# ISO's Work on Tactile and Haptic Interaction Guidelines

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**ABSTRACT**

Tactile and haptic interaction is becoming increasingly important both in assistive technologies and in special purpose computing environments. While considerable research exists, the current lack of ergonomic standards in this area results in many systems being developed without sufficient concerns for either ergonomics or interoperability. This leads to serious ergonomic difficulties for users of multiple, incompatible or conflicting tactile/haptic devices/applications.

A new set of ISO standards is being developed as a set of new parts of ISO 9241 Ergonomics of Human-System Interaction by a working group of ISO TC159/SC4 (WG9 Tactile and Haptic Interactions). These standards, which are being dual-tracked as both ISO and CEN standards, provide ergonomic requirements and recommendations for haptic and tactile hardware and software interactions, including guidance related to the design and evaluation of hardware, software, and combinations of hardware and software interactions.

This paper starts with a short introduction on the background of tactile and haptic perception and devices. Thereafter, we will introduce the work plan for WG9 and the documents that already are, or will be under development in 2006/2007. More details are provided on the guidelines document, including an introduction of the framework that will be used to structure the guidance. The first working draft of this document was developed by experts from 6 countries, and combines guidance from 40 research papers and from 10 ISO standards.

**Keywords:** haptic, tactile, guidelines, standards.

## 1 INTRODUCTION

### 1.1 Introduction to the sense of touch

The sense of touch is often defined as the sensation elicited by non-painful stimuli placed against the body surface. The sense of touch is a very complex system with many different receptors in joints, muscles and the skin, each having its own characteristics and responding to different stimuli [10]. The system is responsible for many perceptual qualities such as mass, size, structure, resistance, roughness, pressure, orientation, etc. Although people are inclined to think that only vision and audition can shape our mind and enable us to understand the world, the case of Helen Keller who became deaf and blind in infancy and learnt to communicate solely on the basis of touch shows that this is not true.

The skin contains several different types of mechanoreceptors to process stimuli, of which the following four main types are found in hairless skin: Pacinian corpuscles, Meisner corpuscles, Merkel disks and Ruffini endings. Generally, stimuli will evoke a response in multiple types, and the experience will be based on the combined response in mechanoreceptors (e.g., [7, 8]) Thought to be less important for touch perception are the hair follicles and the bare nerve endings. The Meisner corpuscles react to light touch and lower frequency vibrations (resulting in a perceptual quality described as light touch or flutter), while the Pacinians react to gross pressure changes and higher frequencies and result in a flutter or vibration percept. The Ruffini endings enable pressure perception while the Merkel disks are thought to be involved in tactile form and roughness perception. The Merkel disks also differentiate between the form of the indentation (e.g., sharp versus flat surfaces) and are used for high-resolution tactile discrimination. The unspecialized free nerve endings are responsible for detecting stretch stimuli other mechanical stimulation such as pressure. There are four additional types of so-called muscle and skeletal mechanoreceptors also used to keep our balance and move about in the world: the muscle spindles (primary and secondary), the Golgi tendon organ and the joint capsule mechanoreceptor. Through joint angles and muscle stretch, they provide information on limb position and movement and on forces. Information that is also necessary to derive information about other mechanical properties of objects in the environment, such as force, stiffness, viscosity, and mass [9].

The sense of touch is the earliest sense to develop in an embryo [5]. Within eight weeks, an embryo shows reflexes based on touch. Also, most of the major reflexes of full-term neonates are based on the sense of touch [11]. The brain uses tactile sensations to develop awareness of the body in space, to perceive space, time, shape, form, depth, texture and all other kinds of (physical) object properties. Touch is indispensable in building a complete picture of the world around us as we know it.

Touch is also essential as feedback mechanism in motor control, illustrated by the ease with which we can find the light switch in the dark and also by the difficulty to walk with a numbness leg, to control equipment or light a match with numbness fingers, or to talk after local anesthesia. Touch is not only critical in the interaction with objects, but also between individuals. Some examples include: in greetings (shaking hands, embracing, kissing, backslapping, and cheek-tweaking), in intimate communication (holding hands, cuddling, stroking, back scratching, massaging), in corrections (punishment, spank on the bottom), and of course in sexual relationships.

