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Tactor Devices

Using Tactile Interface Designs
for Mobile Digital Appliances

A Practice-Based Research Thesis
for the fulfilment of a
Master of Design Degree

College of Design, Fine Arts, and Music
Massey University, Wellington

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2003

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Abstract

This Thesis focuses the potential of communication interfaces that use tactors (tactile actuators) to improve user interactions with mobile digital devices which are currently based on audio and visual technologies. It presents two product concepts, which use tactile signals to enable new ways in tele-operations, such as tactile telecommunication and tactile navigation.

Tactor interfaces, although still in its infancy as elements of modern digital communication and technology, have considerable potential for the future as designers attempt to maximise the use of all human senses in people's interaction with technology. Only the military and a few entertainment companies have introduced tactile signals into Human-Computer Interactions (HCI). Human touch perception uses the hands as the main sensing organs. They perceive tactile signals while handling, typing or navigating with digital devices and receive direct confirmation of physical actions. In contrast to other senses, touch perceptions are based on interactions with the sensed objects.

The study analyses, experiments and evaluates if these interactions are useful in interface designs and recommends how tactile stimulations can be introduced to interface designs besides images and sounds that dominate the control of current digital appliances. Tactile actuators and sensors enable devices to use tactile signals, such as impulses and vibrations, to communicate with the users. Users and tactor devices will be able to communicate in a physical and direct way. Touch reflective interfaces, could react like living creatures that respond to touch, for example a cat that starts purring when touched.

Digital product design is always challenged to create human-computer interactions that meet people's needs. Designing digital devices is difficult because they are not necessarily three-dimensional objects. They are stimulator of the human senses and can be as small as the sensing nerve endings that detect sensations. By miniaturisation, form and function become invisible and Product Design is increasingly incorporating Process Design that explores and enables new interactions between users and products to work interactively

and efficiently.

The study is divided into four chapters:

Chapter 1 gives an introduction to the thesis.

Chapter 2 presents a survey on current literature which examines the five human senses to define the limits and possibilities in interface design. It reviews current research on materials and technologies as well as the psychology and physiology of touch as a potential sense in human-computer interactions. It evaluates the technical feasibilty of tactile signal performances and how they could be used as tele-touch codes in navigation and telecommunication.

Chapter 3 is focused on primary research undertaken to extend the knowledge in tactile sensing. It includes experiments, questionnaires, and concepts that give examples how tactor interfaces can be used in tele-operations. This section focuses on specific user groups, that may primarily benefit from tactile signal transmissions, such as sight and hearing-impaired people or professionals who have to deal with limited perceptions like fire fighters, for example. These case studies are aimed at exploring and expanding a wider range of possibilities in tactile device innovations in the networked society.

Chapter 4 gives a conclusion of the research.

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Glossary

- *Bluetooth*: Short-range radio link intended to replace cables and to connect mobile digital devices.
- *disambiguate*: to clarify, to clear up
- *fricative*: sound or vibration caused by friction
- *GPS*: Global Positioning System
- *HCI*: Human-Computer Interaction
- *LPS*: Local Positioning System
- *SMS*: Short-Message Service
- *Tactor*: Tactile actuator
- *UMTS*: Universal-Mobile-Telecommunication System

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1 Introduction

This practice-based research presents the analysis, conceptualisation and evaluation of alternative ways to improve human-computer interactions by tactile signals. With an emphasis on mobile device operations, it explores tactor interfaces to open up tactile information channels. New ways of using touch sensations to transfer information from human to human, human to machine, and machine to human have been analysed, designed, and evaluated. The study explains how tactile sensations work and how they can be used in interface design to transmit information. It presents new ideas which provide new possibilities in mobile tele-operations.

Secondary and primary research examines, analysis, and evaluates touch and touch interactions between users and computers. The introduction of tactor interfaces is not a panacea but it can help to make mobile device operations more user-friendly. Two design concepts about telecommunication and tele-navigation have been realised to show the potential of mobile tactor interfaces for information input and output. The study also explores aesthetics to bring fun and new experiences to users.

