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Adaptive Interfaces for People with Special Needs

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Abstract. This paper covers those aspects of modern interfaces which expand and enhance the way in which people interact with computers, like multi-touch table systems, presence-detection led displays and interactive virtualized real-life environments. It elaborates on how disabled or conditioned people take great advantage of natural interaction as interfaces adapt to their needs; interfaces which can be focused towards memory, cognitive or physical deficiencies. Applications size-up to serve specific users with customized tools and options, and are aware while taking into account the state and situation of the individual.

1 Disappearing Interfaces

Ubiquitous computing [1] represents an actual view of what information technologies may very well transform into in a near future. As interfaces fade into the background, taking part in our every move without us noticing, new ways of interaction soar to give power to the users where and when they need it. Natural interaction enables infinite possibilities and fills in the gaps for those with special needs. In an environment of passive–intelligent computing no one is left behind and personal limits can be easily forgotten.

1.1 The Necessity of Ubiquity

In classic terms, an interface is a point of connection between humans and machines, located in a specific place from which people can communicate with a computerized system in order to get things done. This traditional concept may be already outdated, and as technology changes we are beginning to discover new definitions for interfaces.

First of all, an interface should not be thought of as a “place” in which to work at, but as an inherited capacity that we have to communicate with the system. It should not depend on where we are or what specific task we want to achieve.

This concept of *the system* instead of *a computer* evolves from the fact that the average number of computers in a room keeps steadily increasing and, in order to maintain an environment of ubiquitous computing, will augment until we reach a point in which hundreds of computers will come to be "invisible to common awareness. People will use them unconsciously to accomplish everyday tasks" [2].

1.2 Transparency and Intuition

The whole point of having disappearing interfaces [3] in ubiquitous computing is not for people to change their lifestyle into constantly giving feedback to every machine which surrounds them, but rather quite the opposite. It is the system, through it's multiple sensors and communications, who "knows" what's happening in the environment under which it operates. It would be logical to think that there is a great deal of changes to be made in the way computers behave and organize in order for this to happen, but we would be wrong. Even though it is the computers which need to enter the human world and not the opposite, the main adaptation needed for the disappearance of interfaces needs to take part in human psychology.

People should not need to change their lifestyle in an abrupt manner in order to be integrated into the system, and the best way they could help with the transition is to demand things to stay as close to traditional as possible, in a functional way. This means that their presence should alter and create sufficient input for the system without adding new routines in order to achieve tasks that they normally expect to do.

Lets imagine a man of advanced age at home. His condition would have required the assistance of a nursemaid in order to achieve certain tasks, but his house equips a complete set of sensor mechanisms and computers setup to help him in what he may need. For example, he may need to be reminded to get his keys and turn off the lights when going for a walk. The system, when alerted by the main door being opened, will do a quick check on lights and key-hanger status, and play an acoustic signal so that the man is notified on remaining tasks before exiting. On hearing this signal (which may consist of a voice message), the man will effectively have been reminded to turn off the lights and get his keys.

His intuitive actions did not differ from those made in case his house had not been equipped with the intelligent system but, even so, they were correctly acquired by the sensors and the adequate signal was processed and sent to him. Not only did the system detect the problematic situation, but it also would have noticed when this situation was resolved.

2 Appearing Interfaces

Once disappearing interfaces have been embraced, and we no longer need to adapt our routine to work with computerized systems, a new milestone arises. Passive computing will belong to the past, but we will still need to work on tasks which require powerful and complex tools. High definition displays with multiple software applications are indispensable for most activities, so what is the ultimate gadget for this moment in time, when interfaces as we know them today have lost all sense?

To answer this question we must first examine the spotlight of the emerging interfaces. They are focused on availability, intuitiveness and scalability. We need an always-ready, easy to use and non-centralized interface. But it is not one unique gadget what will cover these requirements, as this would defeat the purpose of ubiquitous computing; but rather a collection of interfaces, each connected to the system, which offer specific functionality for each type of task.

2.1 Proximity-Sensing Led Displays

At AmILab (Ambient Intelligence Laboratory of the Universidad Autónoma de Madrid) we're researching and developing a new kind of led display that fit's perfectly with the disappearing interface concept. It consists on a matrix of light-emitting and sensing led diodes which can expand to cover large areas like walls or tables. The main function of this type of display is to present valuable information where it is needed.

This kind of low-cost and low-definition interface is perfect for integration under unused surfaces which surround us. While not active, these walls and tables are indistinguishable from those we use today, but when an alert pops-up, we're instantly notified with a text or graphic message up front. The goal of this type of interface is to provide a notification and information workspace with minimal interaction.

A simple example would be a programed reminder to take a pill. At each specified time, a quote with the name/color and number to take will appear before us, and a simple touch of an "`OK`" button (also drawn on the display) would notify the system of our acknowledgement. The user's understanding of the underlying technology is not necessary, and no special manipulation instructions are mandatory in order to operate and take advantage of this display.

