Constructing assemblies for purposeful interactions

Pollini Alessandro
Communication Science Dpt.,
University of Siena
Via dei Termini 6,
53100 Siena
+0039 0577 270565
pollini@media.unisi.it

Grönvall Erik
Communication Science Dpt.,
University of Siena
Via dei Termini 6,
53100 Siena
+0039 0577 270565
gronvall@media.unisi.it

ABSTRACT

This paper describes the development of a modular system of interactive tiles to support therapists' in performing therapeutic activities together with impaired children in a swimming pool. This work is based upon a deep understanding of therapist work practice and it has been integrated with a creative approach along iterative design cycles. These activities created the foundation on which the *Active Surfaces* concept and prototype has been developed.

Active Surfaces support mobile interactions and dynamic configuration of assemblies of tiles. Each tile represents an interactive unit, able to communicate with other tiles and to exchange data. A tile is always aware of its position in respect to the others and able to provide a meaningful feedback in the interaction with the users. This enables the Active Surfaces to engage in the therapeutic activities.

Categories and Subject Descriptors

C.3 **[Special-purpose and application-based systems]** *Microprocessor/microcomputer applications, Process control systems, Real-time and embedded systems, Signal processing systems.*

General Terms

Performance, Design, Reliability, Experimentation, Human Factors.

Keywords

Ambient computing, Palpable computing, end-user composition, programming by example.

1. INTRODUCTION

The notion of ambient computing has been consolidated focusing on the design of distributed, pervasive and reactive systems able to communicate with us and to continuously adapt to our current needs and expectations [1]. These systems have developed hybrid interfaces capable to interpret and represent both the distribution and the embodiment of technologies. From an interaction design perspective the exploration of smart objects and distributed systems gain interest on social interactions in mobile gaming, collaborative activities and location based mobile services.

In order to examine and investigate these aspects we look at an evolutionary approach on ambient computing with the notion of Palpability. Palpable computing purposely addresses the way in which humans meaningfully can interact with distributed computational systems available in the environment. Palpable computing aims at supporting user control by composing and de-composing assemblies of devices and services. These assemblies are configurable by the user depending on the context, her needs and expectations. Consequently, these systems should support the continuous attribution and negotiation of meaning through interaction.

These challenges and others are addressed in the EU-funded Integrated Project PalCom: Palpable Computing – A new perspective on Ambient Computing (http://www.ist-palcom.org). This project uses the term 'palpable computing' to denote a new kind of ambient computing which is concerned with the above mentioned challenges in complex and dynamic ambient computing environments.

These themes become crucial if applied to critical domains such as health care and rehabilitation. In this paper we will present a design concept supporting rehabilitation practice embodying some of the qualities that creates the foundation of palpable computing. The main inspiration for this application comes from the practice built around rehabilitation activities and from the activities performed in the swimming pool to rehabilitate disabled people.

In their current practice, motor and cognitive rehabilitations are mutually separated. Specific tasks and tools are designed for the motor physiotherapy; whereas other tasks, aids and tools are defined to support the acquisition of cognitive skills. The two activities are usually never integrated.

The swimming pool represents a privileged environment for rehabilitation. At the public swimming pool in Siena a volunteer association provides training and group activities for disabled people. The swimming pool by itself represents a powerful setting, because the water supports the body and takes the weight off the joints. Movements within the water are easier and less painful. Moreover, water is a great 'equalizer' for disabled people who find that their movements are easier and less different from those of non-disabled people while inside the water.

Our aim is to join cognitive and physical rehabilitation objectives by providing the children with meaningful activity games supported by a distributed system of smart surfaces. The application system relies on the specification and reference implementation of a virtual machine for PalCom devices, the PreVM, designed to match the evolving needs within the PalCom project [2].

1. ACTIVE SURFACES

Active surfaces is thought of as mobile smart devices that can serve for mobile gaming and rehabilitation activities. In the following section the concept and the early working prototype are introduced.

The tiles act as building blocks that can be combined with a library of content (e.g. images, sounds and pictures). Furthermore they have reactive behaviors in relation to different input actions and orientation. Each tile provides outputs as visual or tactile feedback to support the accomplishment of the tasks and to guide the patients in the interaction as described in the scenario below.

