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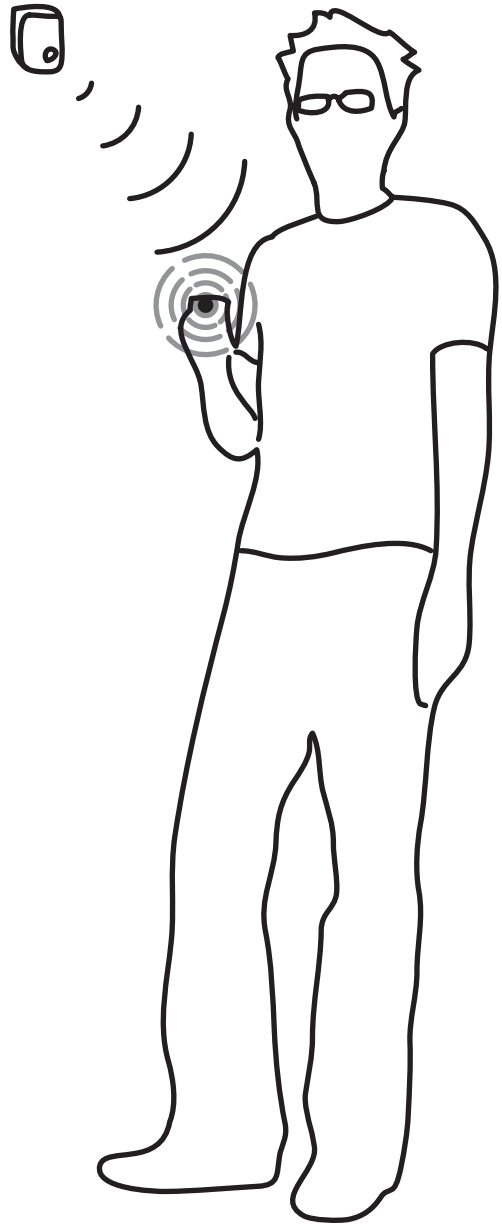

white paper on positioning technologies [under development]

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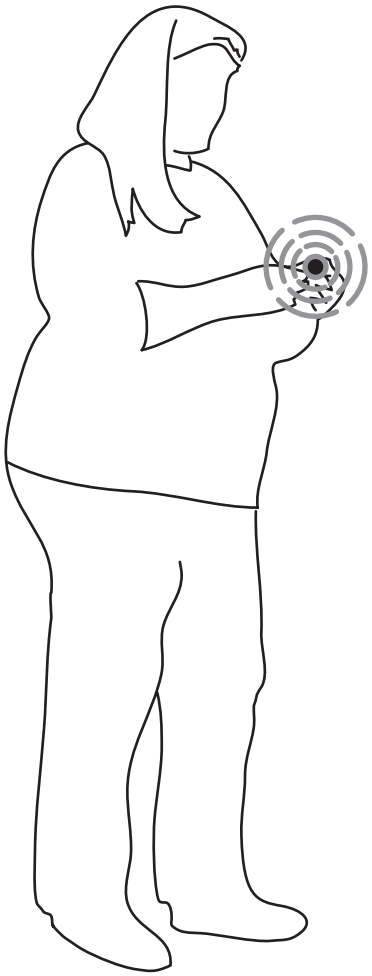
positioning

Since the beginning of ubiquitous computing there has been a request for locating objects and people for the creation of different kinds of digital experiences. This short booklet will not deal with the history and evolution of different methods, nor will compare the state of the art of technology. The only aim of this text is to inroduce the positioning system developed at the University of Zaragoza, Spain, by Dr. Jorge Falcó et al.

During the development process Falcó´s department established a collaboration with K3, Malmö University, Sweden, for the study of applications in the fields of Art, and Education. This collaboration has been going on since 2001 and has brought the development of a joint project and the creation of several concepts.



