Classifying Public Display Systems: An Input/Output Channel Perspective

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Abstract

Public display screens are relatively recent additions to our world, and while they may be as simple as a large screen with minimal input/output features, more recent developments have introduced much richer interaction possibilities supporting a variety of interaction styles. In this paper we propose a framework for classifying public display systems with a view to better understanding how they differ in terms of their interaction channels and how future installations are likely to evolve. This framework is explored through 15 existing public display systems which use mobile phones for interaction in the display space.

Keywords

mobile phone interaction public screen framework

Introduction

Public displays are becoming ubiquitous and provide interactive spaces for engagement, socialising and content and media delivery. The systems vary greatly in terms of the capabilities and functionality they provide, the style and modality of the interactions they support and the affordances they offer. Moreover, they range in the contexts, domains and environments that they are deployed in. Increasingly the screen is not the only source of interaction for many public display systems which now offer an extended set of interaction opportunities and enhanced functionality to mobile or peripheral devices present within the space. This affords users the ability to affect the central display without the need for direct interaction with the display itself. Some display systems even use the mobile phone's screen as a surrogate for large screen display and the mobile phone becomes the only interactive surface within the display space. Consequently, interactions must consider not only the display and nearby individuals, but also the devices these individuals bring to the space. As such we can now provide richer forms of multi-user interaction, not possible with more conventional public display systems.

As public display systems continue to evolve it is important to develop a conceptual framework in order to better understand and predict the features and capabilities of these systems. In this paper we propose a classification framework with which to understand

and evaluate public display systems in terms of their key interaction channels: input and output. The inputs and outputs describe the fundamental interactions capabilities of a public display system and also provide a generalised framework for the design of such systems. By designing using this approach, the capabilities of a system can be identified without the need to specify an implementation. Each mode of input or output can be satisfied by a variety of hardware and/or software solutions. As such our approach to classification is sufficiently generalised and caters for a diverse range of display systems including those which interact through mobile devices. To develop and test our framework we analysed the functionality of a range of known display systems and we provide direct comparison and exploration of 15 such systems through our proposed method in later sections (see Table 1.).

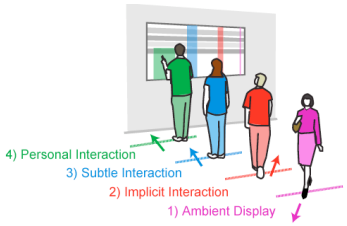

Figure 1. Vogel and Balakrishnan's work identifies a framework for personal interaction with public displays. They describe as "Four interaction phases, facilitating transitions from implicit to explicit, public to personal, interaction"

Related Work

Dix and Rodden [5] [12] have explored similar frameworks for interactive mobile systems. They propose a taxonomy to classify such systems in terms of infrastructure, system functionality, domain, space in which it is used, location, awareness and mobility. Many of the concepts of their approach have direct applicability within the domain of public display systems. Dix notes that it is not the mobile system's functionality that denotes the interaction experience, but rather a combination of the device, infrastructure, system capabilities, domain and the physical and environmental contexts of use. This is also the case for public displays and we provide consideration of these factors in our approach. In Dix et al [5] it is also noted that within mobile interactive systems, functionality does not reside solely with the individual device, but rather can be distributed across a set of devices. We also consider this to be an important feature of public display systems. While the 'display system' normally acts as a central hub, interaction can be, and often is, distributed among mobile or peripheral devices within the `display space'. Our framework is intentionally simplified to generalise effectively to such cases.

The work of Vogel and Balakrishnan [20] is also of interest. They define a framework for personal interaction with a public (ambient) display. They describe interaction as a series of phases ranging distant implicit public to up-close explicit personal interaction (see Figure 1). These states could be used to further describe some of the interaction modes we attempt to describe and capture with our framework, however, as their method is established solely for a screen based display and does not consider interaction via mobile devices in the space, we feel it does not sufficiently generalise to all forms of public displays.