Today exists' three kind of Active Surface components; an Assembler Tiles and a number of 'normal' tiles. Apart from these there is also a user interface, the MUI [3]. The PreVM is the platform running under these components, being a language-neutral virtual machine designed to support object oriented languages running in low power consumption systems. PreVM is dynamically typed and requires each language to implement its proper type checks (e.g., the "instance of" relation in Java), but on the other hand imposes no restrictions on the type system of the languages that it supports [2]. PreVM programs are deployed in binary components which are instantiated as run-time components, objects that encapsulate a set of classes and their required and provided interfaces.

The 'normal' tiles are the ones used in the different activities and games together with the different users. Then there exists a privileged tile, the Assembler Tile is used by the therapists to program the other tiles. The MUI is used in a pre-activity phase to create general game logics and rules that later can be used in the pool. A therapist downloads the general rules created into the Assembler Tile and brings this to the pool. Now the therapists can assemble different 'normal' tiles using the Assembler tile to support a wide range of activities. The tiles themselves once assembled constitute a network of physical (and software) objects that communicate and exchange data and are able to recognize their relative positions.

These features allow constructing meaningful configurations of different tiles. Each configuration is intended as an assembly of components. The therapists can configure these assemblies of components to define rehabilitation tasks. They can save successful configurations, keep memories of previous configurations and generate new assemblies to support patients' specific needs. The rehabilitation activities enabled by the active surfaces allow a smooth integration of cognitive and physical task.

The Active Surfaces concept accounts for the need of configurability, constructability, modularity, physicality and creativity in rehabilitation practice. 'One' Active Surface consists of a tile, measuring 30*30 cm. Each Active Surface is thought of as a modular unit that can communicate with the others by its six sides. The tiles are able to recognize their relative positions in respect to other tiles. A number of tile components can be assembled to constitute a network of physical (and software) objects that communicate and exchange data. Many qualities of palpable devices are embodied in the Active Surfaces concept. Today a prototype is being used for evaluation purposes based upon a Basic Stamp 2 micro controller and IR communication. These tiles offer limited functionality, but sufficient for initial trials and proof-of-concept. The next generation of tiles embedding the full vision and the palpable framework is currently under development together with University of Aarhus (Denmark) and the Lund University (Sweden).

The main idea is to rethink the environment of the pool, making it a place for rehabilitation and play activities. As described above the pool is designed for swimming: the water serves as the mean of interaction. People usually don't have any (strong) relation with the pool by itself: the edges and the bottom are not conceived for any purpose of interaction. The design process aims at re-considering the surfaces of the pool and to change the activities that usually take place there [4],[5].

From an interaction design perspective the goal is to design new activities for the rehabilitation by designing enabling environments and tools. The Active Surfaces is the concept that embodies these issues. The surface of the pool becomes active re-designing the bottom, the edges and even the water surface. In this vision the floating tiles constitute one of the main supports for the interaction and the therapeutic activity.

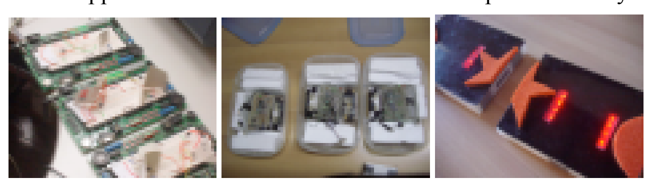

Figure 1. Initial working prototype under construction and final result

2. PALPABLE QUALITIES

Active Surfaces represents an exemplar application for the framework of the palpable computing. It consists of embedded devices and distributed services. Palpability emerges as a property-in-use of the tiles' assembly. Dynamics of physical-logical construction/ deconstruction, mobile interaction and services communication sum up the palpable qualities of the application.

Being conceived as an assembly, active surfaces could provide a valuable example of physical construction / deconstruction of components. In that way the physical construction of assemblies [2] provides end-users with control of the system behaviour and adaptation to the context. The Active Surfaces constitute assemblies on different levels: on the logical level the therapist can define what the rules are and what the purpose is. On the functional level the user can mark out the relations and the sequences. Eventually, on the physical levels user can define which patterns and connections can take place.

To support end-user composition, the Active Surfaces is also complemented by a Migrating UI (MUI) browser mechanism[1]

[1] The MUI End-User Composition Tool is used for programming the behavior of the tiles. MUI, developed within PalCom project

for programming the rules and the behaviours to be instantiated in the tiles. The therapist then creates patterns by physically building tiles' sequences [6]. The tiles address also scalability, offering the opportunity to produce scalable solutions still relying on low level resources management. Palpable computing systems, and indeed any ambient computing system, involve an heterogeneous mix of distributed, embedded devices with different capabilities. The palpable computing system, and Active Surfaces as such, must provide scalability and stability across different devices so that errors in one part the system do not propagate to other parts of the system. These features are supported by an appropriate degree of decoupling between different parts of the implementation.

