Initiating Guidance on Tactile and Haptic Interactions

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ABSTRACT
The Guidelines On Tactile and Haptic Interactions Conference (GOTHI-05) is the result of the realization of the need for the International Organization for Standardization (ISO) to standardize guidance on tactile/haptic interactions. This paper reviews existing international standards on tactile/haptic interactions and suggests ways to construct a relevant ISO standard. It proposes potential dimensions and boundaries for a future standard and provides a preliminary collection of draft tactile/haptic interactions guidelines based on available guidance.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*standardization*

Keywords
Guidelines, haptic, interface, standards, tactile

1. BACKGROUND:

1.1 Initiating work on guidance on tactile and haptic interactions
Guidance on tactile and haptic interactions potentially fall within the scope of two committees of the International Organization for Standardization (ISO). ISO TC159/SC4 "Ergonomics of Human-System Interaction" has developed standards for various other modalities of human-computer interaction (especially for interactions using more traditional computer components such as displays, keyboards, and mice). ISO/IEC JTC1/SC35 "User Interfaces" has developed standards for various user interface elements (especially keyboards and icons). However, neither of these committees currently have any standards dealing with tactile and haptic interactions or the user interface components used for these interactions.

Serious consideration of the need for ISO to standardize guidance on tactile and haptic interactions began with the Canadian position on expanding ISO TS 16071 [12], which recognized that all types of media interactions need to be considered in order to support the widest possible accessibility [4]. This led to the creation of the Universal Access Reference Model [5], which provided a model for identifying, "guidance relating to channels (devices) not already covered in ISO TS 16071". As part of the process of expanding ISO TS 16071 into the international standard ISO 9241-171 [14], Fourney prepared a set of tactile and haptic guidelines on behalf of Canada [7]. These guidelines were largely adapted from ETSI EG 202 048 [6]. 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.

At the 2004 meeting of ISO TC159/SC4, Canada proposed that work commence on a standard on tactile and haptic interactions. SC4 invited Canada to prepare a new work item proposal, which was prepared [18] and is currently out for international ballot. At the same time, Canada undertook to organize a conference, which has become GOTHI-05.

1.2 Existing guidance in International Standards
ISO TC159/SC4 is currently expanding the 9241 series of Ergonomics of Human-System Interaction standards. The original series contained 17 parts and was supplemented by a number of other standards including ISO 14915 [10, 11, 13] and ISO TS 16071. Of these various standards, only ISO 9241-9 [9] contained any guidance directly relevant to tactile or haptic interactions. This guidance is contained in a set of, "basic ergonomic principles that apply to all input devices." These principles are:

- operability (obviousness, predictability, consistency, compatibility, efficiency, effectiveness, feedback, satisfaction);
- controllability (responsiveness, non-interference, grip surface, device access, control access); and
- biomechanical load (postures, effort, user training).

There is a notable lack of recognition of tactile or haptic interactions in ISO 14915-3 [11] which deals with "media selection and combination" only in terms of audio and visual media.

The new, considerably expanded, structure for the ISO 9241 series was also created without an explicit location for tactile or haptic guidance. It has maintained the previous differentiation between software standards (now the 100 series of parts), input devices (now the 400 series of parts), and display hardware (now the 300 series of parts). However, the new structure of the ISO 9241 series is expandable to allow for future additions that hopefully will include the newly proposed work on tactile and haptic interactions.

As parts are developed for this new structure, there is an increasing awareness of the need to consider all possible types of modalities. In part 171 (which will replace 16071) there are now 3 tactile/haptic specific recommendations. Other recommendations in part 171 have been worded or given specific examples so that they apply to all modalities of interactions, including tactile and haptic interactions. In part 400 [15], the part 9 principles, which are worded as general guidance for developers, are reworded to make them requirements that must be complied with by developers.

While the focus of ISO TC159/SC4 is on the ergonomics of interactions, ISO/IEC JTC1/SC35 focuses on standard elements of these interactions. In addition to the new work item being balloted by SC4, there is the potential for SC35 to become involved in defining the syntax and semantics of particular tactile or haptic elements that would be widely used to present defined types of information in a standardized manner or to act as standardized controls.

ISO/IEC JTC1/SC35 does have two standards that can provide models which can be adapted to describing tactile and haptic interactions, a new work item that provides a format for describing user interface objects, actions, and attributes [3] and a framework for designing accessible icons [19].

Although ISO is the senior of all international standardization organizations, there are many other international organizations, fora, and consortia involved in developing standards for their members and for the general public. ETSI 202 048, as already discussed, is a major source of useful guidance.

Two additional sources of potential guidance were examined because of their potential impact on any resulting tactile / haptic standard. Section 508 of the US Rehabilitation Act [1] is increasingly being used as a de facto standard for accessibility expectations. However, despite the importance of tactile and haptic assistive technologies, it does not provide any guidance on this area. Part 1193 of the U.S. Telecommunications Act contains much more detailed guidance than Section 508, including various guidelines relating to tactile and haptic interactions [2].

1.3 Creating a draft standard

Section 2 of this paper presents a brief summary of different dimensions of analysis that could be used to construct a reference model. It also includes a subsection of existing and potential definitions that should be considered.

Section 3 of this paper presents an initial collection of potential guidance, based on the guidance available from the international standards identified above. Individual guidelines were extracted, combined with similar guidelines, reworded for consistency and to meet ISO wording expectations, and structured in the format of an initial working draft of a potential standard. Additional descriptive text (that would be included in a standard) and comments (included only for readers of this paper) were added to clarify the resulting draft.