Public Displays Considered

During the development of our taxonomy we investigated a diverse range of display systems and some of those systems challenged our notions of what might be usefully considered to be a public display system. In short, we feel that public displays are not necessarily contingent upon the use of an electronic screen, and opt to view 'public displays' under a much broader definition. We consider a public display to be any system located in a fixed physical space (indoor or outdoors), which incorporates some computing element, but not necessarily an electronic screen, and which reacts to some stimulus by providing an output to one or more individuals in that space. In short, an *output channel* is a necessary requirement, but by

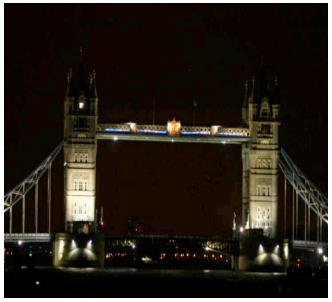

Figure 2: The Tower Bridge during London's Switched On Festival in February 2007 [17]. Even without a traditional screen it can be considered a public display.

Figure 3: Bluetooth Enabled Advertising. Traditional billboards can't be considered a public display, however, if it were to distribute electronic content to passers-by, perhaps via Bluetooth such as in recent Lynx advertising campaigns , it could be considered as such, given that it has a focal visual element (the billboard signage) and also has an electronic component

removing the need for screen-based display, the scope is broadened to encompass a wider range of systems, which accommodate a more flexible notion of `display' such as those that harness mobile, ambient and tangible technologies within their interactions.

Towards a Classification Taxonomy

A public display can be distilled down to two fundamental components: the *inputs* it responds to, and the *outputs* it provides in response to these inputs. Inputs and outputs describe the most basic modes of interaction a public display system will facilitate and provide our framework with its first categorisation type for the description, design and classification of systems. The number and combinations of inputs and outputs provide a clear indication as to the system's complexity and innovation. In order to develop a comprehensive classification scheme for public display systems we reviewed a wide range of well documented systems. This analysis highlighted 5 major types of input and 4 major types of output.

Inputs

Public display systems respond to some external stimulus from a range of sources including humans in their vicinity, mobile devices within the space and/or environmental factors. Inputs form 'gestures' or cues that the system then recognises and responds to. Individual inputs can also be aggregated to form complex gestures e.g. the combination of a touch on a surface and a spoken audio command such as in [19]. Inputs belong to the following major categories:

Haptic: The most common form of input into a system is that of touch, either directly to a touch screen [20], through tangible controls, such as a button or lever connected to the display system or even indirectly from peripheral devices within the space [10], e.g. key presses entered on a mobile device within the space that are relayed to the main display system can be considered as haptic input.

Audio: A range of audio cues can be used to interact within a public display system including: direct spoken commands, ambient audio and specific cues such as taps or whistles.

Content: Media content may be captured from a mobile or peripheral device within the space. In advertising systems, image or video content is transferred periodically to update visual content on electronic screens within the space [17] and in mobile systems text entry via SMS or a form based dialogue would be content-based input.

Presence: Public display systems can be aware of the number and location of people within its space, as well as their body and/or face orientation. This presence information can be used to control the experience of users and allow interaction with the display system. Presence information can be gathered from a range of sources: Bluetooth sniffing, RFID tags and UbiSense networks, while cameras can be used for crowd and face detection.

Environmental: Sensors attached to a display system can detect environmental changes such as temperature, humidity, brightness or rainfall.

Outputs

All public display systems react in some way to one or more of the system inputs

Visual: The majority of public display systems provide visual feedback, typically updating a screen display, though ambient installations can provide visual feedback through changes in colour, shape and/or

texture. Mobile phones may be used as a surrogate display for some visual output.

Audio: Some public displays provide auditory feedback, often coupled with visual feedback in the form of video. For example, a system may change ambient audio tracks in response to changes in the number of present users or in response to environmental changes.

Haptic: A public display system may provide tactile feedback, often in combination with display systems, and to an individual rather than a group. Vibration feedback through mobile devices is also considered.

Content: It is increasingly common for public display systems to deliver content media to the user, often directly to a user's mobile phone.

Other (Taste/Smell): Our analysis has identified only 4 types of output it is possible that other output modes may become available with advances in technology e.g. scent printing for public displays.

