Towards Adaptive Height-Aware Public Interactive Displays

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ABSTRACT

Public interactive displays (PIDs) are becoming more pervasive in urban environments as a means to engage passers-by and to provide interactive features such as wayfinding. However, one of the problems with current PIDs is that they are typically designed around an average specification, potentially excluding a large range of users that for instance might not be able to reach interactive elements. To address this challenge, we propose a number of design concepts for adjusting PIDs to users of different heights. We present a preliminary evaluation of our concepts through a cognitive walk-through study with 10 design experts using a custom-developed experience prototype featuring four height-aware modes. Based on qualitative feedback and observations we discuss design suggestions for future work.

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1 INTRODUCTION

The presence of public displays in urban environments has seen a sharp increase over the past 10 years due to falling display technology costs, their immediate benefits for the advertising industry, and the ability to display information in real-time [6]. At the same time, the rise of public displays has prompted a large body of research on the design and evaluation of interaction techniques for public displays (e.g. [4, 8, 13]) and communicating their interactivity to passers-by (e.g. [5, 12]). Public displays with interactive features, referred to in this paper as public interactive displays (PIDs), can also be increasingly found in public spaces, ranging from shopping centres and train stations to city squares.

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One of the main problems that exist with public displays is that they are often ignored and fade into the background. To potentially resolve this problem, public displays are recommended to be positioned at eye-level [6]. However, 'eye-level' is a subjective specification as potential public display users may have different heights. For example, the appropriate eye-level for a young child would be lower than for their parents and the eye-level for a person in a wheelchair would be lower than for most other users. This issue becomes even more critical when deploying public displays with interactive features, as generalising the definition of 'eye-level' by for example using the average height of users may potentially make using PIDs difficult or impossible for people who fall outside this average specification [13]. In Australia, the digital signage industry is self-regulated, with organisations like the Outdoor Media Association (OMA) specifying guidelines concerning brightness and viewing distance of displays [2]. In the US, the standards fall under the 'Americans with Disabilities' Act [7], which defines interaction design parameters such as the minimum and maximum reaching distance.

Some commercial PIDs address this challenge by supporting manual adjustments to their interface. For example, an interactive directory display located in a shopping centre in Sydney, allows users to adjust the height of the on-screen elements through an 'adjust height' button. The feature removes advertisements displayed in the lower area of the screen enabling other on-screen elements to move down (Figure 1). This solution allows users to change the height of interactive elements, but is limited to only one pre-set height and requires users to explicitly activate the feature. In this paper, we present four design concepts of height-aware modes for PIDs that implicitly adjust their height to personalise their interface based on a user's height. The paper contributes to the field of PID research through an evaluation of our height-aware modes, yielding a better understanding for how PIDs can be designed so that their interface can be personalised according to the height of their users.

2 HEIGHT-AWARE DISPLAY PROTOTYPE

We designed a semi-functional PID prototype allowing people to take self-portraits ('selfies'). This functionality can be found in public display applications and kiosks in cities and at airports around

Figure 1: A public interactive display deployed in a shopping centre, allowing for height adjustment through a dedicated on-screen button.

the world and was chosen as it therefore represents a realistic scenario and for its simplicity. The prototype consisted of a 50-inch touch screen in portrait orientation, a Mac Mini running the display application and a web camera for taking selfies, housed in a custom-made stand. We used a touch-based display to mirror the current standard of commercially deployed PIDs. The height-aware modes were designed to augment the PID, making it aware of a user's height. The PID prototype was able to respond to a user's height using four different modes: (1) Touch; (2) Proximity; (3) Height Sensing; (4) Reaching. The selfie application was created in HTML and JavaScript for rapid development.

2.1 Touch

Adapting the height of on-screen elements can be achieved without any external cameras by detecting the position of where the user touched. This mode required participants to walk up to the display and touch the screen for it to proceed to the selfie taking page (Figure 2a). The selfie taking window on the second page would then be implicitly displayed at the same height as where the initial touch occurred (Figure 3), enabling people of different heights to reach the button. In case of an accidental touch in the wrong position, the selfie taking window's position can be adjusted manually afterwards by tapping on a blank space in the screen.

2.2 Proximity

Proximity (Figure 2b) has been explored in previous research as a way for information stored on an on-body sensor, such as a mobile device [4, 8] or RFID card [9], to be read by a public display system to automatically adapt its content. In our study, we used a dummy RFID card as a way to store the user's approximate height which can be read by the display. The scenario used in the cognitive walk-through study imagined the display having long-range sensors, allowing the feature to work without the user having to take the card out of their pockets. The functionality was simulated in the experience prototype through a study facilitator pressing a keyboard button as the user approached, which triggered the transition to the second screen with the selfie taking window positioned at the user's eye level.

2.3 Height Sensing

The height sensing mode imagined the use of an on-display sensor, such as a Microsoft Kinect depth camera, to determine the user's height as they approach and to automatically adjust the interface accordingly. The experience prototype featured a dummy Microsoft Kinect mounted on top of the display for visually conveying height detection capability in the cognitive walk-through scenario.

