Techniques for Interacting With Small Devices

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***Abstract*— Digital mobile devices keep reducing their size as time goes by. The limiting factor is no longer battery size or electronics miniaturization, but the dimensions of the input and output hardware devices that mediate the communication between the user and the machine. In this paper, the difficulties of interacting with small screen devices are underlined and some of the most promising techniques to address this issue are explained. These techniques include the use of magnetic field detectors, mobile phone cameras to track movement, tangible interfaces and voice controlled virtual joysticks.**

Keywords-interaction techniques; small device interaction

I. INTRODUCTION

Recent evolution of digital mobile devices has produced smaller and smaller products, to the point that some of them can be hidden inside the clothes or even implanted under the skin. The limiting factor of this miniaturization is no longer electronic design or even battery size. The main issue that conditions this constant reduction in the dimension of these mobile devices is the size of the input and output hardware that is required to implement the user interface [1]. The size of a screen should be big enough for a user with normal visual acuity to read the text, and buttons in a keyboard should be big enough for a normal sized finger to press them.

Although the size of the mobile devices keeps shrinking, the fingers of the users, or the size of the text they can read keep constant. If the use of smaller and smaller digital products wants to be fostered, existing technologies should be used creatively, and new technologies should be developed to implement a new generation of user interfaces that can overcome the difficulties of interacting with small mobile devices. Our main purpose in the rest of this paper is to describe some of the most promising innovative interaction techniques, giving a small sample of what interaction might look like in the near future.

In the following section we define what we understand by small mobile devices. In Section III we describe some of the techniques that can be used to interact with these small devices, and we present our conclusions in Section IV.

II. WHAT ARE SMALL MOBILE DEVICES?

Cellular phones are by far the most common mobile device available nowadays. It has been estimated that there were about 6.000 million of these devices in the world at the beginning of 2012 [2]. Most cellular phones fall under the category of small mobile devices because their design is not optimized for interaction and this produces a number of difficulties when the interaction tasks are carried out, namely low readability of small screens and hard to push small buttons.

But, even smaller mobile devices have been marketed, making the problem of fluid and effortless interaction even harder. For example, many devices designed for open air activities, such as GPS systems or training computers have screens of about 2.5’’ in diagonal. *Siftables* are small blocks that include wireless communication capabilities, sensing and a small screen of about two inches in diagonal. This design offers a whole new set of tangible user interface techniques to interact with digital information, making use of our high dexterity in manipulating digital objects [3]. Some of the smallest devices that have been designed are the *Telebeads*: electronic wearable jewelry objects that can be used as mnemonic aids and communication appliances to help in the managing of social network data. These systems have screens as small as a fraction of an inch [4].

III. ASSORTED INTERACTION TECHNIQUES FOR SMALL DEVICES

According to Fitt’s Law [5], target size and interaction time are inversely proportional. But in the small touch screens of portable devices, real state is very limited, so how big should targets be for a comfortable and fast interaction? Interaction guidelines offer different views on the subject [5]. In the *iPhone Human Interface Guidelines* [5] it is suggested that the minimum target size should be 44x44 pixels. *Windows Phone UI Design and Interaction Guide* says that the minimum should be 26x26 pixels, and *Nokia’s Developers Guidelines* propose 28x28 pixels. However, the average index finger is between 45 and 57 pixels wide, more than any of the above recommendations.

In the case of very small touch screens, the so called *fat finger problem* is exacerbated [6]. The finger occludes most of the screen real state and interaction is greatly hampered. In these situations, it has been proposed to move the touch sensitive hardware to the back of the device, so that the screen is visible and the position of the finger is shown by a small cursor [7]. Traditional touch screen pointing techniques try to alleviate screen occlusion by using offset

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cursors or a method called *Shift* where the user is shown a representation of the area occluded by the finger in a free region of the small screen. The exact position of the finger is shown by means of a cursor, and this helps performing the positioning task. When the *Shift* technique was compared with the interaction on the back of the device, it was shown that *Shift* did not work for screen sizes below one inch diagonally, whereas back-of-device interaction was successful almost independently of screen size.

