

Situated web portal for local awareness and transient interaction

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ABSTRACT

When used as part of a larger ubiquitous computing infrastructure, public displays have a great potential for enriching transitional spaces. They can enable brief encounters with information that is relevant for their specific situation, improving local awareness, promoting information sharing and enabling new and much engaging user experiences. The research presented in this paper introduces the concept of situated portal as being a web portal of situational relevant information, targeted for the public display and using large screens or wall projections. In this paper we will briefly describe the architecture of our system, our initial prototype and our early results. Building in our experience of creating this system we then describe some of the main open issues that we plan to address in a multi-disciplinary research project.

Categories and Subject Descriptors

H.5 [INFORMATION INTERFACES AND PRESENTATION]

General Terms

Algorithms, Design, Experimentation, Human Factors.

Keywords

Situated interaction, ubiquitous computing, awareness.

1. INTRODUCTION

Public displays have a great potential for enriching their surrounding physical space. In fact, they present information that is relevant for a specific situation, improving local awareness, promoting information sharing and enabling more attractive users' experiences. However, designing and deploying effective public displays is a considerable challenge, given that it involves serious research from diverse areas and working with many unrelated technologies, such as sensors, visualisation techniques and web protocols.

In this paper we present our specific approach to tackle the problem. We describe the way we extend the traditional concept of the web portal and use the underlying web technologies to design and build the system. We introduce the concept of situated portal as being a web portal, i.e. an organised and customisable collection of web resources, targeted for the public display, using large screens or wall projections, of situational relevant information. The situated portal is thus different from traditional

web portals in two fundamental aspects: being optimised for presentation at a specific location, and being based on interaction paradigms that are radically different from the traditional desktop-oriented interaction paradigms. For example, instead of point-and-click interactions, the situated portal project supports interactions based on alternative channels, such as Bluetooth, SMS, RFID tags, presence sensors, microphones, or video cameras. We therefore exclude the use of touch-screens as an interaction medium, and hypertext as an interaction metaphor.

As a first demonstrator of the concept, we have created a prototype of our system that is currently running at two different locations in our department building. That experience is also presented in the paper as it has allowed us to reason about real user experiences, producing early evaluation results. Building in our experience of creating this system we then describe some of the main open issues that we plan to address in a multi-disciplinary research project.

2. RELATED WORK

The use of large displays has been proposed in multiple settings with very diverse objectives. Semi-immersive visualization environments, normally based on tiled display systems with high resolution per unit area, have been proposed to enable information spaces that surround the user with diverse ways of interacting with data and multimedia flows [2]. Our research differs from such approaches in that we do not want to alienate the user from its physical environment, but rather to enhance its awareness and interaction with that same environment.

A number of projects have also explored the use of large format displays for shared manipulation of data, particularly for cooperative work in office settings, e.g. the Stanford Interactive Workspaces [4] and the Blueboard Large Information Scale Appliance from IBM [7]. The Dynamo system [3] is a multi-user situated display system that allows several users to share a communal display, each of them controlling its own pointer via, for example, wireless mice. People are also allowed to share their interactions and exchange digital media, which can be downloaded from compatible devices, e.g. USB drives or mobile phones. These systems share many technological challenges with the situated portal, but their interaction metaphor is fundamentally different in that their main objective is to support direct manipulation of digital data, possibly in shoulder-to-shoulder collaborations between people sharing a common task.

The webwall system [1] is a framework for multi-user communication and interaction via public communication displays. The system is targeted for a broad, loosely related, non-determined and unstructured audience in public spaces. The main usage scenario is that people in the vicinity of the display can send messages to one of its services, which they can do by using a variety of channels, such as SMS, WAP or HTTP. A set of service classes is used for supporting various types of application such as sticky notes, opinion polls or images galleries.

The Aware Community Portal [8] is a shared display system from the MIT Media Lab that is meant to support short-term awareness of visual activity and long-term community interests. This project includes some early experiments on a number of key topics for this proposal such as the selection by the target community of the relevant information to be presented, the use of proximity and movement as a mean for interaction, and the use of video for capturing people gaze.

