Augmenting Buildings with Infrared Information

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Abstract

We describe a building information and navigation system based on Palm Pilot PDAs and a set of strong infrared transmitters, located throughout a building. The infrared senders stream localized data, thus effectively augmenting areas of space with localized information. This information can be perceived by just entering those areas with the PDA in your hand. We show that this form of augmentation of an environment can serve a multitude of purposes and requires neither the employment of classic 3D augmented reality nor to carry around wearable computers nor to wear head mounted displays.

1 Introduction

The IRREAL system is a building information system that by its pure working principle can also be used as a navigation system within buildings. It is based on the Palm Pilot family of PDAs most of which feature a builtin infrared port located in the middle of the top end of the device, so that it points away from the user when the device is being held in front of the user. By using this port to receive data from strong infrared transmitters located in strategically important places of a building the PDAs can display localized information within the range of these senders. Since each sender is broadcasting different information, the mobile devices seemingly become location aware, or seen from a different point of view, they make visible the data from the infrared data stream that effectively augments this area of the building. In this way it is possible to attach information to certain places such as offices or segments of a hallway. Since no explicit tracking is involved all the problems connected to wide range tracking can be ignored and the devices can be kept extremely light weight.

2 Infrared and PDAs

The grandfather of the IRREAL system is, of course, the ParcTAB system implemented in the early 90ies at Xerox PARC [7]. The ParcTABs were small hand held devices that kept up a network connection through infrared transmission and were explicitly tracked by the infrared cell with which they were communicating at any given time. They were providing services such as note taking, email and file browsing and had an elaborate infrared network infrastructure that basically hasn't been surpassed until today.

When hand held computers eventually became commercially available, systems such as the MOBIS [4] and HIPPIE [5] museum guides were developed. These systems use the idea of infrared markers placed in important locations. The self-contained markers broadcast an ID by which the mobile device can retrieve information that was authored for this ID and thus effectively for this area of space. Retrieval is done either from a database stored on the device (MOBIS) or via a radio network connection (HIPPIE). In the first case all information has to be installed on the device itself and therefore the size of the information space is limited by memory size. Also, information cannot be changed or updated once the user is on her way. In the second case an additional radio network has to be installed, effectively extending the amount of available information, but rendering the mobile devices heavier and more expensive and causing them to draw more power.

The main idea behind the IRREAL system is to use infrared senders to broadcast all information, so neither a large database nor a radio network card have to be installed on the mobile devices. These on the other hand use their builtin infrared ports as receivers without sending back information. While this working principle was caused mainly by technical necessities, it provides several advantages as shown in the next sections.

3 Infrared broadcasting

Today's standard for infrared communication between computing devices is set by the IrDA organization [1]. Many contemporary devices from laptops and PDAs to printers and mobile phones contain IrDA ports although this might change at some point with the widespread availability of bluetooth[3]. The IrDA port in the Palm Pilot PDAs initially was meant to enable the devices to exchange data such as business cards, notes or applications between each other. The IrDA standard limits the range of these transmissions to a distance of $1m$ which is perfectly acceptable for the original purpose. If we wanted to build an infrared network in the ParcTAB manner, this range would, however, be far too short. Since the original approach was to use off-the-shelf devices without any additional hardware, this situation can only be helped on the other side of the transmission, namely the senders. By using relatively strong transmitters and making the PDAs only listen to their data, we were able to bridge distances up to $30m$, but at the cost of giving up a bidirectional connection. We could, however, achieve a certain interactivity of the broadcast presentations by adapting and extending a principle from the European video text system. Video text broadcasts a certain number of text pages, each of which has a unique ID. By selecting different pages by their ID a user can effectively browse within this information space and pages can contain hyperlinks to other pages. All pages are broadcast repeatedly and no back channel is needed, but since bandwidth within the TV signal is rather limited, pages have to be cached in the TV set and from the point of turning it on it can take a while until a certain page becomes available. One special page, however, is broadcast more often than all the other pages. This page has the table of contents which needs to be loaded quickly.

We have adapted and extended this principle by assigning relative probabilities to each packet being broadcast. Furthermore packets can be clustered in order to ensure that several pieces of information become available at the same time. An initial presentation is sent more often via the infrared data stream. Each page has a relative importance assigned to it and is transmitted more or less often according to this value. In this way it is possible to at least statistically assign different average transmission times to different parts of the localized data and while some top level information becomes available almost immediately (mostly within less than a second), other bits of information that will only be needed after some interaction can afford to take longer to be received. Transmission time can effectively be 'hidden' behind interaction time and isn't noticed by the user.