Another approach to the interaction with a small screen is based on a magnetic field detector. Located behind the screen, this device is capable of very accurate positioning and leaves the screen completely visible [8]. In this study, a 1.5 inch screen was used, with a resolution of 280 x 220 pixels. The magnetometer used was capable of providing an angular accuracy of about two degrees at a cost of five US dollars. Users wore a small magnet in the index finger, which provided a useful range of about 10 cm, for a total active area of about 300 cm^2. This setup increased the operational area offered by the original 1.5 inch screen by a factor of more than 50.

TinyMotion is a software that uses the camera of a mobile phone as an input device. *TinyMotion* analyzes in real time a series of images taken by the mobile phone camera and extracts information about the movement of the phone. In order to evaluate the applicability of this approach, the *TinyMotion* team developed a number of applications and video games, all of which were controlled by moving the mobile phone is various ways [9]. In an application called *Mobile Gesture*, the user presses the *OK* button before writing a character, and then presses the # button to indicate the end of the writing process. Writing in this case means moving the mobile phone with the camera on to recognize the strokes of the character.

The recognizer code can detect western characters, punctuation symbols and more than 8,000 Chinese and Japanese characters. It takes about 20 ms to recognize a western character and about 40 ms to recognize one of the Chinese or Japanese characters (the hardware used is a Motorola v710 mobile phone, an unmodified model bought in 2005). *TinyMotion* has undergone several evaluations. To begin with, an informal usability test was carried out with 13 users. The results were very encouraging because the system was found to be very responsive. Many different backgrounds for the camera were used, and most of them worked very well. Even pointing the mobile phone camera to the blue sky gave good results.

The only failures to detect the movement were those with very extreme lighting conditions or very rapidly changing backgrounds such as a dark room, the surface of a computer screen switched off or pointing the camera through the window of a moving car. Some users even found it more convenient not to move the mobile phone and move the other hand in front of the camera instead. One of the most innovative interaction techniques for small screen is the combination of sensing technology and tangible user interfaces used in the *Siftables* project [3]. Tangible user interfaces are based on the notion of providing physical handles for digital objects, thus being able to access digital information by manipulating common objects. In some instances of tangible user interfaces, the system projects graphics onto the handles and in others, these handles are simply used to control more conventional graphical user interfaces. Some of the advantages of tangible user interfaces include [3]:

- Less significant cognitive requirements than an equivalent graphical user interface.
- Faster interaction
- Two handed input of data is supported, although multi touch screens offer this capability for more conventional interfaces.

The other technology that that *Siftables* project uses is the Sensor Network User Interfaces (SNUI). These are sets of elements capable of communication and sensing, that can have an organized behavior and be manipulated so that they conform a tangible user interface to access digital data. *Siftables* are small square tiles of about 36 mm per side and 10 mm thick. Each of them has a small color screen, an accelerometer, a set of infrared transceivers, a battery and an RF radio. With this hardware, the *Siftables* can sense their own motion, and also contacts with another objects. They can detect movements like elevation, tilting or vibration. They can also detect other tiles other tiles situated close by.

The communication capabilities of the system allows tiles to share information with other tiles or with a central computer located in the vicinity. The capabilities of the *Siftable* system are allowing the development of new interaction techniques in the domain of SNUI's, analogous to the more familiar metaphors of graphical user interfaces:

- Shaking or piling several of the elements at the same time could be interpreted as classifying them as belonging to the same group.
- Putting several tiles together could form a bigger screen to show large documents.
- Shaking vertically could mean *yes* and shaking horizontally could mean *no*.

A prototype photo sorting application has been developed by the *Siftable* team to illustrate the possibilities of SNUIs [3].