These systems share many of their objectives with our own research and provide an essential basis for our own work. In particular, their design experiments, their proposed applications, and in some cases their exploration of unobtrusive interaction techniques, will be an important contribution for our research. Despite sharing many of overall objectives, our work is fundamentally different in its web-based approach. The option for web technology as the basis for the situated portal presents unique characteristics and particular design challenges, but we also expect it to enable many new applications that were too costly and complex to be supported by proprietary technology. This will create a much stronger potential for the dissemination of this type of display, as the costs for creating new situations would be much lower.

3. ARCHITECTURE

The main elements in our architecture are the situated portal, the presentation elements and the situations. A situation is an instantiation of a situated display for a particular place. This includes not only the applications and settings for that specific location done at the server side, but also the physical environment, including the display itself and all the other technology within its surroundings (e.g. sensors, cameras).

The situated portal is basically a web server that will generate a dynamic display programme for many situations. The display programme involves the sequential and periodic display of a set of presentation elements, but may also include interactive elements that are only displayed under certain conditions.

In order to set up a situated display on client side, a situation needs to be selected from server. The result is a control window that should be automatically reloaded at every refresh time, typically one second for interactive situations. Whenever it is time to change the displayed page, the control window is responsible of instructing the browser to open or reload another window with the presentation element to be displayed. After the display time is finished, the process continues and the next page is loaded for presentation.

The same computer supporting the situation's browser is also used for collecting input from video cameras, Bluetooth connections, and a barcode reader. This information is then posted to the situated portal or to specific applications.

3.1 Presentation scheduling

One of the main roles of the situated portal server is to organise the schedule for the presentation of the various presentation elements. This is a challenging task, mainly because there are many conflicting requirements that need to be met:

- Some pages may need to be presented more often than others.
- Regardless of what could be scheduled, some pages may need to be presented immediately, e.g. because of some user request.
- When a page requests to be presented outside the normal schedule, that schedule should be redefined to take into account that that page has just been presented.
- Some pages are only meant to be displayed when specific events occur, e.g. a user request.

Our approach builds on a pre-defined sequence of pages to be presented. That sequence will dynamically change depending on a set of parameters associated with each page and on events that may occur in the situation, e.g. user interactions.

The base schedule is a sequence of presentation elements, each having a URL and a set of attributes. Among those attributes, there is a minimum and a normal display time. The first is the minimum time that the page should be presented, even if other pages are requesting immediate presentation. The other is the time that the page will be displayed if there are no interruptions. Another important attribute for the scheduling algorithm is the frequency, which indicates how often that page should be presented.

The selection of the next page to be presented uses an algorithm that is an adapted version of the second chance page replacement algorithm used in memory management. Initially, each page has a counter that is initialised with the value of its frequency. The algorithm will then go through the pages, and if the counter equals 1, the page is selected for presentation and the counter is set again for its frequency level. If the page is greater than one the counter is decremented and the page is not selected.

In order to allow external events, such as user input, page updates or sensor output to affect the sequence of pages that are presented by the portal, pages also have an interactivity attribute that determines what the portal is going to do when there is an event associated with the portal. Table 1 describes the behaviour associated with each of the five levels of interactivity supported.

Table 1 - Interactive actions

| Level | Action |
|-------|---|
| 1 | There has been a direct and explicit user interaction, e.g. showing a bar code. This page should be shown immediately. |
| 2 | There has been an indirect user interaction, e.g. presence at the place. This page should be shown as soon as possible (after current presentation is finished) |
| 3 | There has been a relevant update in the information associated with this page. It should be scheduled to be presented significantly sooner than planned |
| 4 | There has been an update in the information associated |

| | |
|---|--|
| | with this page. It should be scheduled to be presented sooner than planned |
| 5 | Page presentation is not affected by events |

When the portal receives the notification of an event associated with pages with interactivity level 4, the respective counter is decremented by 1. For pages with interactivity level 1, 2 or 3, the page is placed on a separate queue for immediate presentation ordered by interactivity level. Pages are only selected from the base schedule when this queue is empty. Otherwise the first page from the interactive pages queue is selected, and its counter on the base schedule re-initialised. Interestingly, some very interactive pages, such as the application that receives barcode queries can have a frequency level of zero and an interactive level of 1, meaning that they will only be shown when a barcode is read.