2.2 Multi-Touch Table Interfaces

Another gadget which represents future interfaces is the multi-touch table. This advanced interface, which we are also developing at Amilab, consists of a high resolution display, capable of rendering anything we can get from a modern display; a tactile and fiducial[1] sensing mechanism which captures interacting

[1] Fiducial: A small special figure, with an unique ID, drawn on objects which can be placed on the table.

elements in any given time [4]; and a central processing unit integrated into the table, and merged into the global system.

We could imagine this type of interface as a classic computer with a touch-input display, but the possibilities available are far more powerful and should not be confused. The most important difference is the integration of the multi-touch table inside the intelligent environment system. It's functionality is not given by the contents of the integrated CPU, but by the information about people and personal preferences that it can obtain from the main system, and which will be used to offer each user the functionality he or she may want.

Interaction Interaction comes from using hands and objects which we place on the table, and move around to manipulate the interface. Due to the technology used to capture interacting items, multiple people can use the table simultaneously without waiting their turn; thus we obtain the multi-touch capability.

From the perspective of people with reduced mobility, there's a drastic trim on the precision and complexity of actions needed to use the interface. Gestures made with hands will include actions like tapping, dragging, pressing, resizing (by joining or separating two fingers), etc... and even customized ones.

Intuition is also an important topic in this subject, as learning can suppose a severe handicap for people with memory limitations such as those who suffer of Alzheimer's disease. If the gestures used equate those for manipulating physical objects, no new concepts need to be learned. For this to happen, the visual interface must be built in such a way that it's usage can be fully accessible through such gestures.

Visual Interface The visual interface itself plays an important role in the success of the multi-touch table. It is designed so that manipulating and navigating through menus is direct and intuitive, minimizing the time spent learning how to use it. The aesthetics will take in mind gestures, combinations and precision of finger actions so that no task is too complex and no screen too bloated, reaching the sweet spot between simplicity and functionality.

New design rules come up when focusing on gesture interaction. Things like important information being hidden under the hand when dragging a slider must be taken into account [5]. Even human anatomy is vital for calculating gesture distances and hand movements, so that strain doesn't appear after prolonged use. In the chapter *Natural Interfaces* we will approach these concepts.

There's another main matter which keeps us innovating: interfaces which help and teach while serving a purpose. Our goal is to expand functionality as the user gets the hang of a tool. This is oriented to any user, but specially to people with conditioned learning capabilities. This will be further explained in the *Adaptive Interfaces* chapter.

3 Natural Interfaces

Our hands are greatly underrated and underemployed in terms of interface manipulation by today's standards. In a social atmosphere, people move, gesture and interact through a broad range of movements of which the dexterity of our hands has special importance. If carefully observed, patterns with a fairly standard lexicon of gestures and movements emerge [6].

3.1 Gestures

These patterns serve to standardize an association between gestures and actions, which remain consistent throughout every application used. Some common gestures [7] are already beginning to signify standard actions on multiple multi-touch devices we can use today:

Tap The action of briefly touching with a finger an item on display. It's linked to the action of opening, activating or selecting something.

Drag The action of pressing and moving a finger around the display to acquire moving, sliding or spinning a visual element. For sliding, the movement of the finger is typically rectilinear, while a spinning action requires the movement of a single digit (usually the index finger) in a circular motion.

Fling A moderately fast and short drag of an element in order to browse through lists or large areas. It's implementation is normally followed by "physical" effects of inertia and friction, meaning the flinged object will stop gradually rather than abruptly.

Pinch With two fingers which touch a same visual element at the same time, the action of dragging them closer in order to zoom out or reduce it's scale. It can also be used to decrease the value of a scale.

Spread The opposite of pinch, the action of separating two fingers which touch the same element in order to zoom in or make it bigger. Conversely, this action could increase the value of a scale.

The main difference between actual input peripherals (mouse, keyboard, sketch-pad...) and direct physical manipulation is the layer of indirection. We move a mouse in order to move a pointer drawn on the screen, and we draw on a special tablet to create brush strokes on a painting program. Peripherals act as the middleman between the interface and us, and with natural interfaces we remove them allowing a direct and unconverted form of input. There no longer exists the necessity of a cursor or a slider to select and scroll through menus, as we can tap and drag on the physical screen as we would handle real objects that we use every day.

While most people would see this as a commodity improvement, others who had difficulty dealing with complex mechanical peripherals will suddenly be able to "do" what they meant to in an interface, without actually having to make the mouse translate the actions for them. No longer will they need to be reminded that the alternative menu, which pops out when the right mouse button is clicked, contains a "resize" option. They can simply pinch or spread the object in order to achieve the action, just as they would deform a piece of clay.