The hands can be avoided altogether in the interaction with very small screens, thus eliminating the *fat finger problem*. The *Vocal Joystick* is a system that allows the control of a pointing device by means of the voice. The technique can be used for onscreen selection, arbitrary point navigation and path following as required in drawing applications and videogames [10]. *Vocal Joystick* can recognize verbal and non verbal vocalizations, and other sound characteristics, such as loudness and pitch, and transform them into movements of the cursor. The process is continuous, and mouse movements are generated without delay. The *Vocal Joystick* can be implemented in an average personal computer and only requires a microphone and a sound card. The sound produced by the user is continuously monitored, and the movement of the pointer is immediately generated. Vowel quality depends on the articulation configuration of the mouth, and depending on the ability of the user two methods can be used: four direction or eight direction modes. In addition to the above, the system can also recognize a number of short sounds that can be used as trigger actions to perform functions such as a mouse click. There is a standard set of sounds, but adaptation to particular users is also possible, improving the performance of the interaction. As users become more experienced with *Vocal Joystick* they can reach interaction speeds comparable to hand operated joysticks.

A technology that completely eliminates the need of a screen is the use of passive magnetic tags. Magnetic tracking does not need a direct line of sight, but in the case of motion capture devices, they require active sensors, and this involves complex equipment and a wire connection between the detectors and the processing unit. On the other hand, passive magnetic tags can be powered by radiofrequency energy sent by the base station, and if attached to common everyday objects, these can be tracked, their orientation can be detected, and they can even respond to other actions such as pressure, finger position, etc. With this passive magnetic tag technology, and a few plastic objects, an interesting digital musical instrument with a tangible user interface has been developed.

A total of sixteen small plastic objects have been used to control a music producing application. Some of the objects have three orthogonal magnetic tags to monitor orientation in addition to distance to a reference point.

Each tagged object produces a different output when it is close to the receptor. An attached computer generates the corresponding MIDI messages that are sent to a number of music synthesizers. In addition to the sound output, the computer also generates background graphics. Although tags working in neighboring frequencies may show small interferences, all of the tagged objects can be used together.

The general public has had a very positive reaction to this system, and because of the simple interface, its use is very intuitive. The output of the system is somehow limited, so improvements are being made to turn this enjoyable demo into a full fledged musical instrument.

Another approach that can be taken is that of implanted interfaces. Just as pacemakers or hearing aids can be surgically placed underneath the skin, small input and output devices can also be permanently implanted under the skin of the users. In a recent work, it has been proposed that user interfaces could be implanted to allow users to perform simple interactions with their own bodies. In this study, a simulated implant was made to obtain an initial qualitative feedback on the use of implanted interfaces. A device with three inputs (button, tap sensor and pressure sensor) and three outputs (LED, vibration motor and piezo buzzer) was placed on the left arm of four volunteers and covered with silicon artificial skin. The volunteers had to perform some simple everyday tasks, such as taking a bus or asking for directions to go to the post office. As a secondary task, they had to pay attention to the output of the device and *answer* with the appropriate input control. In general, the participants considered that the device was easy to use, and all felt that the vibration motor was the easiest output channel to perceive. All users were able to see the blinking LED when looking at it, even in direct sunlight. Although the authors conclude that it is feasible to operate small and simple user interfaces implanted under the skin, they put forward some challenges associated with the use of these interfaces. Regarding input, it has to cross the skin, so the use of sound or light is somehow limited. Also, accidental operation of the controls has to be considered and avoided. Output is normally visual, auditory or tactile, and the bandwidth is small. For example, in the case of visual stimuli, typically a small LED flashing through the skin is used. Tactile feedback could be specially appropriate because it would not be perceived by anyone except the users.

IV. Conclusion and Future Work

The continuous reduction in size of digital mobile devices is presenting new challenges to interaction designers. When input and output hardware is reduced beyond a certain point, traditional interaction techniques have to be applied in creative ways or new interaction techniques have to be developed [11-15] to meet communication needs between the user and the system. In this paper, several innovative techniques have been described, including the *Shift* method, magnetic field detectors, the use of mobile phone cameras to track movement, tangible interfaces and voice controlled pointer management systems. Future work should widen the spectrum of the techniques reviewed here, and provide some kind of categorization.

Educators and practitioners should be familiar with these new trends in interaction with small devices to prepare future professionals for the interface design scenarios that they will meet in their careers.

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