2.4 Reaching

The reaching mode (Figure 2c) provides assisted pointing functionality. As the user reaches for an interactive element, a digital mirror representation in the form of a silhouette appeares as an extension of themselves. The user can then activate elements by dwelling on them, akin to the gesture-based dwell interaction used in commercial Microsoft Kinect applications. This method has been previously used to reach elements on-screen [10] and to convey interactivity while at the same time supporting serious interactions [1]. As with the previous mode, a dummy Kinect sensor was used in our experience prototype to convey depth camera sensing capability to the user.

3 STUDY DESIGN

We evaluated our experience prototype featuring the four height-aware modes through a cognitive walk-through with 10 design experts (4 female and 6 male) between 24 and 50 years. Eight participants were UX designers and lecturers from our university; the other two participants worked as designers in the industry. Participants individually interacted with our prototype and were asked to follow the set task of taking a selfie using the four modes, which were counterbalanced across participants. Each mode was first completed standing, followed by sitting in a mock wheelchair to simulate a scenario where someone could not reach, such as wheelchair users or shorter adults. Participants were asked to think aloud while performing the task and all sessions were audio recorded. We interviewed the participant after each mode, asking them about their experience with that particular mode and whether they had any suggestions for improvements. We further conducted an exit interview with each participant asking them to compare each interaction mode and whether they had any further suggestions. The aim of the evaluation study was to collect feedback and insights from our expert participants in regards to the design of each mode, suggestions for improvements, and ideas for alternative modes.

4 RESULTS

After running the study we analysed the audio-recordings of each session and compiled the comments participants made about each height-aware mode. In this section, we discuss results from the study relative to the height-aware modes and additional ideas that were generated during the study.

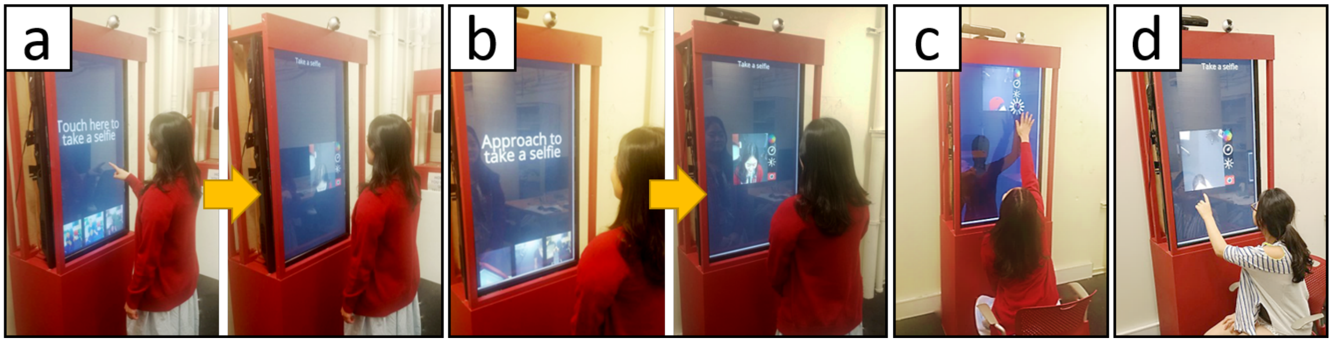

Figure 2: (a) Touch mode: Implicit height detection based on the position of touch input; (b) Proximity and Height Sensing modes: Implicit height detection through on-body (e.g. RFID) or on-display (e.g. Microsoft Kinect) sensors; (c) Reaching mode: A digital mirror representation is displayed to assist the user in activating elements out of their reach; (d) Interacting from the side for easier reaching.

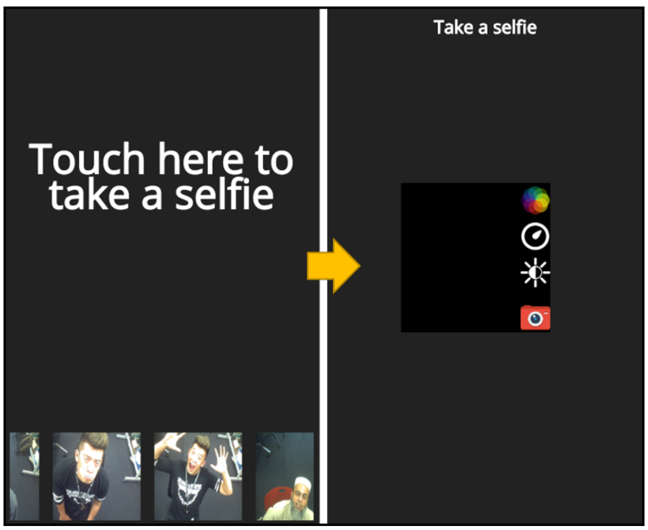

Figure 3: Touch mode: The selfie taking window's position on the y-axis is determined by the position of the user's initial touch in the previous screen.

4.1 Suggestions for Improving the Height-Aware Modes

Touch. Participants were observed to not understand that the selfie taking window moves with the touch position straight away, with one participant mentioning that there needs to be *"tap suggestions around the screen"* to help people realise the functionality. However, another participant mentioned that tapping may not be intuitive to most and that a more accessible interaction would be to *"have some type of magnetic effect to gravitate elements towards the touch point"*. Two other participants had the idea of touching and dragging the element for precise control over its position.