Finally, imagine what it would be like to live without touch. Even if you survived as a newborn without many basic reflexes, it would be doubtful if you could grow up into a normal functioning human being, it would be difficult to stand, walk, and talk; to interact socially with others, to find your way in dusk or down, to hold a glass without breaking it, to eat nuts without dropping some, to enjoy the feel of smooth silk, to interpret the back patting of an acquaintance, the stroking of a friend and the tender loving care of your lover, to turn pages one by one, to find your keys in your pocket, to relieve your headache by stroking and so forth and so on.

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### 1.2 Introduction to tactile / haptic devices

Haptic devices process information in both input and output directions. In the case of feedback information, they are often used in conjunction with a visual or auditory display because of their particularly useful characteristics. However, visual or auditory displays are sometimes inappropriate due to either human or environmental impairment. When haptic devices are not used in conjunction with devices linked to other senses, they must be designed very carefully. The interaction produced by a haptic device has to be a combination of:

- a method of indicating the point where control is required;
- a means of executing commands or some control;
- a means of providing feedback to the user.

Each interactive device will use one or more of the following physical attributes:

- Force
- Shape
- Size
- Friction (including slipperiness and viscosity)
- Texture
- Mass / weight
- Hardness/softness (compliance)
- Temperature
- Orientation
- Location
- Vibration
- Duration
- Motion
- Deformation

The above considerations influence the form that any attempt at classification of haptic interaction devices should take. The following is a list of interaction techniques that provide direct correspondence between real and virtual environments:

- moving a pointer relative to an object;
- moving the object itself;
- possessing the object;
- applying forces to the object.

However, when working within the rules of a virtual physical space, anything is theoretically possible. For instance, navigational cues could be represented by haptic temperature differences (following the "getting warmer" principle applied to getting closer to a point). This can be an advantage to experienced users but, if misused, it can also be a huge disadvantage to naive users. Care must be exercised when mixing physical metaphors and any guidelines should indicate where clear advantages can be gained in the clarity of information presented to the user.

#### 1.2.1 Future devices

In generating guidelines for tactile / haptic devices and applications, it is important to bear in mind future developments in this rapidly expanding area of interaction. Factors that contribute to the future growth in the range of devices include:

- the rate of increase in computer system power, especially CPU performance;
- developments in micro-mechanical and electronic technology;
- novel concepts for applying haptics;
- the perceived need for haptics in task applications.

The innovative thinking applied to interaction will itself generate the need for new applications and advances in technologies to provide solutions. The result will be the production of novel interaction devices which will utilize combinations of attributes which had been rejected previously.

### 1.3 Introduction to ergonomics standards

Ergonomic standards go beyond providing consistency and interoperability. They help enhance usability in a number of ways including: improving effectiveness and avoiding errors, improving performance, and enhancing the comfort and well-being of users. Ergonomic standards provide a basis for analysis, design, evaluation, procurement, and even for arbitrating issues of international trade.

As part of the process of expanding ISO TS 16071 into the international standard ISO 9241-171 [6] (see also Figure 1 for ISO's organizational structure) Canada prepared a set of tactile and haptic guidelines [3]. These guidelines were largely adapted from [2] and [12]. When the committee drafting ISO 9241-171 considered these guidelines they noted that they were not limited to accessibility issues and suggested that they be used as the basis of a new standard on tactile and haptic interactions. The inaugural meeting of the Working Group on Tactile and Haptic Interactions was in October 2005. As of 2006, the following countries are actively participating in WG9: Canada, United Kingdom, The Netherlands, Sweden, Germany, Japan, and Australia.

## 2 WORK PLAN OF WORKING GROUP 9

WG9 started working on ISO 9241-920, the document on guidance for tactile and haptic interaction. ISO 9241-920 includes the same two step compliance procedure as many other parts of the 9241 series. Developers are first to identify the guidelines which apply to their particular situation. This procedure does not allow developers to use this as a means of ignoring guidelines that are inconvenient. Rather it allows for the documentation of why selected guidelines really do not apply. Guidelines that are recognized as applying then become part of the requirements that need to be satisfied. The second part is to evaluate whether guidelines that apply have been satisfied.

