrees vertical and 57 degrees horizontal) and range (i.e. ∽ 50cm to 5m) and then performing simple gestures to navigate and browse the content. A number of gestural interaction paradigms were researched as part of prior work (i.e. direct and indirect cursor control; device-based pointing; and finger, hand, and body gestures) [6], and based on that research, we chose to implement a small set of four upper body gestures, each with high postural disparity from the other gestures to ensure high reliability and recognition rates. In particular, the implemented gestures to navigate the content datasets include a 'left', 'right', 'more', and 'back' gesture (see also the icons in Figure 2). These gestures allow a user to navigate 'left' and 'right', and also to delve into and out of a particular level of the content with the 'more' and 'back' gestures. Successful recognition of a particular gesture by the system is indicated back to the user in the form of the visual gesture icons changing colour. To differentiate between those items that do and do not lead to 'more' content, a small 'i' symbol is overlayed over certain media items.

Similar to the results described in past work [7], observations with our platform showed a distinct lack of users actually approaching the display to actively engage with the display and its content. This the focus of the study outlined in the next section.

4. A STUDY ON CONVEYING PID INTERACTIVITY

Past work on conveying public display interactivity [12] has found that user silhouettes are more effective than other types of user representation (like avatar and abstract representations) in conveying display interactivity, with users being able to more quickly (i.e. in 1.2 seconds) and more accurately (with a 97.5% success rate) notice interactivity when passing by a display. That work also showed that significantly more passers-by interacted when immediately shown their silhouette compared to a more traditional form of attract sequence with visual call-to-action.

Observations with our platform have shown that there is still much room for improvement in conveying display interactivity and transitioning this into increased user interaction. This is particularly important for interactive PIDs in which the goal is to inform the user on a (possibly complex) topic, rather than - for example - just showing them an advertisement or increasing advertisement click-through rates. In other words, whereas some public displays - like those that serve digital advertisements - can often be successful in providing their users with only the most simple of messages, interactive PIDs open the potential for a focus on more complicated communications and can contain hierarchical content that is not immediately visible to the user, thus making it very important to effectively convey their interactive capabilities.

The goal of this study is to show how a user's dynamic skeletal representation can be combined with different interactivity cues to further improve the ability for a display to convey its interactivity. In particular, we show how both a 'follow-me' and a 'spotlight' condition (when combined with the skeletal representation) significantly increase the percentage of users that face the display when passing by the interactive PID's field of view.

4.1 Study design

This study was conducted during the annual University Open Day, in which prospective students and their families come to the University to explore the campus and learn about the courses on offer. The day includes mini lectures, faculty information stalls, career advice, live events, and

