Setting the Standards for Haptic and Tactile Interactions: ISO's Work

Jan B.F. van Erp[1], Ki-Uk Kyung[2], Sebastian Kassner[3], Jim Carter[4], Stephen Brewster[5], Gerhard Weber[6], and Ian Andrew[7]

[1] TNO Human Factors, Soesterberg, The Netherlands
jan.vanerp@tno.nl
[2] ETRI POST-PC Research Group, Daejeon, Korea
kyungku@gmail.com
[3] Technische Universität Darmstadt, Germany
s.kassner@emk.tu-darmstadt.de
[4] Computer Science Department, Un. of Saskatchewan, Saskatoon, Canada
carter@cs.usask.ca
[5] Glasgow Interactive Systems Group, Un. of Glasgow, UK
stephen@dcs.gla.ac.uk
[6] TU Dresden, Dept. Comp. Science, Dresden, Germany
Gerhard.Weber@inf.tu-dresden.de
[7] HF Engineer, United Kingdom
andyand@talktalk.net

Abstract. Tactile and haptic interaction is becoming increasingly important and ergonomic standards can ensure that systems are designed with sufficient concerns for ergonomics and interoperability. ISO (through working group TC159/SC4/WG9) is working toward international standards, which are being dual-tracked as both ISO and CEN standards. This paper gives an update on the status of the work in progress and the recently published International Standard on tactile/haptic interactions. Active involvement of experts is sought for work on terms and definitions and measures to characterize devices and operator capabilities.

Keywords: guidelines, haptics, human computer interaction, standards, tactile.

1 Introduction

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. Material providing guidance on the design and use of tactile and haptic interactions is sparse [1, 2]. Therefore, an ISO expert group has been working on standards documents for haptic interaction since 2005. ISO TC159/SC4/WG9 reported on its progress at several conferences

A.M.L. Kappers et al. (Eds.): EuroHaptics 2010, Part II, LNCS 6192, pp. 353–358, 2010.

[3, 4, 5] and published its first standard in 2009 [6]. Here we provide an update on our ongoing work and the work items that will start in the near future:

- 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 item has not started yet.
- ISO 9241-910 Framework for tactile / haptic interactions which will include a detailed list of terms and definitions. This is work in progress and more details are given in Section 2.
- ISO 9241-920 Ergonomics of human-system interaction - Guidance on tactile and haptic interactions. This document has been accepted and published as an International Standard, the first standard on haptics (see Section 3).
- ISO 9241-930 Haptic / tactile interactions in multimodal environments will provide guidance specific to immersive and other multimodal environments. This work has not started (see Section 5).
- ISO 9241-940 Evaluation of tactile / haptic interactions will provide guidance on evaluation methods suited for evaluating tactile and haptic interactions. This work is in progress and the current status is elaborated in Section 4.
- 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. Work on this item has not started (see Section 5).

As of 2010, the following countries are actively participating in WG9: Canada, USA, UK, The Netherlands, Sweden, Germany, South Korea, and Japan. Drafts produced by WG9 go through a thorough review process including rounds of commenting and voting on the drafts by National Technical Advisory Groups.

2 Framework for Tactile and Haptic Interaction

This part of the standard series provides a framework for understanding and communicating about various aspects of tactile/haptic interaction. It contains definitions, structures, models, and explanations that are used in other parts in the series and provides general information about how various forms of interaction can be applied to various user tasks.

There have been several efforts to define terminologies for haptics [7, 8]. While there is no difference between haptic and tactile in most dictionary definitions [9], many researchers and developers use *haptic* to include all haptic sensations and limit the use of tactile to mechanical stimulation of the skin. We adopted a similar distinction, also reflected in Figure 1. The science of haptics and the creation of haptic devices depend on knowledge of the human body, especially its capability to sense both touch to the skin and kinaesthetic activity in the limbs and body joints. Figure 1 shows the relationship between the components that make up the field of haptics.

The framework document defines interaction elements and task primitives for haptic interaction. Users can carry out application tasks by employing one or more task primitives enabled by the haptic device and its associated software. Task primitives

are provided by system functionality to users as tools for carrying out the tasks for which the device is designed. In any task, the user should be able to *search, gain an overview, navigate, target, select and manipulate*.

The framework document also contains recommendations for ergonomic design guidelines of haptic interaction for individuality, interaction space, accessibility and resolution. In addition, this part of the standard series introduces physiology of haptics, application areas of haptics, device types and selection criteria.