3.2 Presentation Elements

One of the interesting characteristics of using web technology is the diversity of presentation elements or pages, which can be integrated for presentation. Basically, anything that can be displayed on a web browser can be integrated in the situated portal, from static html pages to videos or complex web applications. These presentation elements can be presented individually or aggregated on a single page.

The situated portal is a platform for serving many situations, and it is the presentation elements that are actually going to enable the association between the portal and the physical space. Some presentation elements may not have any association with the particular location where they are displayed, e.g. sports news, and can thus be used in many portals regardless of their locations. Some elements may be created specifically for a particular location, and thus are not usable in other situations. Finally, there are also elements that build their own association with the situation on the local interactions and information collected from the environment. These elements need to be configured with their information sources, e.g. local sensors or local services, but can be used in many situations.

A presentation element can also be designed to serve many different situations, either providing location-based contents to each of those situations or by collecting information from the various situations and then providing aggregate or exchanged content to each.

4. PROTOTYPE

We have created a prototype of our system, involving two situations at different locations in our department. A single server was used for supporting the two situations.

On the client side, the minimal approach could be just to use a web browser, but since we used the same computer for controlling the sensors and the video camera, we also added some additional software for controlling the camera and sending the sensors output to the portal.

For this prototype we have developed a set of presentation elements of various types and various interaction modes. Some of those elements were just web pages with information about the department, news, or weather. An important criterion for external pages was their ability to be used on the very specific setting of the situated portal, i.e. presenting all, at least the most relevant,

information without requiring user input or page scrolling. Interestingly, this was not a problem, especially with commercial web sites, as most of them are already designed to convey significant information on their first page. We have also tried without any problems including presentation elements that were videos and full page images.

One of the applications that we developed specifically for this situation was called Moments (see Figure 1) and the objective was to present images of that same location at various points in the past. In this application, a video camera is used to take photographs whenever it detected movement of someone in the area where the display was installed. Those photographs are then presented in a page showing a series of moments that could go from a few moments ago to one year ago.

The recent images provided a sense of awareness about the recent past of the place, while the older ones show up as short glimpses of a more distant past and provoked an interesting and contrasting sense of continuity and change.

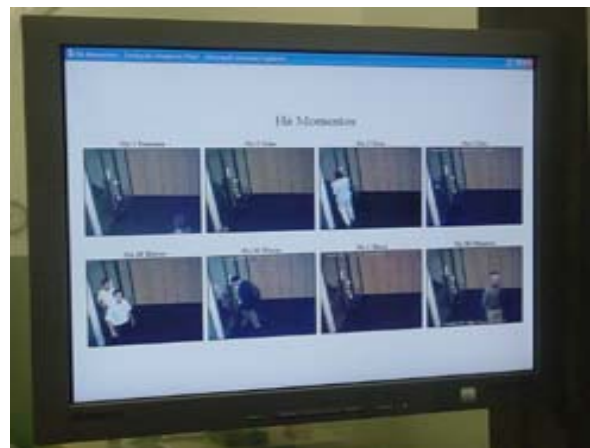


Figure 1. Application Moments

Another application, created for this situation was the WhoIsThere that shows the currently connected machines from a set of selected personal computers from people at the department. By using a combination of colours, the produced image explores the concepts of background awareness by providing an aggregate view of how many people are currently using their machines. Information about individual machines is also available for someone that approaches the display. The use of DNS names provides a certain degree of privacy as normally people will only remember the names of the people with whom they usually work.

5. RESULTS

Such prototype has provided an important proof-of-concept and has allowed us to gain considerable feedback on its usage and technological challenges.

In general, one of the most compelling characteristics that we were able to observe from our prototypes was that once the system is in place, and people start to understand its concept, there are always many new ideas on how to use it, many of which unforeseen by the development team. This represents an enormous potential from the perspective of its possible applications and potential for network effect. For this reason, we believe that work on public displays can have an inspiring effect

on a vast community and play an important role in the promotion of ubiquitous computing.