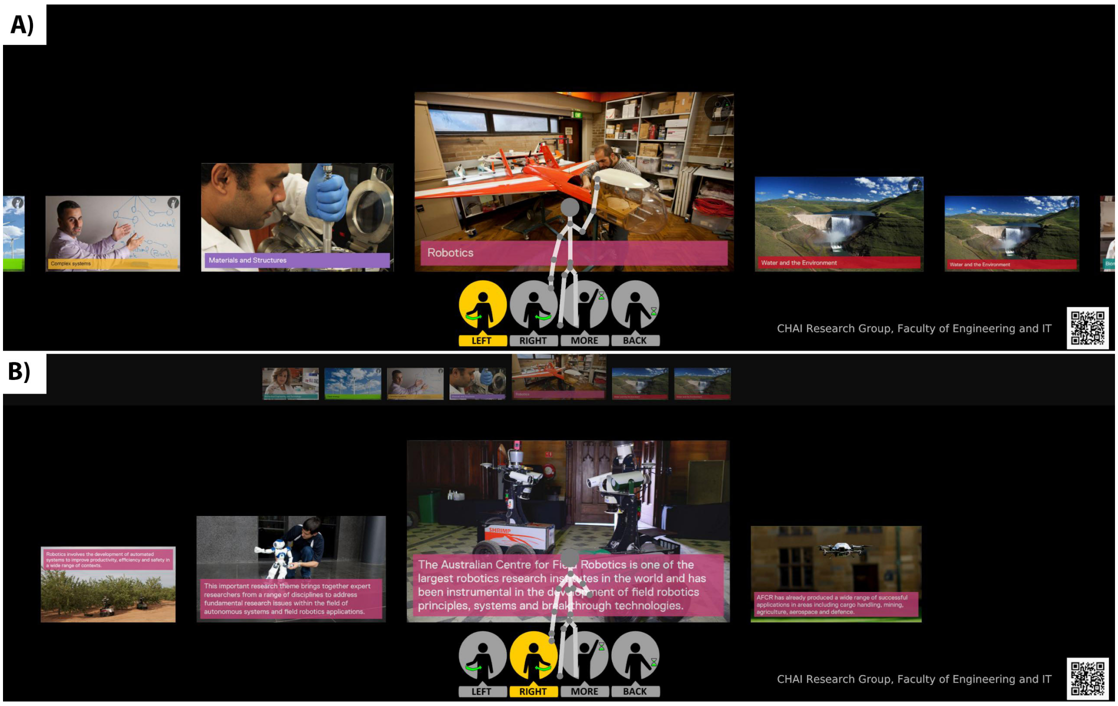

Figure 2: The ribbon interface showing two levels of hierarchical content, with A) representing a higher level and B) representing a lower level of content.

tours. Many interesting exhibits are also displayed, including our interactive PID, which was configured to display content on the different research themes that our faculty specialises in.

As suggested in [1], we decided on conducting the experimental study as a field study, as these typically have high ecological validity compared to lab studies. In addition to the logs that were captured by the system, we also collected a total of eight questionnaires (two per condition). These questionnaires were designed to complement the system logs with qualitative data. We further observed people interacting with the screen, and one researcher was present throughout the testing period, recording observations into a logbook.

The location of the interactive PID was that of a large internal building corridor that also served as a foyer for a number of lecture theatres that held mini lectures throughout the day, and thus provided a steady flow of pedestrian traffic throughout the four separate testing periods. Similar to Figure 1, the hardware deployment for this study was based on a rear-projection of the user interface onto a glass wall, with a tripod-mounted Kinect sensor located at the glass wall at waist height.

During the course of the day, the public display was configured to test three different interactivity cue conditions, with an additional condition making up the control. These conditions each ran for one hour, over which time log data was gathered by the system for a total of 2,312 skeletal arrivals. These results focus on noticing interactivity (i.e. phase 2 of the 'audience funnel' interaction paradigm for public displays). The control condition simply showed the dynamic skeletal representation when users entered the FOV of the interactive display, as well as three simple cue videos to illustrate the gestures left, more, and right (see Figure 3A). Similar to the control condition, each of the other three conditions also triggered only once a user entered the FOV of the interactive display. Before this point, the display showed the media ribbon, its encompassed media items, and the visual gestural cues. The three conditions are described below, and are also illustrated in Figure 3:

- **Spotlight**: The spotlight condition added a tapered column halo effect to the lead skeleton upon discovery.
- **Follow-me**: Follow-me added left and right continuous movements to the media ribbon, such that the media ribbon items would follow the path of the closest detected skeleton while nobody was directly facing the display.
- **Welcome**: Welcome added a full-screen welcome image, which needed to be dismissed with one of the system's recognisable gestures before the ribbon could be used. Like the other conditions, the welcome screen was only shown to users upon detection of a skeleton, prior to which the media ribbon was shown.

4.2 Study results

Interaction logs from this study[1] captured a total of 2,312 skeletal arrivals. 511 (22.1%) of these were detected as having faced the display for at least one second, and a further 119 of those facing the display (23.3%) performed at least one gesture during the period for which they were tracked by the system. The act of 'facing' the display was calculated based on the coordinates returned by the skeletal tracker

[1] This study was approved by Sydney University's Human Resources Executive Committee under Protocol No: 13989.