At the same time the understandability of the system can still be guaranteed. This also concerns the balance between system automation and therapist' (i.e. user) control: the tiles have to preserve the understandability and support the users to maintain control over the technology.

Flexible ad-hoc networks support the connections among single devices where each tile preserves its own identity thus dynamically seeking for available tiles in the vicinity. The tiles continuously inspect what communication processes are taking place at the moment looking for specific connection on all its sides.

The concept also enables the exploration of the relation between change/stability in configuring the tiles. In fact the assembly' behaviors are instantiated in physical configurations that can be saved, reused (also in part) and instantiated in different physical patterns. She can show the right pattern (sequence) to the system and record(save) the configuration by using an assembler tile. Being a flexible system it has to guarantee a proper level of persistence as well. The dynamics between configurations' change and stability may address the future practice of rehabilitation and the way in which the Active Surfaces could support it.

3. SCENARIO

Along the different phases of the work analysis we used scenarios to evaluate, together with our stakeholders, how the defined concepts could suit their needs and to envision possible usage of the final tools. Scenarios themselves were used as design objects and they evolved along the design process being created, refined and also sometimes dismissed [7].

The Active surfaces concept was refined through an iterative scenario-based design process. Most of all, the concept has been assessed and validated in order to try out the envisioned solutions. These sessions with users have informed the next phase of the design process: the prototyping. During these sessions we decided to focus on floating tiles to make a proof of concept through the early prototype. The prototype we developed has been used for early exploratory tests with the targeted end-users, both therapists and patients, during ongoing rehabilitation sessions in the swimming pool.

As mentioned above, the Active Surfaces is today based upon a number of tile-components. There are two kinds of tiles: the Assembler Tile (AT) and the normal play tiles (about 15 to start with). A part from these different tiles there is a graphical user interface called the MUI that is used to create general input/output schemas for different games.

In the scenario below the Tiles' states are described through the use of a "happiness" state. These terms are used with specific meanings in the scenario and in the code development. We consider different states of happiness (conditions' satisfaction) for the position and orientation of the tiles in the assembly.

- *SideHappiness* means that a tile realizes that it is correctly connected on a particular side. On the side(s) that are Happy the tile provide the users with HappySide feedback. If all its sides are correctly aligned, LocalHappiness is instead achieved.
- *LocalHappiness* means the tile is properly connected to the others and it has on each side the tiles it was looking for. It is in the right position and it is correctly orientated in the assembly
- *AllHappiness* means all the tiles satisfy the *LocalHappiness* and, knowing that all the others are sending that feedback, they realize a global happiness, satisfaction of the activity game.

These different happy-states are also visualized in figure 2.

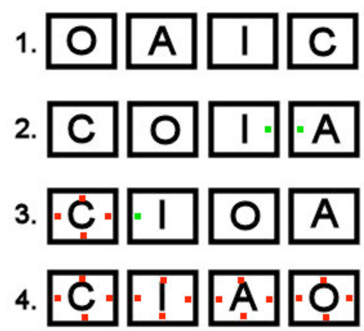

Figure 2. Row 1: No happiness.

Row 2: HappySide for 'I' and 'A' between the 'I' and 'A' sides (Green feedback on HappySides).

Row 3: 'C' is LocalHappy (Red feedback) and 'I' has one HappySide (Green feedback).

Row 4: All tiles are LocalHappy, this gives a complete happiness within the system.

4.1 Active Surfaces in use

The configuration of the activity is performed outside the pool, maybe even at the home of the therapist/trainer or in a remote office. This can also be done in the vicinity of the pool, but there is no specific need for that from a system perspective. The therapist brings the assembler tile (AT), attach it to the Service Browser (SB) and configure the future activity by setting configurable game parameters (e.g. Type of Game: Position game, Output Mode: Blinking Light).

The AT can have either a cable connection (i.e. RJ-45 Ethernet) or a wireless one between the system (e.g. a laptop or a hand-held device like a PocketPC) hosting the SB and the AT.

(www.palcom.dk) at the University of Lund, lets the therapist browse existing tiles and their configurations. She can discover the tiles currently in use, and design a new exercise in a MUI browser (running on a PDA or a laptop).