3.2 Spoken Interaction

Voice recognition has been since long ago an area of experimentation for human interaction with computers, and it's integration to natural interfaces is direct and evident [8]. Voice commands resemble simple application orders with minimal translation so that no physical interaction is required for certain tasks.

The boundary of *simple application orders* must be present while developing the interface. As a standard principle, all control orders can be assumed to be adequate for voice commands as they consist of unitary and concise sentences.

Different methods of interaction should not always be exclusive, but can also work in parallel. If we want to control our TV, we should be able to do so by means of the most intuitive action we find in each context. If sat down on the sofa, using the remote control is not a problem. But if we're carrying something with both hands or hand manipulation represents a problem due to mobility limitations, and we need to turn the volume down a notch, we should be able to do so via a voice order.

A great advantage is the reasonably low-cost facet which implies on the establishment of this technology inside an intelligent environment. Microphones, strategically situated to hear from every angle, and their corresponding controlling system will suffice as input peripherals [9].

3.3 Collaboration

As part of human nature, we tend to work on assignments as a community. Each person might have a designated job, but it is integrated inside a chain of workflow that consists of several other people. A community as such needs to share information and appliances both internally and externally. It can be considered a natural way of interaction for the purpose of obtaining results.

Natural interfaces go beyond usage and appearance. Beneath the local workbench, the interface is connected to a broad network in which all the relevant information is available for consultation. Multiple individuals can access the same document and use it simultaneously, being aware of every person using it and having the opportunity to discuss their progression with them.

Once again, distance and limitations fade away as natural interfaces fill in the gaps when traveling is not an option for certain people or under certain circumstances.

4 Adaptive Interfaces

Interfaces as we know them offer a certain spectrum of functionality, most of which is always available for anyone who has the correct formation. These people will have no complaints about the arrangement because they are capable of taking full advantage of the appliances and do not mind the extra menus, items and options. The aim of this approach on interfaces is not focused on advanced users, but on beginners or mid-learning people. It also covers some important terrain on people with special needs or learning impediments.

Adaptive interfaces offer the user an adequate functionality depending on their learning status, their requirements, and/or their capabilities. The assessment of such parameters is integrated into the interface itself, and not asked for (as some of the traditional applications do).

There are two main processes by means of which functionality will expand to satisfy the user's demands. The first one consists on the progression of the user at learning and being skillful at a certain stage, thus the interface will acknowledge it and begin unlocking advanced features the user may begin to take advantage of.

The second progression is oriented to people with learning difficulties. Rather than the interface deciding if a new tool should be made available, the choice is awarded to a social assistant or a teacher so that they can set out a learning road-map that they consider adequate for the user.

Adaptation is also taken into consideration as a personalization feature. The interface is aware of the identity of the specific users accessing to any of its applications, and examines their profiles and limitations in order to offer a consistent state of data and functionality. Their progression must not only be saved between sessions, but stored in a global repository so that it can be accessed from any other interface, no matter their location.

5 Conclusions and Future Work

Ubiquitous computing helps dissipate the potential problem of information overload. Interfaces spread out and integrate into the environment until they metaphorically disappear, making their appearance again when and where they fit into context. This context becomes increasingly flexible as new interaction methods are invented, and the facilitation of interface usage augments the capabilities and reduces the limitations of people who suffer of reduced mobility.

The fabrication of modern natural and adaptive interfaces handles other kinds of limitations such as memorization difficulties or learning handicaps, and offers progressive expansion of functionality to keep up with the user.

In order to be able to offer this ambiance of intelligent computing, a sturdy and reliable infrastructure background is vital. This infrastructure will begin with the inclusion of a main central system which acts as the brain of the environment, using every input available to take decisions and to be aware of the physical world. The construction and configuration must be systematized so that a standard set of communication buses and interface slots are found with minimal hustle.

All interface types, regardless of their nature, must use a common protocol to communicate with the main system and even directly with other peripherals. This can be made possible through a common translation layer, or multiple possible protocols.

At Amilab we believe in breaking boundaries between humans and machines, and our work is focused on being able to reach out and help people with their tasks, no matter how. Our area of interest begins inside the intelligent home, and expands to accompany the user throughout their daily actions.

We feel that these new methods of interaction can offer extra functionality to the average person, and bridge the gap for people who can normally not achieve tasks by their own. To do so we are developing a set of new natural adaptive interfaces so that people with special needs can work, and which adapt to their personal potential.

The steady pace of the evolution of our projects gives lets us put to work our ideas under very short notice, and check for incoherences and misleading roadmaps *in situ*. Some projects have reached a maturity at which they can serve as base for other more recent ones, as is the case with our main central system: the Blackboard [10].

Our goal is to fully develop these interfaces and integrate them in an interconnected environment, giving volunteers the opportunity to test and give feedback about real life usage. We're concerned about designing applications which fulfill our client's requirements at an individual level, and serve the purpose of teaching at the same time as helping.

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