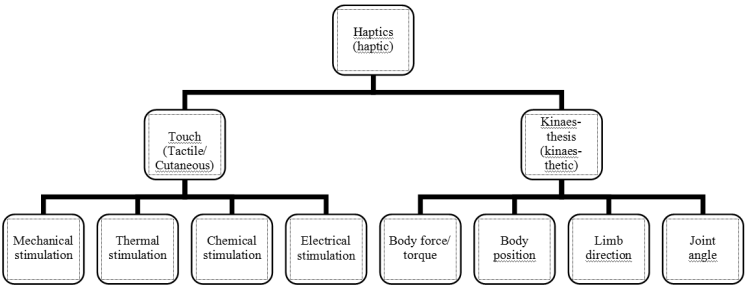

Fig. 1. The components of haptics. "Touch" includes such diverse stimuli as mechanical, thermal, chemical and electrical stimulation to the skin. The "kinaesthetic" sense can be matched by kinaesthetic activity by which a user exerts force or torque on an object external to the active body part.

3 Guidance on Tactile and Haptic Interactions

The document on guidance on tactile and haptic interaction has been accepted by the ISO members as an International Standard and is published by ISO in 2009 [6]. This standard contains guidance in the following areas:

- Applicability considerations for haptic interactions, 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 and multimodal use of haptic interactions, intentional individualization, and unintentional user perceptions.
- Attributes of tactile/haptic encoding of information, including: using properties of objects, using perceptual attributes, and combining attributes.
- 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.
- 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). Guidance for specific haptic interactions related to reading tactile alphabets and notations suitable for blind or deafblind people are handled by Unicode and other national standards.

4 Measures to Characterize Haptic Devices and User Capabilities

Characterizing physical properties of haptic/tactile interaction is fundamental in the specification, design and evaluation of haptic/tactile devices and interactions. Characterization may range from applications such as the development of new devices to the checking of contractual requirements. Due to this importance, we are working on methodologies that can be applied to perform characterization and evaluation tasks. The methodology mainly comprises the definition of sets of measures and corresponding measurement setups. The goal is to provide a set of measures and setups that can be effectively applied. We will cover:

- physical measures specifying technical properties of devices e.g. in the field of mechanics, electronics, computation and control theory,
- human performance measures related to perception, speed of operation, frequency of errors, effectiveness and user satisfaction, amongst others.

Current activities of ISO TC159/SC4/WG9 regarding the characterization of haptic/tactile devices and interactions are focused on the definition of physical measures. At this stage we differentiate between three levels of complexity: "elementary measures", "compound measures" and "derived measures". A few basic examples are given in Table 1.

Table 1. Examples of physical measures

Level of complexity	Measure	Example/ application
Elementary measures	force, time, temperature, distance, …	perceptual thresholds, maximal/minimal capabilities of users and devices, resolutions, …
Compound measures	speed	e.g. maximal speed of a device's handle
	frequency	perception of vibration is frequency depended, e.g. [10]
	thermal conductivity, …	material constant, …
Derived measures	impedance	e.g. mechanical behaviour of a user
	transparency	transmission performance
	roughness, …	various measures such as R_a, R_z, R_q, and R_{sk}, …

Haptic/tactile devices and interactions may be characterized by numerous parameters because the interaction is often bidirectional [11]. This distinguishes haptic devices from visual and auditory displays where information is presented unidirectionally. This bidirectional interaction leads to a coupled system and derived measures such as mechanical impedance Z (ratio of force F to speed v, see formula 1) and transparency T (a measure and stability criterion from a control theory point of view as introduced by Hannaford [12, 13], see formula 2) might be applied to rate the performance of a coupled haptic system as shown in figure 2.

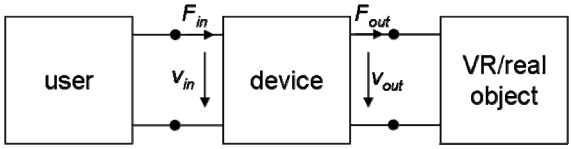

Fig. 2. Two-port representation of a coupled haptic/tactile system transmitting force and speed

$$\underline{Z} = \frac{\underline{F}}{\underline{v}} \,. \qquad T = \frac{\underline{F}_{out} / \underline{v}_{out}}{\underline{F}_{in} / \underline{v}_{in}} \,. \tag{1, 2}$$

Other measures such as "force" or "distance" can indicate perceptional thresholds, sensory resolutions (e.g. two-point discrimination on a Braille display) or other human capabilities such as maximal forces a user can exert on a device. Ergonomic measures may be used for formative or summative evaluation. For example, the multimodal nature of applying and analyzing haptic mock-ups [14] and prototypes requires an adaptation of other ISO 9241 documents related to user centered design.