In addition to ISO 9241-920, there are a number of other standards for tactile and haptic interaction now being planned. TC159/SC4/WG9 is currently looking for potential ergonomic contributions to each and for ergonomic experts to help in their development.

- ISO 9241-900 Introduction to tactile and haptic interactions will be a technical report providing an overview of the 900 series. It will be regularly updated to include references to the various parts of the 900 series and to other standards containing guidance relevant to tactile and haptic interactions. Work on this part will commence late in 2006.

- ISO 9241-910 Framework for tactile / haptic interactions will provide a detailed explanation of the model used to initiate work in ISO 9241-920 and the definitions used for the 900 series. This model will identify the various dimensions and properties of tactile/haptic interactions, based on in the GOTHI model [1]. ISO 9241-910 will also describe how this model can be used to analyze, design, and evaluate interfaces that make use of tactile/haptic interactions. Work on this part will start in 2006-2007.

- ISO 9241-930 Haptic / tactile interactions in multimodal environments will provide guidance specific to immersive and other multimodal environments. The start of work on it is not yet scheduled.

- ISO 9241-940 Evaluation of tactile / haptic interactions will provide guidance on evaluation methods suited to evaluating tactile and haptic interactions. This part will require mechanisms for evaluating the overall effects of the multidimensional nature of tactile and haptic interactions that is identified in ISO 9241-920. The start of work on it is not yet scheduled.

- ISO 9241-971 Tactile / haptic interfaces to publicly available devices will provide guidance relating to specific accessibility concerns of using tactile / haptic interaction in public environments and systems, and especially those systems where assistive technologies cannot be connected by users. The start of work on it is not yet scheduled.

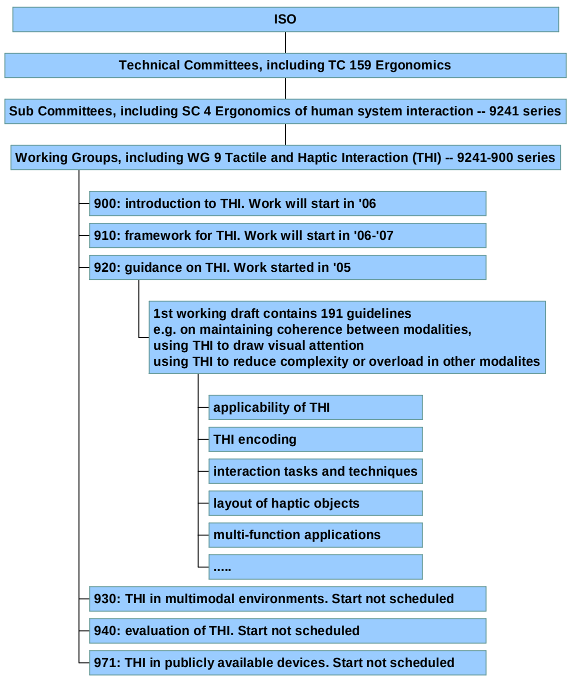


Figure 1: The position of Working Group 9 (WG9) in ISO's organisational structure, and the documents planned as output of WG9.

Additional parts may be added to the 900 series, as the occasion (both in terms of research and practice) provides. One possible area of future addition would be a part providing guidance on the design of tactile / haptic devices. However, it is anticipated that such further parts will not start before 2008.

## 3 THE STATE OF TACTILE AND HAPTIC GUIDANCE

ISO 9241-920 is collecting ergonomic knowledge from both research and practice and presenting it in a technology idependent manner intended to remain relevant along with the various evolutions in tactile / haptic devices and applications.

The first working draft of ISO 9241-920 structured 191 guidelines obtained from 40 research papers and from 10 ISO standards. The second working draft used the initial structure evaluate, organize and combine these guidelines. It has also identified a number of areas where further guidance is needed.