This paper will focus only in one particular application: the Space Software Development Kit, by PhD. Candidate David Cuartielles, and in how it could be used within the field of SoundArt for the development of soundscapes.

what

By positioning we mean to use a piece of technology to locate the postion of an object or a person. Originally this system was meant to be an external tool for pacients residing in hospitals. They could carry it as a non-intrusive piece of technology in order to monitorize their movements indoors. The main idea was to create a system as cheap as possible. The different phases of the project have been funded by spanish research institutions. The first version of the system´s hardware has been developed by PhD. Candidate Roberto Casas and the precise details on the hardware configuration will be published during the Autumn 2004 in an international journal.

how

There are many different ways of doing for positioning, but we choose to use active tags (to be carried by whatever is being positioned) and active beacons (objects in the system´s infrastructure). Nowadays functionality is very similar to GPS, the different beacons in a room send small chunks of information that the active tags use to measure the flying times of the data. After capturing several of those chucks (never less than three), the tag can either operate its position or send it to a central computer to be calculated there.

The trick here is to have chose different technologies for positioning than for the transmission of data, this allows to have vey high refresh rates in the positions of the tags, as well as to use other technologies - like accelerometers - for increasing the accuracy of the measurements.

The limit in the amount of objects to be located is of 256 per cell, being the cells of 10x10x10 meters of size. With the latest hardware version we can push the refresh time down to 0,8 seconds, but the theoretical limit that we expect to achieve is of 20 times per second (50 ms).

About accuracy in space, or as we like to call it "space resolution" the system reaches half a centimeter in direct line measurements, what means that after the triangulation process the uncertainity of a measurement is of about 5 cm radius.

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single cell

By "single cell" we mean a system that can give coverage to one single space with a maximum size of 10x10x10 meters. The differences of the single cell system compared to the multi cell (to be explained later) are significant in terms of technology. The second one has been created thinking about the cost and efficient ways for handling the system, while the first one is meant to be a totally portable system, ready to place in a suitcase and place it elsewhere to augment a certain space.

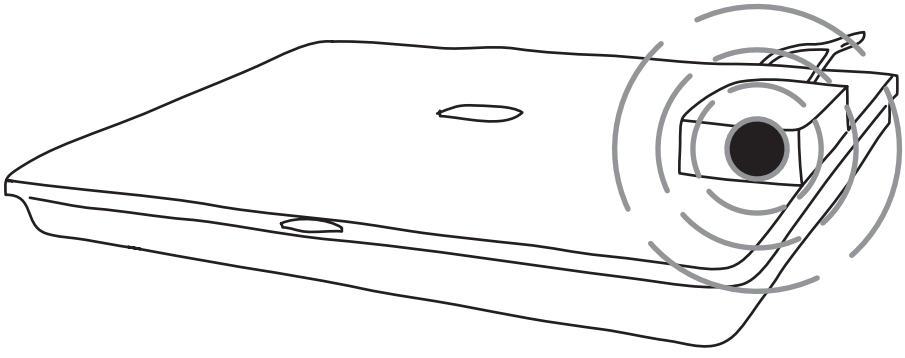
technology

In the single cell system, the different beacons and the tags are exactly the same piece of hardware. It is just the firmware what makes them different. Historically this was the first system to be developed. All the different beacons would be synchronized wirelessly and the only connection they would need would be to either a power supply or a 12VDC battery.

The way of interfacing the system is through a server that gets the information from the system and reconstructs it in the form of XML. The definition of this block of the software, as well as the dtd to control it came from K3's concept development team, in an attempt of making the system as standard and understandable as possible for those that would be willing to develop applications on it.

how does it look like?

The following figure shows the configuration of a single cell system and how it connects to a computer with the control system, etc. The screenshots correspond to the first generation of the SoundScape software called "ActiveZones".