Overall, up to forty measures are currently being discussed. This number of possible measures indicates the complexity and variety of haptic/tactile perception and interaction. We are also developing two scenarios to demonstrate the application of particular measurements. One scenario on a 3D force feedback display and one on a large tactile display with 7200 pins.

5 Future Objectives

TC159/SC4/WG9 has identified two additional areas for future work: the use of haptic interactions in multimodal environments (potential 9241-930) and public environments (potential 9241-971). While the other standards in the 9241-9xx series focus almost exclusively (with the exception of a few high level guidelines in 9241-920) with haptics, these two new areas both focus on the combination with haptics with other modalities. 9241-930 will provide the more general of the two sets of guidance, focusing on where combinations of modalities are intended to be used simultaneously by a user (such as immersive environments) and will consider multi-modal issues (such as allocation of function to different modalities). 9241-971 will focus on the accessible use of haptics in public environments, where the users might not be able to interact via other available modalities. It will consider systems where users are or are not allowed to connect their own assistive technology. The start of these activities is dependent on finding suitable experts to work on them and on obtaining suitable research and expert opinion that could be used in them.

6 Getting Involved

TC159/SC4/WG9 is continuously working on ensuring that all guidelines are technically correct and feasible. You can get involved as an expert member of TC159/SC4/WG9 actively developing drafts of the planned work items. Independent

from actively being involved, the members of WG9 are very interested in your opinions on tactile/haptic-related terms and definitions and experience with measures for haptic devices or human performance. The authors would be happy to get you involved in the ongoing work.

Acknowledgment. This work was supported by the IT R&D program of MKE/KEIT [2009-F-048-01, Contact-free Multipoint Realistic Interaction Technology Development] and The Netherlands Organization for Applied Scientific Research TNO.

References

[1] Van Erp, J.B.F.: Guidelines for the use of vibro-tactile displays in human computer interaction. In: Proceedings of Eurohaptics 2002, pp. 18–22 (2002)
[2] Van Erp, J.B.F.: The multi-dimensional nature of encoding tactile and haptic interactions: From psychophysics to design guidelines. In: Proceedings of the Human Factors and Ergonomics Society 2006, pp. 685–688 (2006)
[3] Carter, J., Van Erp, J.B.F.: Ergonomics of tactile and haptic interactions. In: Proceedings of the Human Factors and Ergonomics Society 2006, pp. 674–675 (2006)
[4] Van Erp, J.B.F., Carter, J., Andrew, I.: ISO's Work on Tactile and Haptic Interaction Guidelines. In: Proceedings of Eurohaptics 2006, pp. 467–470 (2006)
[5] Van Erp, J.B.F., Kern, T.A.: ISO's work on guidance for Haptic and tactile interactions. In: Ferre, M. (ed.) EuroHaptics 2008. LNCS, vol. 5024, pp. 936–940. Springer, Heidelberg (2008)
[6] ISO: Ergonomics of human-system interaction – Part 920: Guidance on tactile and haptic interactions. ISO 9241-920:2009. ISO, Geneva (2009)
[7] Srinivasan, M.A., Basdogan, C.: Haptic in virtual environment: Taxonomy, research status, and challenges. Computer and Graphics 21(4), 393–404 (1997)
[8] Oakely, I., McGee, M.R., Brewster, S.A., Gray, P.D.: Putting the feel in look and feel? In: Proceedings of Conference on Human Factors in Computing Systems, pp. 415–422 (2000)
[9] Merriam-Webster Online Dictionary, `http://www.merriam-webster.com/dictionary/`
[10] Gescheider, G.: Psychophysics: Method and Theory. Halsted Press, Mahwah (1976)
[11] Hayward, V., Maclean, K.: Do it yourself haptics: part I. IEEE Robotics & Automation Magazine 14, 88–104 (2007)
[12] Hannaford, B.: A design framework for teleoperators with kinaesthetic feedback. IEEE Trans. Robot. Automat. 5, 426–434 (1989)
[13] Adams, R., Hannaford, B.: Control Law Design for Haptic Interfaces to Virtual Reality. IEEE Transactions on Control System Technology 10, 3–13 (2002)
[14] Miao, M., Köhlmann, W., Schiewe, M., Weber, G.: Tactile Paper Prototyping with Blind Subjects. In: Altinsoy, M.E., Jekosch, U., Brewster, S. (eds.) HAID 2009. LNCS, vol. 5763, pp. 81–90. Springer, Heidelberg (2009)