Height sensing. Participants appreciated the pervasiveness of this mode, with one describing it as giving them a *"welcoming feeling"*, which may also be appreciated by short adults, children, and wheelchair users as it *"does not make any physical adjustments"*. This links back to the problem of social embarrassment [3], where users are afraid of doing something wrong in front of others and being in the spotlight.

Proximity. Participants brought up privacy issues and barriers to entry that would potentially prevent people from interacting if this mode was implemented. In particular, the issue of storing specific information about someone, such as their disability, was considered by two participants as difficult for people to accept as it could raise privacy issues. Another participant mentioned that if the card had a purpose other than "*exclusively being utilised for a public screen*", such as height information stored on a driver's license or conference badge, then it may be fine. However, this interaction would be limited to only those with cards and therefore having an automated depth-camera or touch based height detection system would lower the barrier for interaction.

Reaching. Participants suggested that reaching should involve more visual cues indicating that it is an option, such as an on-screen Kinect skeleton, echoing findings from previous research [5]. An alternative suggestion, was for the silhouette to grow from the user's arm position on-screen, rather than a whole body silhouette. This would give more hints about how to perform this interaction and not block as much of the on-screen content from view.

One of the participants tried to reach from afar when they saw the Kinect, later stating that they were *"familiar with the Kinect and therefore expected that functionality"*. This may be resolved with more specific on-screen and physical cues, such as a sign on the ground indicating the location of where to stand.

4.2 Suggestions for Improving the Prototype in General

Physical relationship between display and user. While one of the participants was sitting in the mock wheelchair, they mentioned that it was hard to reach the screen at times, with one participant stating "*imagine if I have paralysis and I need to bend over to reach this*". Another participant managed to find an easier way around reaching by using the display from the side while sitting in the chair so they could get closer (Figure 2d). However, this made taking selfies difficult as it took time to get into position.

Another suggestion was to have the screen physically move up and down based on someone's height or ability. However, one participant highlighted this could cause potential social issues by drawing attention to a user's physical limitations, therefore embarrassing the user and making them feel like they are "*bothering others*". The participant further suggested that on-screen adjustments are better as it *"gives a welcoming feeling that works the same for everyone else"*.

Conveying accessibility. Being specific is important when trying to convey that a screen is interactive. All participants had trouble understanding what '*Approach to take a selfie*' meant, with some assuming they could interact from a distance and one participant stating that "*for someone familiar with mid-air gestures I might not know I need to touch*", as the height sensing mode still required touch interaction to take a selfie. Therefore, mixing of interaction modes may be confusing if not explained adequately. A potential solution could be to change the message based on proximity, beckoning interactions.

For the height sensing and reaching modes, participants mentioned that a marker on the ground informing people of how far they need to approach would be useful. An approach also commonly found in other public gesture-based installations [11]. The screen should also react according to proximity to convey interactivity. This could be in the form of already detecting the height of a passer-by and bringing the interface to their eye level. One participant particularly mentioned that combining the height sensing with the touch would enable implicit interaction in the form of automatically detecting height, so people immediately understand the display is adaptive, with a familiar explicit touch interaction.

4.3 Limitations and challenges

Selfie taking. As the camera was placed on top of the display, every participant mentioned that users would need to look up and away from the feed which makes it difficult to be in a desired pose. Three participants explicitly mentioned that this issue is common with laptops and web-cams because the feed is far from the camera. However, according to one participant this issue is less prevalent with smart-phone selfies, "*the camera is close enough to the screen so I can see my face and my eyes don't move too much*".

One participant mentioned that it is not as simple as making the camera low enough because when someone taller than the camera's position takes a selfie it can create a double chin effect, as described by another participant "*People are very conscious about double chins, which is why they normally hold selfie sticks up high*".

Making the screen smaller could be argued as a solution to this issue, however this limits the amount of screen real-estate and may create a height issue where the screen placement is either too high or low. Therefore, an adjustable solution may be necessary.

Outdoor use of computer vision. As public displays are commonly deployed outdoors, it is important that natural elements do not affect its functionality. However, participants raised the problem of Kinect's outdoor limitations, as it uses an infra-red camera for depth sensing and therefore its tracking would be affected by sunlight. Blob tracking with a normal camera was suggested as a more robust option.

5 DISCUSSION AND CONCLUSION

We presented an evaluation of a height-aware PID experience prototype and reported on the feedback and ideas generated during a cognitive walk-through study with 10 design experts. Based on the findings from the study, we derived accessible design suggestions for public displays.

Our study uncovered some of the complexities and challenges in terms user experience and usability when designing PIDs that can be personalised according to the height of their users. The adjustments on the display should be subtle and empower the user without impacting on others, otherwise there is potential for social embarrassment. Current commercial solutions simply offer an on-screen button that moves the content up or down. In this paper we have suggested alternative height-aware modes that cater for a wider range of physical differences in users and support implicit height personalisation.

Ultimately, future work would be needed to test the identified solutions with a broader range of participants of different heights.

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