Location of Output (or Input)

The output response from a system can be considered to be either *local* or *remote*. A *local* output is one which occurs immediately in the space proximal to the display system, whereas a *remote* response occurs where the response is delayed or outside the vicinity of the display. To highlight this distinction, consider this example. A user enters the vicinity of a public display and an alert is provided to an operator in another building, at the same time a greeting video is displayed to the person present at the display. The former is a *remote* visual output while the latter is a *local* visual and audio output. Often this distinction will be related to the mode of content delivery, however some scenarios can further complicate this distinction. For example, if content is automatically delivered to a user's phone but there is no immediate alert it should be considered remote, however, if the user is prompted to accept the content delivery but and after accepting the content is not immediately displayed, how should this best be classified? This issue is further compounded if acceptance notification is prescribed by the mobile device and not by the public display software.

Reactivity of Output

Output from a system can be either *interactive or non-interactive*. An *interactive* output is one which varies depending on the attributes of a *local* input, for example, displaying a greeting on screen as a user arrives into the space. Reaction to remote operator input or changes in external data sources should not be considered as interactive. Interactive outputs can be further described through *personalisation*. A personalised output attempts to address a specific individual within the space, potentially by leveraging information in stored user profile or provided as part of the input. An example of this would be displaying a greeting message containing the user's name.

Note: (1) Inputs to the system may also be classified as local or remote if required. (2) Inputs will typically be interactive in nature, however, some content inputs may be static. (3) Inputs cannot be personalised.

System	Inputs	Outputs
Underpass [17]	presence	visual, audio
Hermes [4]	content, haptic	content, visual *
Tower Bridge [1]	presence	visual
Whereabouts Clock	presence	visual

Type	Input Channel	Output Channel
Presence	7	
Content	9	5
Haptic	4	1
Audio	0	3
Enviro.	0	
Visual		13

A summary of the various inputs and outputs used in the 15 systems analysed.

Consumption	Systems
Remote	2
Local	12
Both	1

Systems' consumption summarised

Reactivity of the systems is not summarised as all of the reviewed systems provided only interactive outputs. There are a number of systems that provide static output but none were present in this collection.

[15]		
Grab & Share [8]	haptic	content *
Ecko Unltd [10]	haptic, presence	visual
Web Wall [6]	content	visual
Mobilenihn [14]	content	visual, audio
Context Sensitive Advertising [16]	presence	content, visual, audio * #
Rotating Compass [13]	presence, content	visual, haptic *
PINS POUTS [11]	haptic, content	visual
Manhatten Mashup [18]	content	visual *
Collect [9]	content	content *
CAMM [7]	content, presence	visual, content * #
Digital Graffiti [3]	content	visual

Table 1. Comparison of Public Display Systems using mobile devices for interaction *(* = remote consumption;#= dynamic personalized reactivity)*

Comparing Systems

In Table 1 and the accompanying summary tables we categorise each of the 15 systems under the varying input and output headings detailed in our framework.

5 of the 15 systems examined were dual input systems with 4 of these receiving content (either text or file based) and either haptic or presence information. None of the systems examined exploited audio inputs or environmental inputs. When examining outputs we see a dominance in visual output. This is expected as maximum audience number can be achieved when outputting to large screens. Visual output to the mobile phone itself is also prevalent. Content output is the second most prevalent output, this is in the form of files (audio, video, text etc) and can often be saved by users for consumption in an area remote from the area in which it was sent. While all systems react with interactive outputs, personalisation of output is limited.

Conclusions

In this paper we have proposed an initial classification scheme that can be used for the design, evaluation and comparison of public display systems. Given the importance of mobile-device interactions within current and emerging display systems, we have applied our scheme to 15 such systems to demonstrate that it appropriately generalises to, and caters for, such systems. We are also confident this scheme will support a range of other interaction technologies such as ambient or tangible interaction., Our analysis of current mobile phone public display systems highlights that conventional input (haptic and content) and output (visual) channels are favoured. This suggests that the full range of input and output modalities available are not as yet being fully exploited. We hope that this provides a cue to public display system developers to break conventions and become more innovative with their interaction modalities.

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