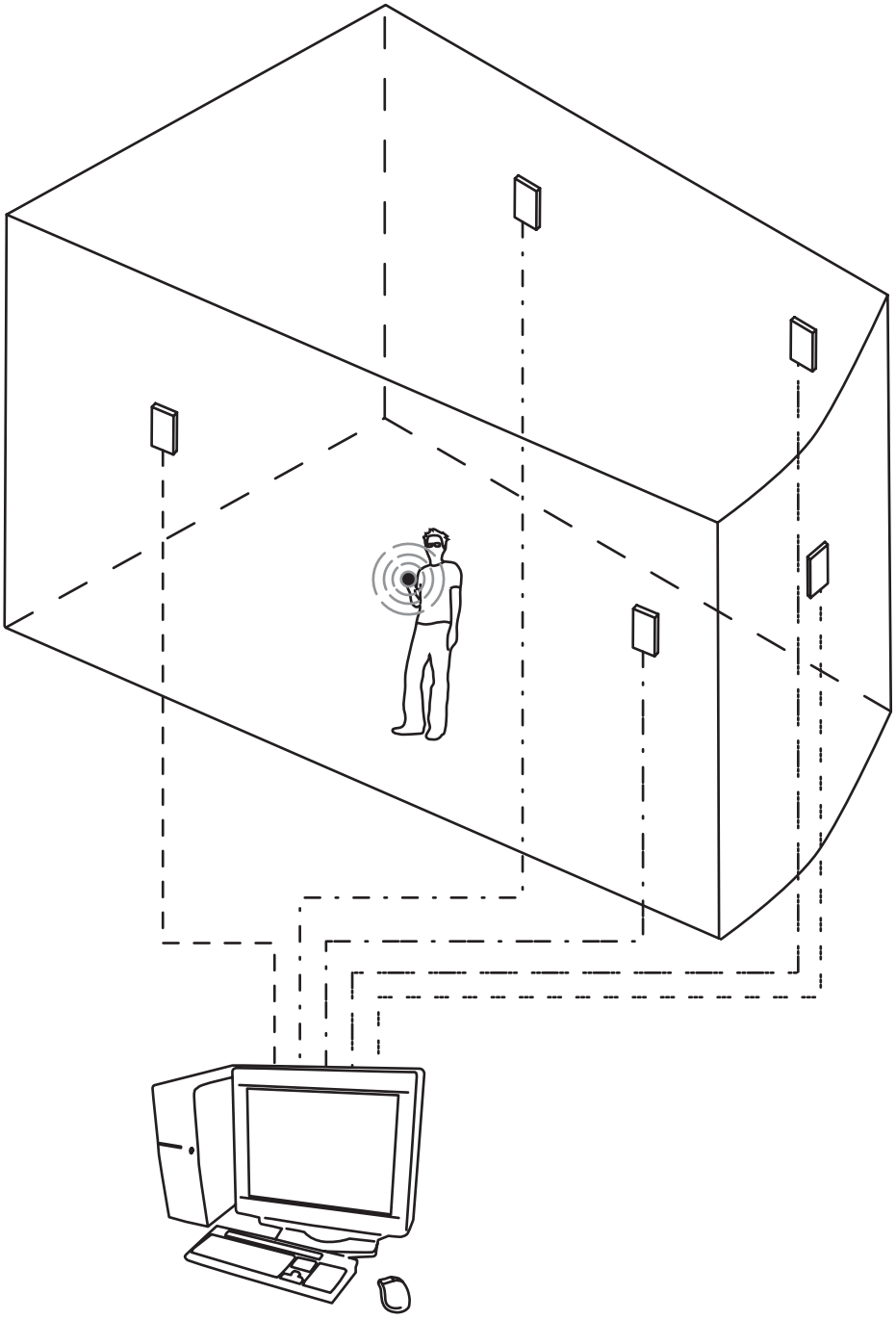


figure 1: single cell postioning system

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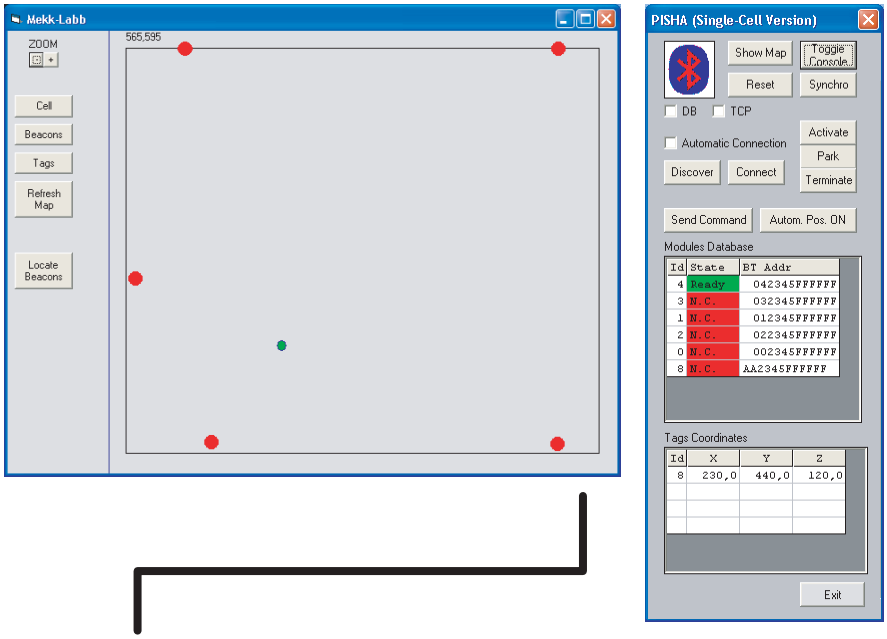
p.i.s.h.a. program capturing information from the tags and beacons, as well as taking care of system's configuration



XML relay server program that can serve the p.i.s.h.a. to a theoretically endless amount of other programs, in easily readable XML format

activeZones program exemplifying how to assign virtual events (in this case sounds) to the locations of a certain tag in a room

figure 2: flow diagram between programs composing the SSDK version 1.0 beta

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multi cell

Multi cell systems can give positioning coverage to big indoor areas. They work by overlapping single cell coverage areas and including a special software package to deal with tags moving from one cell to the next one. We call this process "roaming" and it is similar to the problem of maintaining a cell-phone conversation while moving, then the phone needs to get connected from one station to the next without interrupting the communication.

The technical special features that make this system able of supporting to be expanded to have multiple areas of coverage (that do not need to be physically connected) allow it to be single cell, too.

technology

Tags and beacons are different hardware-wise, what reduces the production cost drastically. The key feature is that the installation is wired. The information between the beacons and the control system is not transmitted wirelessly any longer, but through a RS-485. This type of communication port supports cables of hundreds of meters. As an example, Malmö's installation covers more that 500 sq. mt. and required 300 meters of cable ot be installed.

This is a very convenient feature when thinking about systems that are going to be placed for a long time in the same location. It becomes easier to monitor the proper functionality of the system and to handle things like how to bring power to each one of the beacons, since the data cable can cover that too.

how does it look like?

The following figure shows the configuration of a multi cell system at K3, out Swedish site. It includes 23 beacons and covers the whole cafeteria area (more than 500m2). The aim of the system is to provide with the information of location of tags for us to create applications on it. The pictures correspond to K3's cafeteria, and we include them in order to give an idea of the magnitude of the installation.