The therapist can now bring the AT to the poolside and align the tiles she would like to include in the game in the 'winning' position or pattern. Now the AT is connected to the structure of tiles and this initiates a number of activities. The therapist triggers the motion sensor on the AT with a 'one touch'-input. This sends a broadcast message to the connected tiles to remember their own and their neighbour's positions.

After executing this command all the tiles have memorized their own and their neighbour's position and orientation. They also notify the therapist that the configuration and assembly of the game is successful completed through the requested output (since the tiles now are in the AllHappy state).

Figure 3. Exploring the use of the Active Surface prototype

The therapist is now ready to start the activity with the patient and throws the tiles into the pool. The child tries different wrong alternatives by moving the tiles around the pool.

At first the child puts two tiles aligned correctly, but still not with the complete solution presented. This gives a local feedback that the two tiles are correctly placed while the final feedback is still not given. This LocallyHappy, or even only HappySide provides the user with a (for example) light output, isolated to the correctly aligned side(s). The child finally aligns all the tiles in the right position. This gives the final output. The game is solved.

4. DISCUSSION

The concept of Active Surfaces elaborates on a new challenging view of the rehabilitation practice and mobile game design.

The scenarios we developed are based on the idea of end-user composition, mobile interaction and control and it seems promising and interesting for the stakeholders. In particular, users appreciate the idea of being supported by ready-at-hand technology, easy to program and to manage. The Active Surfaces provides them with the possibility to improve the day by day rehabilitation practice.

The concept elaborates on a new challenging view of construction complemented with deconstruction of physical assembly. The therapist is asked to manipulate and physically configure the tiles while the dynamic and self-configuring discovering of components occurs. This guarantees minimum skills in technology and programming for the users.

Active Surfaces provides the therapist with the possibility to adapt the technology pursuing extreme changing and flexibility beyond system stability. In that way we have situations where total control is desirable, but has to be complemented with sense making and meaning attribution of events.

Palpable computing can be seen as extending ambient computing with additional characteristics for user control. Palpable computing systems offer not only invisibility (the capacity of unobtrusively performing computing tasks in the background environment) but also visibility, that is, the capacity of making visible to users what they are doing and what they may do. Moreover, systems should offer both construction (the ability to support end-user composition of devices or services to form new devices and/or services) and also deconstruction, that is, the ability to disassemble a device or service into its constituent parts to enable understanding and manipulating of each part individually [2].

Palpable computing may constitute the framework for the definition of design guidelines for mobile interactive systems. Challenges in the shape of dichotomies as the ones described above, can serve as means through which the designers might interpret and re-define pervasive applications.

5. ACKNOWLEDGMENTS

Thanks to Laura Cardosi, Maria Grazia Burroni and the therapists at the Functional Rehabilitation Unit of the "Le Scotte" hospital, Siena, for their open-minded collaboration and continuous support during fieldwork and participatory design. The research was part of the EC IST PalCom project.

6. REFERENCES

[1] Weiser, M. The Computer for the Twenty-First Century. *Scientific American*, pp. 94-10, September 1991.

[2] Schultz, U.P., Corry, E., Lund, K.V. Virtual Machines for Ambient Computing: A Palpable Computing Perspective *OT4AmI ECOOP Workshop Position Paper* 2005.

[3] Svensson, D., Magnusson, B., Hedin, G. Composing ad-hoc applications on ad-hoc networks using MUI *Proceedings of Net.ObjectDays, 6th Annual International Conference on Object-Oriented and Internet-based Technologies, Concepts, and Applications for a Networked World*, Erfurt, Germany, September 2005.

[4] Greenbaum, J. Kyng, M. *Design at Work*. Hillsdale, NJ: Erlbaum, 1991.

[5] Marti, P., Rizzo, A. Levels of design: from usability to experience. *HCI International 2003, 10th International Conference on Human - Computer Interaction*, Crete, Greece, Lawrence Erlbaum Associates. 2003.

[6] Gronvall, E., Marti, P., Pollini, A. Rullo, A, Active Surfaces: a novel approach for end-user composition *NordiCHI, Fourth Nordic Conference on Human- Computer Interaction* 2006 (submitted)

[7] Rizzo, A., Bacigalupo, M., Scenarios: Heuristics for action *Prooceedings of XII European Conference on Cognitive Ergonomics, D.J. Reed, G. Baxter, M. Blythe (eds.)* 2004.