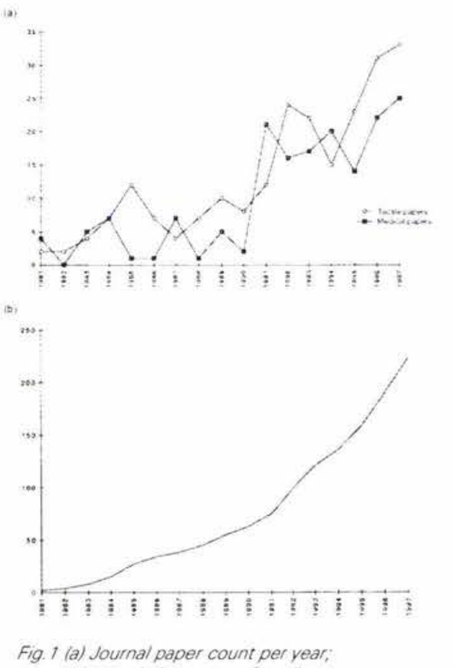

Fig. 1 (a) Journal paper count per year; (b) cumulative count of tactile papers

The development of tactor displays has been investigated in the USA since the 1950s. The first aim was to find new ways for the deaf to receive information.[1] Due to the mechanic character of the displays and the size of the apparatus, those devices were created for static use only. They have been found to be inadequate for mobile use. Mobile tactor displays had been out of reach until recent developments in miniaturisation emerged. New technologies put into focus tactile signals for mobile device operations. Nicholls and Lee report on an increasing number of publications about tactile sensing in scientific and medical papers from 1991 onward.[2] The publishing rate was doubled in 1991 and is still increasing every year (fig.1).

Tactor interfaces are useful in various applications. Electronically generated touch feedback can help to operate digital devices that normally do not cause any mechanical tactile feedback. Tactors provide a channel of human-machine communication that was lost when mechanical machines became digital. According to Doerrer the use of touch can help to organise tasks more efficiently or allow information be received simultaneously to other perceptions like hearing and seeing.[3]

Touch has a big influence on our whole psyche and feedback system. Tactile feedback makes learning easily, provides better precision and makes some tasks more enjoyable. Touch is significantly undervalued in human-computer interactions, although direct contact and tactile feedback is an important source of information in many man-made tools or machines. The screwdriver, a hammer, a pen or tooth brush are good examples of simple tools that require good tactile feedback for their efficient use. Every mechanical process produces pressure, friction, vibration or heat that can be detected by the sense of touch. But, the decreasing physical interaction with automatic digital machines has led to a decreasing use of tactile information about the state of a tool or a machine.

1.1 Touch - A Potential Sense in Interface Design

Touch sensations are not new in interface design. They are always present when hands are used in HCI. Buttons, regulators, keys, and scrolling wheels give tactile feedback. They confirm an action by a click, clatter or impulse. This feedback is passive rather than active, because it is only a mechanical reaction. Active tactile feedback, generated by electro-mechanical tactors can transfer much more information through touch. Digital machines that utilise tactile feedback can interact with their users and can inform users about the state of machines, working processes, or hazards. They can judge interactions and may support operations by sending tactile signals such as vibrations or impulses about right or wrong use, expectations and warnings.

A silent way of tactile data transmission, independent of hearing and vision, can be used to enhance or even substitute hearing and sight perception. The emphasis on the conceptual work in this study is to demonstrate different examples of tactile interaction processes. It includes human factors' analysis, concept explorations and design.

Tactile sensation or touch does not exclude anybody. The user groups engaged in this study included the young and able-bodied as well as old or disabled people. Even paralysed people normally have touch-sensitive areas on their body. Deaf and blind people totally depend on touch interactions to communicate with others.

It is important to state that the sense of touch is fairly underestimated in western society and current product design. Touch is the most important sense during childhood and touch experiences or the missing of them effect our life. According to Ackerman premature infants who spend the first weeks in an incubator develop much faster when they are touched and massaged.[4] Massaged babies gain weight as much as 50 percent faster than unmassaged babies. They are more active, alert, and responsive, more aware of their surroundings, better able to tolerate noise, and they orient themselves faster and are emotionally more in control.

What is good for babies cannot be bad for adults. Considering an increasing number of isolated people, stress and depression in modern societies, touch might be an alternative medium to communicate and to express emotions, respect, and reliability. The handshake, the clap on somebody's shoulder, the kiss or the embrace introduces a conversation and builds up a confidential atmosphere. Even the slightest touch is recognised subliminally and may have an influence on behaviour. Ackerman states:

> "In an experiment in Boston, a researcher leaves money in a phone booth, then returns when she sees the next person pocket the money; she casually asks if they have found what she lost. If the researcher touches the person while asking for their help, touches them insignificantly so that they do not remember it later, the likeli-

hood that the money will be returned rises from 63 to 96 percent."

Touch and touch feedback are extremely necessary for our well-being. The technology-driven interface design has not taken into account this human need up to the present day. It is timely to introduce touch output signals and force feedback into human-centred design of digital appliances. Touch sensations by pressing buttons are minor information compared to the capability of human touch to convey complex data. It can be used in many ways to interact with machines and people. Redesigning the Morse Code into a tele-touch code, for example, is one possible approach to silent tactile telecommunications.