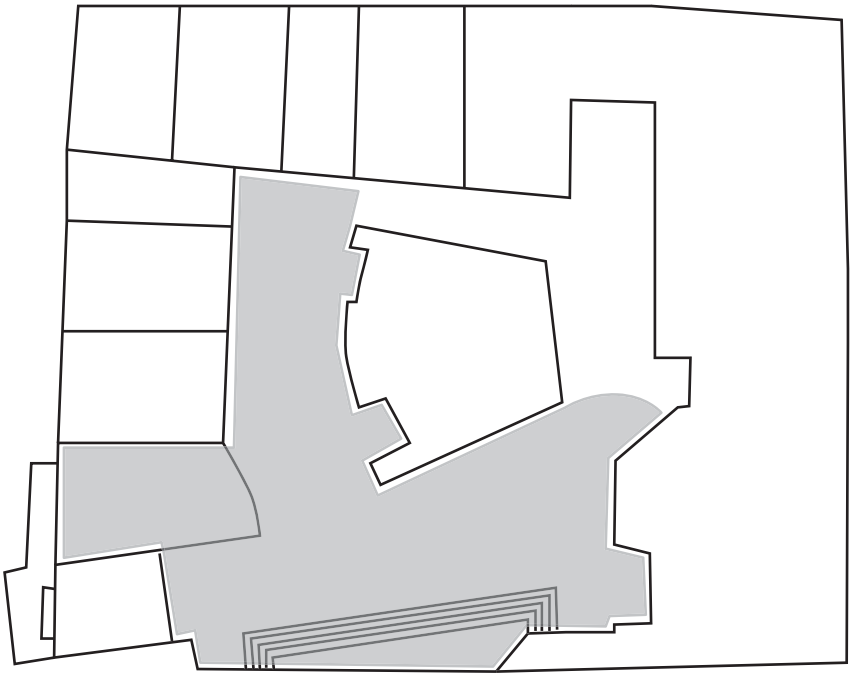

figure 3: coverage area at K3, Malmö University, Sweden, about 500m2

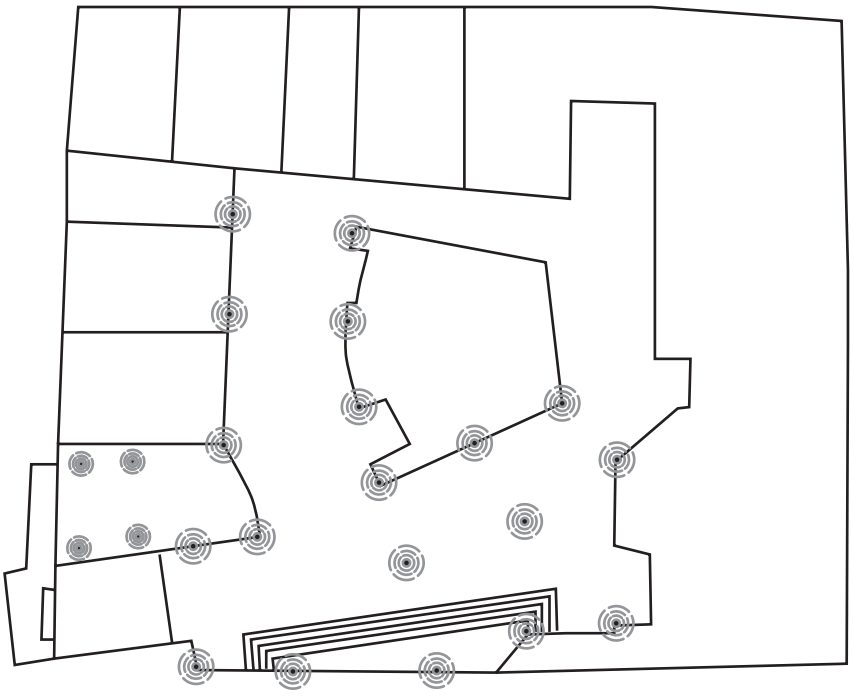

figure 4: beacons at K3, Malmö University, Sweden, all over the caferia area

figure 5: picture from K3's cafeteria

figure 6: a different view of the cafeteria

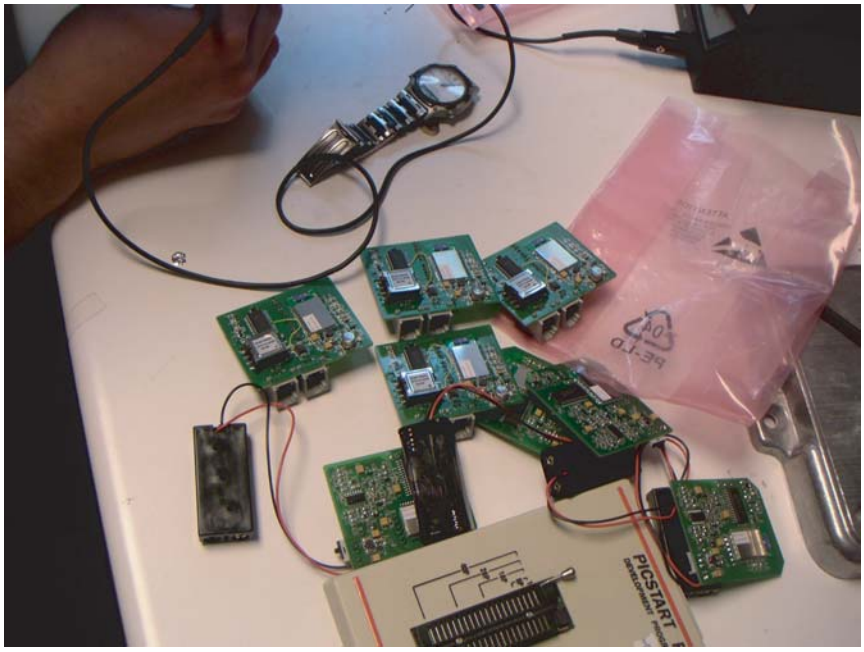

figure 7: beacons and tags for multi-cell systems outside their boxes

figure 8: beacon ready to be hanged from a wall

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space software development kit

SSDK is the software package that we are developing for making a physical programming of digital events (mainly sound) in a space counting with location facilities. This software could be plugged to any postioning system, and not only the one presented before, making some adjustments in the format the information is taken from the hardware and streamed into the application.

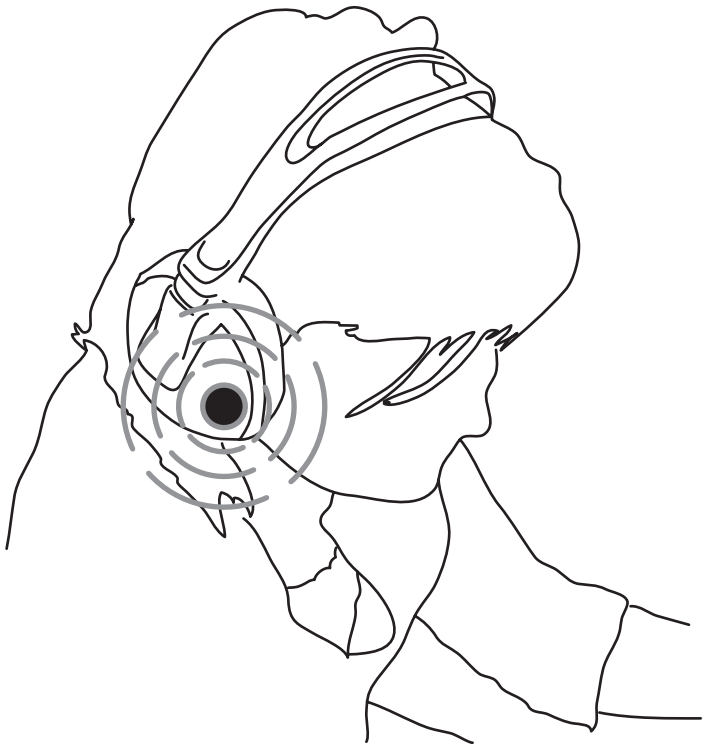
The SSDK is a collection of API's that support the creation of 3D tables with time, event, and location as axis. On the side, we have created a tool that allows us to physically place the virtual object on the space. It consists in an augmented positioning tag that allows the selection of events from a database and the insertion of them through pressing a button to a particular location. The programming of space can be made both through this tool, or through a graphical user interface.

technology

Version 1 beta of the software has been created with Java, from Sun Microsystems. The reason is that it allows the installation of the software on almost any OS existing in the market. It should me mentioned though that we haven't had the chance to check the software on any other platform but PC running W2K or WXP.

The software counts with two blocks: the XML streaming server, and the programming interface. Both blocks can be independent from each other. Actually, we have made a version of the streaming server running in Visual Basic, but we are not considering to continue that line of development, since we prefer to have full compatibility with as many OS platforms as possible.

The programming tag is counting with a small display as runs a microcontroller that takes care of the communication between the display and the interface back in the computer.



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embodied sound [proposal pdc04]

[This text is an extract of the proposal we send to PDC2004's arts track, it is pending to be approved but it illustrates one example on how to use the positioning system and the SSDK]

statement

In the origins of ubiquitous computing Mark Weiser spoke about which constrains would stop technology of becoming truly ubiquitous. In one of his writings back to 1999 he claimed that one of the main problems would be to find ways for offering a highly precise positioning system that could allow locating objects in the three dimensions of our physical environment.