The second working draft of ISO 9241-920 includes ergonomic guidance in the following areas:

- *Applicability considerations for THI*, including: limits to effectiveness, workload considerations (efficiency), user acceptance considerations (satisfaction), meeting user / environmental needs (accessibility), health and safety considerations, and security and privacy.

- *Tactile/haptic inputs, outputs, and/or combinations*, including: unimodal use of THI, multi-modal use of THI, intentional individualization, and unintentional user perceptions. Typical guidance in this section includes: providing information on tactile/haptic elements; providing navigation information; using appropriate interaction styles; providing alternative input strategies; avoiding or minimizing fatigue; providing additional information to support exploring objects; maintaining coherence between modalities; combining modalities to enhance spatial memory; enabling users to change modalities; enabling users to individualize tactile parameters; and enabling the overriding of force feedback.

- *Attributes of tactile/haptic encoding of information*, including: using properties of objects, using perceptual attributes, and combining attributes. Typical guidance in this section includes: using familiar tactile/haptic patterns; making tactile/haptic encoding self-descriptive; using sensory substitution; using appropriate spatial resolution; using appropriate object size; using apparent location; using apparent motion; coding information by temporal pattern; encoding information using vibration amplitude; enabling users to discern different simulated textures; preventing vibration of non-activated vibrators; coding information by vibration frequency; and preventing spatial masking.

- *Content-specific encoding (what to encode)*, including: encoding and using textual data, encoding and using graphical data, encoding subjective data, and encoding and using controls. Typical guidance in this section includes: encoding and using textual data; asynchronizing the use of Braille; displaying tactile/haptic graphics; maintaining separation between walls of objects; using kinesthetic information to enhance spatial location; using landmarks in tactile maps; providing scales for tactile maps; using size and spacing of controls to avoid accidental activation; avoiding difficult control actions; and using tactile/haptic controls.

- *Layout of tactile/haptic objects*, including: resolution, separation, and consistency.

- *Interaction*, including: interaction tasks (such as navigation, selection, and manipulation) and interaction techniques (such as moving objects, possessing objects, and gesturing).

## 4 THOROUGH DEVELOPMENT

ISO uses a rigorous development and reviewing process to ensure the validity of published international standards. Throughout the development, various versions are published for information and for international review and acceptance voting. Each country participating in an ISO or ISO/IEC technical area has a team of reviewers (often called a Technical Advisory Group) making comments and deciding their national vote. All ISO votes require that at least 70% of the countries voting accept a document. Each vote may involve reviewing by over a hundred nationally recognized experts and may result in many pages of comments that have to be considered by the ISO working group (WG) that is developing the standard.

An ISO working group, made up of expert members nominated by the national standards bodies of a number of participating countries, creates an initial working draft (WD) and guides it through its various stages of development. The working draft is iterated through various versions until the WG is satisfied with its contents and its correctness. It is then sent for an international vote (reviewing) as a committee draft (CD). CD's that are accepted are revised to satisfy as many of the national comments as possible and then are submitted for another international vote as a draft international standard (DIS). An accepted DIS usually will have further revisions to satisfy national comments before being submitted for a final vote as a final draft international standard (FDIS) which if acceptable will be published as an international standard (IS).

## 5 FUTURE

TC159/SC4/WG9 is working on accumulating additional guidelines and ensuring that all guidelines are technically correct and feasible. The specific guidelines within ISO 9241-920 and the overall structure of the guidelines will go through three levels of international commenting (as a committee draft, a draft international standard, and a final draft international standard) before final publication as an international standard, which is anticipated to happen in 2009.

According to [4], new technologies develop through the phases of breakthrough, replication, empiricism, theory, and automation on their way to maturity. Tactile and haptic interactions have gone through numerous breakthroughs and replications and are now entering a period of developing empiricism. ISO TC159/SC4/WG9 is leading in this new phase of activity. ISO 9241-920 is the first part of this new development. Now is a good time to get involved. Now is also when the first benefits of this new development are becoming available.

You can get involved as an expert member of TC159/SC4/WG9 developing drafts of the standard or as a member of your national Technical Advisory Group commenting and voting on the drafts produced by TC159/SC4/WG9.

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