1.2 Trends in Human-Computer Interactions

Nowadays people cannot avoid contact with digital technology, even if they do not want to. Communication, transportation, professional or leisure activities are nearly unthinkable without using computer-aided systems. This trend of increasing use of computers will surely not diminish in the future but will certainly be enforced and increased. Tactor interfaces are one option to improve computer interfaces.

A new interface design and the redesign of human-machine interactions have become evident with the advancement of digital technologies. Most human-machine interactions will become human-computer interactions in the future.

Not only experienced people have contact with computers - all kinds of people are confronted with them. For example, senior citizens have to use cash dispensers to get money, or ticket machines before they use public transportation. To design easy and intuitive communications between humans and machines is particularly necessary for user groups that do not have any experience with computers.

1.3 Increasing Complexity of Digital Devices

Operating machines with an increasing number of functions provided by technical systems does not only imply advantages for the user. Since every function has to be started or selected, and some function-specific parameters have to be set and the operation of machines becomes more complicated with every additional feature. One solution is to add more buttons and switches to the control panel, but it is limited by space that is available and the amount and complexity of the functions offered by the device.

Satisfying interfaces for digital device operations are difficult to design because increased complexity also increases the psychological and physiological demands on users. This can easily cause frustration and stress. Consequently, product design has to create easy processes and functions in new forms.

Tactor Interfaces present one alternative in interface design that is based on human perception rather than on technical possibilities. It is clear that the practice, which puts the emphasis on purely technology-based visions, will be obsolete in the future. Such a technology must be complemented by:

- User-friendly designs, looking at new ways, users will interact within digital systems;
- New services and applications that become possible with new technologies.

1.4 New Technologies

In the past, technical devices offered limited numbers of different functions. A significant increase in functionality can be observed, today, mainly through the success of modern microelectronics. Miniaturisation and cost reduction of electronic circuits enable the designer to provide mobile appliances at little extra costs compared to static systems. Tasks that never could be performed without powerful and cheap microelectronics are now executed by new mobile digital devices. Some examples of this trend are:

- Laptops that are small but as powerful as static computers;
- Small digital video recorders and camcorders providing a wide range of possibilities that was limited to professional devices in the past;

- Mobile phones serve as organisers, alarm-clocks, cameras and provide video-games;
- Mobile MP3 music players that are as small as pocket lighters.

There are many possibilities for new mobile applications. Due to the breakthrough in mobile telecommunication technology, high rates of mobile data transfers can be provided. New mobile services that demand a high data flow are possible: videoconferences, complex navigation systems, and virtually augmented realities are recent innovations brought about by new technologies.

1.5 Innovations

In the future, technical elements will become even smaller and more powerful. Various radio signal systems will offer the networking use of mobile devices. It is expected that major innovations will come from new designs and new interactive processes within mobile systems.[5] Useful ways of HCIs and comfortable interfaces are becoming more important than the technology itself. Product design and interface design are key activities to make the digital networked world accessible.

Who could foresee the incredible success of Short Message Service (SMS) that provides text-messaging on mobile phones, for example? Cell-phones were originally designed solely for verbal communication. This example shows how unpredictable and complex new ways of human-machine and human-human interactions could be in the future.

The success of SMS surprised most people in the mobile telecommunication industries. Few have predicted that this user-unfriendly service would be accepted. There was hardly any promotion for or mentioning of SMS by network operators until SMS started to be successful.

Mainly the younger generation accepted SMS as their medium because it was difficult to use. High entry barriers to learn the service became an advantage because parents, teachers and other adults were unable or unwilling to use it. A whole new alphabetical or numerical phonetic shorthand has emerged because SMS messages are difficult to type.

They are shortened because people try to say as much as possible with a few keystrokes. Abbreviations such as "C U L8er" for "See you later" have sprung up for time-saving and coolness. Short signs like Smilies that look like happy or sad faces are composed of colons, dashs, and brackets. They are used to reduce the abruptness in short text messaging and to show the mood of the person in a way that is difficult to express with words .[6]

The success of SMS is a total paradox to common marketing and innovation strategies. It is a good example for the need of 'lateral thinking' as proposed by Eduard De Bono, one of the most influential promoters of a non-linear thinking.[7] Combining things which have not been combined before is the key to innovations. It is almost impossible to come up with totally new ideas, but putting existing ideas into new contexts or combining ideas in formerly unthinkable ways offer a range of new options, such as tactor interface designs.