Regarding the presentation elements, their development can still be very challenging, even within the framework of the situated portal, as each of them normally raises complex issues that are specific to its objectives. One of the most important design trade-off was the level of integration between the portal and each of the presentation elements. At the lowest level of integration, the portal has no interaction with the presentation element, and simply instructs the situation browser to access the element URL. At the highest level of integration, all the elements are integrated into the portal itself and follow strict design rules for their interaction with the portal. In between there is a vast range of approaches in which elements remain external, but may follow certain interaction rules for initialization, status information or configuration. From our experience, there are good reasons for any of these approaches, as well as for intermediary ones, depending on the nature of the elements, and the situation. Therefore this is a design aspect in which flexibility is very important in order to address the varied requirements.

The most popular element turned out to be the Moments, either because of the natural way photographs were taken or by its dynamic nature, allowing people to always find a different content. An interesting issue regarding this element was the position of the camera that was taking the photos. Initially, the camera was placed immediately above the display, typically taking close-distance photos of the people watching the display. This has had the effect that, after a short while, people would avoid standing in front of the display. While most people do not care about showing up in photo when passing by at the hall, very few were indifferent to the idea of having many close distance photos displayed on the portal, which is what would happen to frequent visitors of the portal. After a while, we decided to change the camera position to a higher location above the display, still photographing people passing by, but not people standing in front of the display. As a result movement detection was not so accurate, and people were often confused by the lack of typical photography metaphors, such as posing (where to look, how do I look), or clicking to take the photograph (when to smile, how to force the system to take me a photo now, how to prevent the system from taking me a photo now).

Another interesting observation made by users regarding the use of the portal was the will to have a "hold" button that would prevent the currently displayed page from changing. A frequent sequence of events was for someone to be passing by the portal, and then noticing some interesting page was being displayed, and thus approach the situated portal. What often happens is that by the time the person stops in front of the display to watch the interesting page more closely, the time for that presentation element is just finishing and the page disappears.

Another important result of this work was the experiment of trying to use a technology, in this case MS Windows XP and Internet Explorer, under different assumptions from those for which the technology was primarily designed. Removing the use of the mouse and keyboard from the system, may not seem very complex when there is the invaluable help of Remote Desktop solutions, which were intensively used for almost all the administration tasks. However, unexpected input requests by the system can become a disturbance, which was what happened with

messages about the availability of application updates or about the level of the wireless connection. Every time a message like these was detected the systems manager would have to connect remotely to the situation system and click on the notification to close it. A similar problem would also occur with Internet Explorer. When trying to access certain web pages from external sites, a warning window could be prompted, caused for example by a missing plug-in. The warning window would then stay in middle of the display until the systems manager would be notified, and once again, though remote desktop click on the buttons to close it. While some of these problems can be addressed through a careful configuration of the system, the assumption that a simple click will not be too annoying to the user still prevails, meaning that unexpected messages requiring user input are always possible.

Regarding the evaluation of the reliability of the system, and since the displays are located at public places, an important measure is the time in which the situated displays were showing an adequate behaviour. In order to maximise this time we made the system start automatically whenever the computer was re-started. The system however, was not so resistant to network failures, meaning that once there was a network error the system would stop working because the reloading of the control pages would fail. These situations were often not obvious as only after some time watching the display would people realise that the presented page was not changing.

6. FUTURE WORK

The prototype development is now being extended regarding a campus-wide prototype. This represents the availability of situated displays to a larger community, which will allow us to explore new situations and look at a broader set of applications.

We are also involved in a multi-disciplinary team that will use the campus prototype as the basis for studying the application of image processing techniques, sensor networks, awareness models and multi-modality to the specific requirements of situated portals. We will now describe in more detail our future work in those areas:

6.1 System Architecture

Building on our experience with the first version of the system, we intend to create a new version that addresses the main requirements derived from the prototype. One of the main conclusions from that initial prototype was that different usages of the situated portal can impose quite different requirements and call for totally different architectures. Since this variety of requirements cannot easily be achieved with a static architecture, a more likely solution is to build a common framework that can support multiple variations in the underlying architecture (client-side vs. server-side) and thus be instantiated to multiple scenarios.