4 Types of localized data

Currently the IRREAL senders transmit formatted text and vector graphics which may contain hyperlinks to each other (hypertext, hypergraphics). Information is structured as a directed acyclic graph of hyperdocuments and in each graph there is a specific starting point or root node. Figure 1 shows a screenshot of our hyperdocument authoring tool. One sender can send several hyperdocuments each of which has a list of user or group IDs assigned to it. Links can lead to elements (text or graphics) within the same document or to the root node of another document. In this way it is possible to broadcast information in different languages or, more generally, for different user profiles. Elements of one document can be reused in in all other documents which prevents the wasting of bandwidth by duplicating data, such as language independent graphics. All the documents are broadcast in a cycle and the relative probability of every element being broadcast is controlled by its relative importance value. A more detailed description of this probabilistic broadcasting scheme can be found in [2]. Figure 2 shows some screenshots of a Palm Pilot simulator (Xcopilot) running our client software 'BrowsIR'.

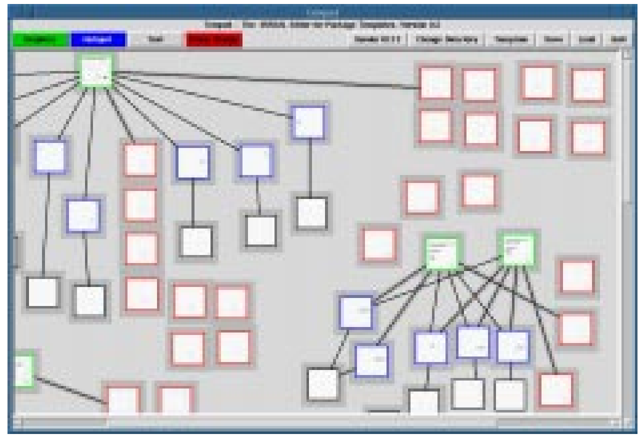

Figure 1. Screenshot of the hyperdocument editor. Different colors indicate different types of data. Lines indicate links. Documents are represented by thumbnails. Grouping is indicated by highlighting subgraphs.

5 Implicit tracking

The mobile devices basically display whatever they receive within sight of a certain transmitter. Since every sender streams locally adapted information this results in a seeming location awareness of the device without ever dealing with explicit locations on the client side. The granularity of this kind of implicit tracking is determined by the (adjustable) range of the senders. Since human perception structures the surrounding space largely based on its visual appearance and infrared light follows the same physical rules as visible light, the information space is effectively structured in a very adequate way. Information behind a wall cannot be received, since infrared light is blocked by it, but in the vast majority of cases this is just what we want. Radio networks and radio bearing have to deal with this fact explicitely by employing a 3D model of the building and explicit tracking, while in the case of infrared light it is a side

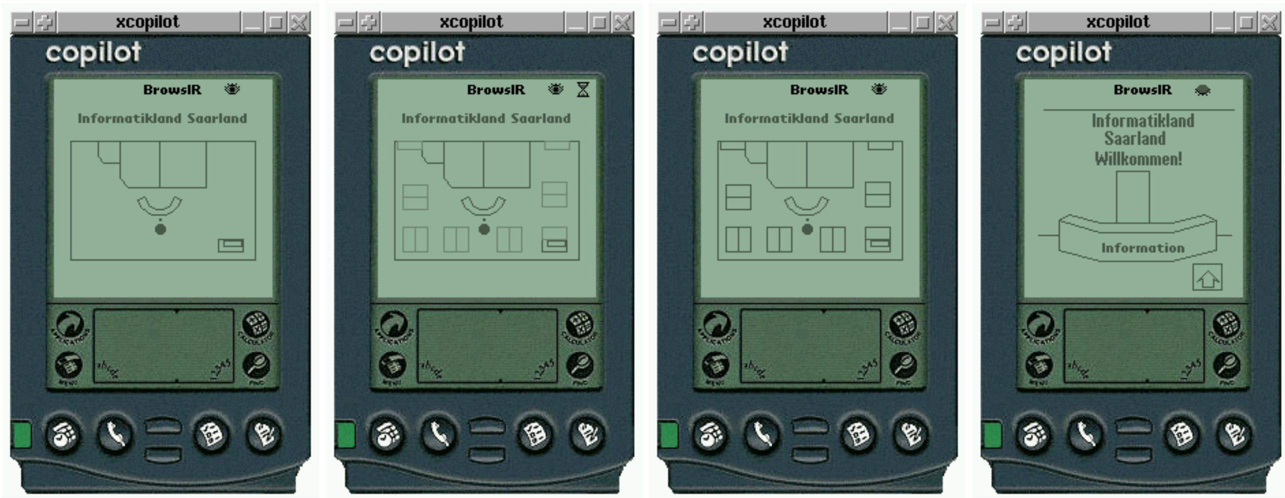

Figure 2. Screenshot of the hyperdocument browser software BrowsIR. The initial presentation only contains the floor plan with the exhibit in question. Then additional exhibits are displayed gray and as information comes in they turn black to signal that they are clickable. A perspective view of the current location can be chosen by selecting your own position (black dot).