Figure 3: The four test conditions in this study: Control (A), Spotlight (B), Follow-me (C), and Welcome (D).

for the left, centre, and right shoulder joints as well as the skeletal head.

Table 1 shows the division of users who faced and interacted with the display under each of the tested conditions. The population sizes detected by the system across the four different conditions ranged from 446 users in the control condition to 842 users in the welcome condition.

Condition	Skeletal Arrivals	Facing Display	Interaction
Control	446	78 (17%)	18 (23%)
Spotlight	532	134 (25%)	44 (32%)
Follow-me	492	121 (24%)	33 (27%)
Welcome	842	178 (21%)	24 (13%)

Table 1: Tabulation of users that faced and interacted with the interactive PID during the experimental study.

Non-parametric Chi-square tests were used to evaluate the significance of those users that faced the display under the different conditions. Results show that users of the spotlight condition were significantly more likely to face the display than those in the control condition, $Chi^2(1,N=978)=8.471$, $p=0.004$. Similarly, users of the follow-me condition were also significantly more likely to face the display than those in the control condition, $Chi^2(1,N=938)=7.065$, $p=0.008$. The welcome condition was however not significantly different to the control condition, $Chi^2(1,N=1288)=2.441$, $p=0.118$, and no significant differences were shown for the conditions spotlight versus follow-me, spotlight versus welcome, and follow-me versus welcome. Analysis of the interaction results show that there were no significant differences in interaction between the control and the other conditions, meaning that the increase in users facing the display did not equate to a significant increase in users interacting with the display. Increasing user interaction with interactive PIDs is left as future work.

4.3 Discussion

Our observations and questionnaires reinforced the results reported in the log files. In particular, the spotlight condition was observed to perform the best out of the three conditions, with this interactivity cue attracting the attention of detected users and particularly those who were casually looking at the display at the time of skeletal acquisition.

Groups of passers-by affected the three conditions differently to single passers-by, and the skeletal tracker did at times report false-negatives when larger groups of people passed-by and interacted with the display (though this limitation was constant throughout all four of the test conditions). Our observations found that the follow-me condition was not particularly effective for groups, with experimenter observations recording that users found it difficult to determine the cause of the movement when many people were around. The welcome screen also performed poorly for groups of passers-by; this was primarily due to all but the first in a group being able to observe the change from the ribbon to the welcome screen, with the rest thus not realising that the welcome screen was a reaction to their presence. Additionally, users in a group did not seem to realise that the welcome screen was occluding the ribbon (possibly because they had not seen it pop up) and therefore may not have understood the actual purpose of the interactive PID under this condition.

Another unexpected finding of this study is that although many users interacted with the display and their skeletal representation, it is likely that only a much smaller set of users actually interacted with the *content* provided by the display. Based on our observations, we thus hypothesise that in addition to noticing a display and interacting with a display, it will be important - particularly for interactive

PIDs - to determine in future work whether the user is interacting with the representation of themselves shown on the display or with the actual content that the display is providing to them, i.e. is the dynamic skeletal representation a distraction to the user? and if so, what can be undertaken to minimise this effect on interactive PID installations.

5. CONCLUSIONS

This paper has presented an interactive public information display that has been designed, tested, and deployed within an Australian University. It has described the platform's rich user-interface that is capable of presenting simple to complex hierarchical content datasets to end users, and the gestural interface with which users can navigate and browse hierarchical content on the display. This paper also presented results from a study based on 2,312 skeletal detections, in which it was shown that users are significantly more likely to notice an interactive display when a dynamic skeletal representation is combined with a visual spotlight effect (+8% more users) or a follow-me effect (+7% more users), compared to just the dynamic skeletal representation as has been used in past studies.

This paper has also provided discussion on how interactivity cues are affected differently in busy spaces and by groups of people compared to single users: the spotlight cue was robust to such conditions, whereas the follow-me and welcome cues were less robust. This work also suggests a future avenue for research into whether the dynamic skeletal representations that have previously been shown to be so effective at conveying interactivity, also distract users from the display's actual information-providing purpose.

6. ACKNOWLEDGMENTS

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