Other important requirements that we plan to introduce are as follows:

- The ability to support multiple situations from a single portal server
- Adequate abstractions for enabling support to new types of sensors or interaction modalities without significant increases in complexity.
- Support for multi-modal interaction

- Support for multiple levels of integration between the portal and the individual presentation elements.
- Customization of presentation elements based on current situation and display capabilities
- Flexible window management, allowing multiple, and possibly overlapping windows
- Support for presentation templates composed by multiple elements
- Conditional presentation of elements, based on time of the day, local context, or other arbitrary conditions

6.2 Ambient sensing

With the increasing availability of sensing technologies and tools for analysis of video and audio data, several types of sensor can be used to infer the current situation and also to enable natural interaction paradigms. Information such as the existence of motion, the position of users' relative to the display, the number of users in front of the display, or the presence of mobile devices can be captured and used for improving the interaction with users or even for generating content, e.g. provide information on the level of activity on that area. Situated interaction with the portal can also be supported through a variety of other mechanisms, such as barcode or RDID readers, proximity-based networks, such as Bluetooth or IR, and other networks, such as Wi-Fi, or GSM.

The possibilities are considerable, but the main challenge with the use of all these sensors is the complexity that they can introduce into the system. Each type of sensor can have very specific characteristics and impose new requirements on the situated portal platform. As a result, supporting this rich ambient sensing becomes a complex engineering issue in which every system is a new prototype with new design challenges.

One of our lines of research is to create a sensor model that would provide the adequate abstractions for managing the output of various types of sensor, thus supporting the integration of all these types of sensor on the situated portal framework, either for context sensing or situated interaction. The model should allow sensors to adapt without specific training to the particular characteristics of their environment. For example, a movement sensor should after a short learning period be able to indicate levels of movement as unusually high, high, normal, low or very low. The sensor model should thus provide an additional layer of abstraction that can reduce the complexity associated with deploying new sensors and using their output in the portal behaviour. The application of image processing techniques to infer user behaviour, and especially to enable natural user interactions, based for example in gestures or movement, will also be studied with the objective of supporting their use in the situated portal framework.

The model should also consider the requirements of low-bandwidth and high bandwidth sensors, the use of sensor gateways, and also the use of logical sensors, e.g. to provide high-level information based on the processing of video images.

From the perspective of the low-bandwidth sensors, the approach will be to explore the use of embedded web servers as a mechanism for enabling the integration of sensors into the portal framework. From the perspective of video the main goal is to

develop different ways to interact with the portal, based on the following functionalities of the vision system:

- detection of the presence of people near the portal;
- detection of the presence of a particular person staring to the portal;
- detection of specific gestures to interact with the portal.

These functionalities and other related ones (like number of peoples passing by, number of peoples staring to the portal) can be achieved using cooperative work between different network cameras, dedicated image processing mainframe and advanced image processing techniques.

The approach will thus be to create an architecture of logical sensors that integrate with the portal but isolate image processing tasks from the awareness model of the portal.

6.3 Awareness and interaction model

We expect context awareness to improve the richness of the communication supported by the portal and thus aim to develop new ideas on how to explore the ability to sense context to improve the modalities and the sequences of interaction with users. An appropriate awareness model should be able to consume information produced by sensors associated with the situation, and by applications running on the situated portal to produce higher-level abstractions that will drive the interaction modes of the portal. Such high-level information can be generated from fusion models that combine the information obtained from lower-level data from sensors, and also from the discovery of patterns in the information collected over time. For example, after a period of usage and given the collection of sensing data, the awareness model might be able to generate patterns of busy hours in front of the portal's space during the day. This information is certainly important to adjust the portal's interaction mode into single, group, or crowd's user mode approach, for example.

The social aspect of shared public displays also requires the awareness model to reason about the relationship between the several users that pass across and interact with the system. This is an interesting feature we also intend to tackle, always taking into account the privacy issues especially those related with the presentation of private information in public displays

In addition to being adaptive to the current situation, the interaction with the portal should also support the combined use of multiple interaction modalities, including intuitive interactions based on voice or gestures. A specification of an awareness model for situated portals should thus include its inputs, outputs, control policy, and also a description of how multi-modal interaction can be supported within this context.

Regarding multi-modality, the approach will be to rely on existing API's, such as Microsoft Speech or OpenCV, for signal processing, and concentrating the efforts on the tasks of interpreting, integrating and generating the interactions. Given our focus on web technologies, the efforts of the W3C on multi-modal interaction on the web will be given special attention.