Looking in the world of art, since the origins of "musique concrete" composers have been trying to position auditori stimuli in space, creating soundscapes that would take into account not only the sound itself, but its relationship to space, and the embodiment of the audience into the physical room and the virtual but tangible sound.

There is a clear link between Weiser's claims and the aim of soundscape composers, it is within this framework: sound art, ubiquitous computing, and augmentation, where I position my work, and the piece I am submitting to PDC2004.

The idea is that, in the future, virtual events will be easy to program in the space through the embodiment of the space-programmer. That will allow him/her to experience in the first place the physical quality of the work. To be precise what I have been producing over the last two years is not a piece of art in itself, but the virtual canvas of the sound artist. Thanks to the combination of a very precise positioning system that has been created for tracking movements of human beings inside buildings, together with a self developed software package, I want to present a tool for sound artists to fill up rooms with sound structures. What I will bring to PDC2004 will be a collection of sound pieces programmed by several artists especially for the event. The visitor will have the possibility of catching the sound from the air, delete it from the piece, or transport it to a different place within the installation.

why sound?

To use sound is just the first step that seems easy to understand and is culturally accepted. With this last sentence I try to address the fact that e.g. virtual reality helmets never succeeded as an everyday tool, but everyone is used to one or many forms of personal sound augmentation: walkmans, cell-phones, walkie-talkies, and others. The VR helmet was non practical, and it provoked a lot of discussion around being a too direct form of alienation from reality, making them socially unacceptable. On the other hand, sound has gained a very important position. There are experiments addressing the importance of music for situated actions, like efficiency at work. We have discovered the relationship between music and the sate of mind. Now it is the time when sound can be attached not only to the individual's activity or state of mind, but to his/hers relationship to space.

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collaborative processes

The production of the software and hardware involved in this construction are examples of collaborative processes of development. The concepts for the software and the so-called SSDK (Space Software Development Kit), and SHDK (Space Hardware Development Kit) are the result of two years of workshops, seminars, meetings and discussions around the topics location aware content and methods for installation of technologies. The software has been programmed by students at K3, as well as the Space Programming Suit, while the hardware infrastructure is the result of several years of research at the University of Zaragoza, Spain.

From a more theoretical perspective, the influence of location based services (LBS) in the development of collaborative processes seems to be clear according to the contemporary trends in interaction design. There are several approaches to what it means to be talking about LBS, but it is clear that Weiser's original demand about getting to know where people and objects are present in the physical world, is been explored from different points of view, and the one presented here is one more.

practicalities

The installation is a multi-user experience that allows the visitor to perform actions on the sounds that are virtually paced in the room. For the montage we need an empty room of about 3x3 meters. We need to hang 5 sensors from the walls, and each one of those runs either on batteries or ac/dc adapters. The room does not necessarily need to have walls, but we still need to have a way of hanging the devices somehow (columns, room separators, etc). We should count with two computers and 4 sets of wireless headphones.

The way the system works is as follows:

- each visitor gets a set of wireless headphones, those are having a special tag that can be located through ultrasound, this allows to know exactly where it is in 3D
- the infrastructure on the walls sends tones that allow the tagged headphones to triangulate their positions
- the tags send the information back to the computers that play the sound according the zone and send it via the wireless headphones back to the user
- there is a programming suit that consists of a set of headphones and a glove, this is the tool that allows to reprogram the original soundscape

About times, the installation of the system is the only thing that takes time. I would say that we could need about 2 hours to set up everything counting on installing the software from scratch in the computers, mounting the positioning system, and checking out the correct functionality of everything. When it comes to for how long the system could be running, so far we manage to have it running for 30 hours without draining the batteries, what means that we could have it installed during the whole duration of the exhibit.

disclaimer

The postioning hardware and P.I.S.H.A. software are property of the research group under Dr. Jorge Falcó at the University of Zaragoza, Spain. Some parts of the system have patents pending.

The Space Software Development Kit is under Open Source license, the concept was created by PhD. Candidate David Cuartielles at K3 Malmö University, Sweden. The Space Hardware Development Kit will be under Open Hardware license once finished, again created by D. Cuartielles.

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