
Tackling Challenges of Interactive Public Displays using Gaze

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Abstract

Falling hardware prices led to a widespread use of public displays. Common interaction techniques for such displays currently include touch, mid-air, or smartphone-based interaction. While these techniques are well understood from a technical perspective, several remaining challenges hinder the uptake of interactive displays among passersby. In this paper we propose addressing major public display challenges through gaze as a novel interaction modality. We discuss why gaze-based interaction can tackle these challenges effectively and discuss how solutions can be technically realized. Furthermore, we summarize state-of-the-art eye tracking techniques that show particular promise in the area of public displays.

Author Keywords

Gaze; gaze-based interaction; public displays; pervasive displays; digital signage

Introduction

Public displays have become ubiquitous in public spaces, such as shopping malls or transit areas in airports and train stations. Equipped with an increasing number of sensors, their interactive capabilities promise informative, entertaining and engaging applications that provide tangible benefits to users. Such sensors include, for example, touch screens, cameras, and depth sensors, thereby enabling interaction

based on touch, mid-air gestures, smartphones, and recently also gaze. Nevertheless, the uptake of interactive public displays has been slowed due to many challenges.

This work suggests using gaze to tackle core challenges of display interaction. Gaze-based interaction has numerous advantages: gaze is intuitive [21], natural to use [22], indicates visual attention and usually precedes action [13].

Eye Tracking Techniques for Public Displays

Classical eye tracking techniques require performing time-consuming and cumbersome calibration [13]. This prerequisite has slowed the adoption of gaze for public displays. Previous work overcame this by estimating gaze with low accuracy based on head tracking and face detection [5].

More sophisticated calibration-free eye tracking methods, that show promise in the domain of public displays, were recently introduced. Examples include the work by Zhang et al. [23] that relies on relative eye-movements (e.g. distance between the pupil and eye corner). Vidal et al. [22] proposed leveraging the smooth pursuit eye movement to enable spontaneous gaze-based interaction. Pursuits has been evaluated on a public display and was shown to be well-perceived by passersby [11]. The method has also been used for flexible calibration [18]. Nagamatsu et al. [17] enabled calibration-free eye tracking using a sophisticated hardware setup (2 cameras and 8 LEDs).

With our work we aim to identify which of the techniques are suitable for particular applications and situations.

Addressing PD challenges using Gaze

Gaze can be used both implicitly and explicitly to enhance the user experience with public displays. By looking into existing work, six main challenges that hinder the uptake of interactive public displays have been identified, in this

section we shed light on why and how gaze can be superior over existing techniques in addressing these challenges.

Detecting the user's attention

Attracting and detecting the user's attention are core challenges at the outset of the interaction process with public displays [7]. Previous work presented readily interactive displays and tried to attract the passersby's attention using physical objects [10] or user representations such as mirrored silhouettes [16]. Although inferring "attention" to a display is complicated, the passerby's gaze indicates overt visual attention and in many cases precedes action [13]. Recent research used wearable eye trackers to detect visual attention to displays [6]. Also remote eye trackers can be used to detect a user's gaze, which can be a plausible indication of his/her attention to the display, particularly when combined with head orientation and body posture.

Communicating Interactivity to the Passerby

In order for the passers-by to distinguish interactive displays from static advertising screens, a public display needs to communicate that it is interactive [7]. Existing approaches include flipping an edge of the display [12], using *call-to-action* labels, using signs next to display [14] or assigning someone to invite passersby to interact [9]. Based on gaze-data, it is possible to show a concise *call-to-action* label right where the passerby is looking, at the moment s/he attends to the display. This makes it is less likely to be overlooked compared to existing approaches.

Accessibility and Social Embarrassment

Another challenge is the accessibility of the displays. Touch-based interaction is not always possible due to the display's location (e.g. in many cases the display is behind a glass window or mounted above head-height for visibility and security [7]). Gesture-based interaction is often difficult due to the lack of a generally agreed-upon gesture-to-action map-

pings. Moreover, mid-air gestures were found to be embarrassing for users in public [4], particularly if visible from afar. By using remote eye trackers, interaction via gaze becomes very subtle and can be hardly recognized by others in public; thus overcoming the embarrassment problem, while maintaining the advantage of at-a-distance interaction.

Immediate Usability

When it comes to interaction, there is the requirement of immediate usability [7]. Interaction time with a public display is often short (in seconds) [15]. So far this has been addressed by using interaction concepts that require a low learning curve, and by using *call-to-action* labels [14]. Gaze-based interaction is fast [19] and intuitive [21]. Gaze can also be used alongside other interaction modalities to improve their usability. Combining midair gestures and/or touch interaction with gaze tracking in public displays holds promise by, for example, adapting UIs based on users' visual attention.

Privacy in Public Spaces

As displays become more interactive there is a need to enable personalization and to allow users to input data (e.g. add a post [2]). Consequently, displays need to deal with sensitive data (e.g. passwords), that users will be skeptical to provide in a public environment. This problem is currently mitigated by asking users to exchange sensitive data through their mobile devices [3]. Using gaze-based authentication was shown to be more secure than classical methods [8]. Moreover, previous work has demonstrated the feasibility of content exchange across devices via gaze [20]. This makes content-exchange less prone to observations and less likely to leave exploitable smudge traces.

Gaze as a Performance Indicator

Unlike websites, public displays have no equivalent of a user "click stream", which makes it difficult to track user ac-

tions for evaluation purposes [7]. Gaze can offer metrics to quantify the performance of displays. Such metrics include, among others, dwell time and number of fixations; these can be used as indicators of attention, perception, understanding, and interest.

Limitations

Eye tracking could be challenging outdoors as the trackers can be influenced by varying light conditions. Moreover, eye trackers have usually been intended for desktop settings, where a single user interacts at a time from the same distance. However, public displays expect multiple users of different heights to interact from different positions. Recent work suggested guiding passersby to certain positions in front of displays using on-screen visual cues [1].

Conclusion

In this paper we discussed why we believe gaze-based interaction to be a promising modality for tackling many challenges related to interactive public displays and introduced different gaze tracking techniques. In addition we provided pointers for future research in this area.

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