6.4 Background awareness

It is sensible to expect that a situated portal in a transient place is most often being seen by people that are just passing and not necessarily focusing their attention on the portal. To those people,

the portal should provide what is often called a brief encounter with situational relevant information. In order to be effective, these lightweight and transitional interactions should not force users to stop and draw their attention of the display. Instead, they should allow users to obtain subtle and peripheral awareness of information naturally placed in their environment [8]. This type of passive informing is particularly adequate for ambient awareness and for many of the applications we envision for the situated portal. Another reason why these background interactions should be explored is because the portal should not strongly assert its own presence in the local environment, which would probably inhibit its original use. Instead, it should augment the local affordances with new digital services that promote new ways of supporting the traditional social activities of the place.

There is considerable work to be done in exploring presentation techniques that are able to convey information in subtle ways for people that are simply passing by. We intend to produce a set of portal elements based on those design principles for the campus prototype. The elements should be independent of the information to be presented, in order to be applicable with minor changes to a vast range of similar data types.

In particular, the work will explore the use of concepts such as informative art [5], in which images resembling art works are actually dynamic images in which certain parts reflect that state of some varying data source, and net art, in which the network and its information is used as the basis for art work. Specific visualisation techniques used in data intensive sectors, e.g. stock markets, will also be experimented to explore their applicability to this scenario.

6.5 User studies

Situated displays can have an important impact on individual and social behaviour, and more research is needed to understand the implications of usage related issues. Furthermore, considering the novelty of the concept, there is an obvious need to study the characteristics that may drive the acceptance of this technology. In our campus prototype, we will have the opportunity to expose the system to a vast community of users, and evaluate its contribution to promote community awareness and interaction.

7. CONCLUSIONS

The work described in this paper refers to the early results of an on-going research programme that we plan to develop much further. Regarding the infrastructure, we are at the point of beginning the deployment of campus-wide prototype, in which the situated displays will be available to a much broader

community, and in which we will be able to explore a new set of applications. We believe that such system can have a seminal role in our work on ubiquitous computing because it will enable an infrastructure of situated portals on top of which many new ideas can be explored. Considering that the unique nature of situated portals makes them particularly attractive as a complementary mechanism in other ubiquitous computing projects, we expect this prototype to promote many smaller projects that will leverage the created software and infra-structure for exploring specific research topics.

8. REFERENCES

- [1] Ferscha, A. and Vogl, S., The WebWall. In *UbiComp 2002 Workshop, Collaboration with Interactive Walls and Tables (CIWaT02)* (Göteborg, Sweden, September 29, 2002).
- [2] Hereld, M., Judson, I.R. and Stevens, R.L. Introduction to Building Projection-based Tiled Display Systems. *IEEE Computer Graphics and Applications*, 20, 4 (July/August 2000), 22-28.
- [3] Izadi, S., Brignull, H., Rodden, T., Rogers, Y. and Underwood, M., Dynamo: A public interactive surface supporting the cooperative sharing and exchange of media. In *Proceedings of the 16th annual ACM symposium on User interface software and technology (UIST 2003)* (Vancouver, Canada, November 2-5, 2003), ACM Press, New York, NY, 2003, 159-168.
- [4] Johanson, B., Fox, A. and Winograd, T. The Interactive Workspaces Project: Experiences with Ubiquitous Computing Rooms. *IEEE Pervasive Computing Magazine*, 1, 2 (April-June 2002), 67-74.
- [5] Ljungblad, S., Informative Art In *UbiComp 2002 Workshop, Collaboration with Interactive Walls and Tables (CIWaT02)* (Göteborg, Sweden, September 29, 2002).
- [6] Lueg, C., Information Seeking as Socially Situated Activity. In *CHI 2000 Workshop Research directions in situated computing*, (The Hague, The Netherlands, April 1, 2000).
- [7] Russell, D.M. and Sue, A., Using Large Public Interactive Displays for Collaboration Art. In *UbiComp 2002 Workshop, Collaboration with Interactive Walls and Tables (CIWaT02)* (Göteborg, Sweden, September 29, 2002).
- [8] Sawhney, N., Wheeler, S. and Schmandt, C. Aware Community Portals: Shared Information Appliances for Transitional Spaces. *Personal and Ubiquitous Computing*, 5, 1 (2001), 66-70.