effect of the very working principle. Another advantage of optical transmission over radio cells is its sensitivity to orientation in space. A visitor of an exhibition might stand closer to one exhibit, but still look at another one. If a person has to be guided across a large building, the information that has to be shown (such as arrows or floor plans) depends not only on her position, but also on her walking direction. Similarly several senders can be installed in one position streaming different data in different directions. By making the simple assumption that the PDA is always held upright in front of the user we are able to position several senders in such a way, that, depending on where a person is facing from the same position, different information is displayed. The 3D space is thus augmented not only by location specific, but also by orientation specific information.

Finally a unidirectional communication is the most effective way to protect a user's privacy within this kind of system. Since there is no global tracking and since the mobile devices never send back any information or request, there is no way to find out about people's locations within the building. Systems such as the active badge system [6] take the opposite approach and customize the environment based on a badge wearers tracked position. While this is an acceptable approach in homogeneous and cooperative communities such as a company or a research institute, it will be hard to convince people at a fair or exhibition or in public buildings that the digital trail they leave as they use the system will never be used against their personal interest. On the other hand the aforementioned digital trail can very well be collected on the mobile device and a visitor might easily decide at the end of an exhibition day to give out this information and have the fair organizers send him additional material about selected exhibits she has seen on her journey. The important difference is that this decision is made consciously by the user and that there is no way for the system carrier of cheating around it.

6 Currently implemented services

The first real world installation of the IRREAL system took place at the German computer fair CeBIT 2000 in Hannover. We installed 20 senders throughout an exhibition booth of $400m^2$ and augmented the exhibits by short and long descriptions in German and English and contact information for the products on display as well as floor plans and simple annotated 3D graphics of what people would roughly see from their current positions. People arriving with their own devices received a 26Kbyte PalmOS application at the information desk within a few seconds and could thereby use the information system with their own devices. They initially chose a language and a level of detail for informational texts which set the mobile device to filter out only content for a certain user group ID internally. Information received in certain locations could then be saved locally on the device and taken home while all other data was deleted when they left the booth. Changes in the booth staff could immediately be reflected in the broadcast data, so visitors would always take home the contact information of the people they actually were talking to at the exhibits. Within a month after CeBIT we installed senders on our floor and at central locations of the Computer Science building of Saarbruecken University. These senders provide services such as the (daily changing) menu of the University restaurant or the bus schedule from the bus stop in front of the building for the next 30 minutes. This information is fetched from existing web pages, converted and updated in the infrared data streams automatically. People can conveniently walk through these areas without even having to stop and review the received information on their way to the restaurant or bus stop. We are currently working on finer grained information services such as information of the operational status of computers in different rooms, office hours of room inhabitants or navigation information. Eventually visitors will be able to select the name of a person they want to see from a list upon entering the building and then just follow the arrows and plans displayed on their device to be guided to that person's room.

The client program for all these services is our own hyperdocument browser BrowsIR, which can eventually be replaced by more standardized tools such as WWW or WAP browsers for the Palm Pilot. Every user only has to install the client program once, since all the content is broadcast dynamically. The current implementation has been tested on all the PalmOS PDAs that incorporate an infrared port. This includes the Palm Models III, IIIx, IIIc, V, Vx, VII, all the IBM Workpads and the Handspring Visor.

7 Conclusions and Future work

The working principle of IRREAL has been filed for Patent and we intend to further develop the system's infrastructure. Currently every sender is fed by a serial cable from the next available workstation with a free serial port. In environments other than a computer science building or a rather overlookable exhibition booth this installation can become somewhat cumbersome. We are therefore working on a radio link to each sender. Also power consumption of the current transmitter hardware is relatively high, so that each sender requires a power outlet close to it. For situations such as temporary exhibits or conferences a battery solution nevertheless seems feasible, effectively turning the broadcast transmitters into self-contained units roughly the size of a small smoke detector. User feedback has been very positive so far, especially because of the fact that everybody can use their own device to use the service. People found that the invisible information they could collect with their Palm Pilots had some effective value for them. This might, of course, be biased by the inherent play instinct of Palm Pilot users, but it shows that by scaling down the technological requirements radically, certain forms of augmenting the space around us with information can actually be of use for a considerable number of real life users.

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