Our initial starting point for organizing this guidance was the "topics of interest" in the GOTHI-05 call for participation. The contents of the "topics of interest" structure were primarily intended to help encourage contributions to the conference, which is intended to develop a more suitable structure. We have modified this structure, where necessary, to better contain the available guidance and potential further guidance. We have not made major revisions to the structure, since the final structure to be used for the standard will need to take into account all the guidance that it will contain.

2. ESTABLISHING THE BOUNDARIES AND BASIS FOR STANDARDIZATION

Detailed guidelines need to be substantially complete and consistent to be useful. This section identifies three high level components (reference models, a scope, and a set of definitions) of a possible tactile and haptic interaction standard that can help ensure a reasonable level of completeness and consistency and can aid developers in applying detailed guidelines. While we deal with reference models before the other two, a formal ISO standard would deal with reference models after scope, normative references, and definitions.

2.1 Reference models

Reference models can help ensure that a standard or set of standards cover the breadth of their intended scope and can identify the main terms requiring definition. Lynch and Meads advocated the use of reference models of human computer interactions as a basis for the development of standards. They state that a reference model should, "provide a generic, abstract structure which describes the flow of data between the user and the application, its conversion into information, and the auxiliary support which is needed for an interactive dialogue" [21].

2.1.1 Interfaces

According to ISO 9241-400, interfaces can be considered in terms of the, "bodily part used for operation." It identifies the following types of controls, which it uses, "to group the provisions for certain types of input devices":

- Hand and finger controlled,
- Foot controlled,
- Speech controlled,
- Eye controlled,
- Motion controlled.

While ISO 9241-400 chose this model to use, we do not recommend it as the main basis for understanding tactile or haptic interactions. This model violates a number of accessibility considerations. It assumes a user with no disabilities and an environment with no handicaps, and does not consider substitution of one body part for another. It also does not model the total capacity for a given user to interact with multiple different tactile or haptic controls at one time.

2.1.2 Interactions

ISO 9241-400 identified a "typology by task primitive" that is helpful for classifying different interactions, regardless of how they are instantiated:

- Code entry,
- Pointing,
- Dragging,
- Selecting,
- Tracing.

ISO 9241-9 also contains guidelines relating to the following interactions: anchoring, resolution, repositioning, and button activation.

ISO/IEC 19766 defines a similar set of interaction primitives:

- Icon selection (comparable to pointing in ISO 9241-400)
- Icon manipulation
  - Move icon (comparable to dragging in ISO 9241-400 and anchoring and repositioning in ISO 9241-9)
  - Remove / restore icon

- Obtain description
  - Modify pallet
  - Select language
  - Other manipulations
- Function activation (comparable to selecting, code entry, and tracing in ISO 9241-400 and button activation in ISO 9241-9)

The ISO/IEC 19766 set of interaction primitives identifies the need to go beyond the ISO 9241-400 set. By comparing the 19766 set with guidelines in Section 3 of this paper, we can suggest that:

- "Remove / restore icon" suggests reconfiguring a tactile / haptic interface.
- "Obtain description" suggests obtaining the description of a tactile / haptic control without activating it.
- "Modify pallet" and "Select language" suggests modifying the parameters used for tactile / haptic objects (including resolution in ISO 9241-9).

We believe that it is important to be able to distinguish between different types of interactions. Further investigation is required to identify the optimal classification of different types of interactions.

2.1.3 Encodings

ISO 9241-400 identified two aspects of encoding information; a "typology by the property sensed":

- Pressure,
- Motion,
- Position;

and a "typology by number of degrees of freedom":

- Single dimension,
- Two dimensions,
- Three dimensions.

ISO 9241-9 also contains guidelines relating to the following encodings: button force, button displacement, consideration of handedness, pressure points, signal speed, stability, surface temperature, weight, and gain.

An examination of the guidelines in Section 3 of this paper shows that both time and changes over time are not covered by the various topologies presented in ISO 9241-400. Further investigation is required to identify the optimal classification of the different types of encodings.

2.1.4 Using the ISO/IEC format for describing user interface objects, actions, and attributes

The ISO/IEC JTC1/SC35 new work item on a format for describing user interface objects, actions, and attributes combines both interactions and encodings. It also provides for translation between tactile/haptic modalities and other possible modalities and for discussing permissible variations that still satisfy the standard. This format can be summarized in terms of:

- Identification
  - External label
  - Internal identifiers
- Interaction
- Representations (encodings)
  - Graphic representation
  - Tonal representation
  - Tactile and Haptic representation
- Variations

We suggest that this format be used as the basis for organizing a reference model for tactile and haptic interactions, which takes into account the other models discussed above.

2.2 Scope

An international standard requires a scope statement. The new work item proposal for Guidance on Haptic and Tactile Interactions [18] includes the following initial scope statement:

> *This standard will contain ergonomic requirements and recommendations for haptic and tactile hardware and software interactions. It will provide guidance related to the design and evaluation of hardware, software, and combinations of hardware and software interactions. It will include guidance on:*
>
> - *the design/use of tactile/haptic inputs, outputs, and/or combinations of inputs and outputs, including:*
>   - *general guidance on their design / use*
>   - *guidance on designing / using combinations*
>   - *use in combination with other modalities*
>   - *use as the exclusive mode of interaction*
> - *the tactile/haptic encoding of information, including:*
>   - *textual data*
>   - *graphical data*
>   - *controls*
> - *requirements placed on users of tactile / haptic interfaces*
> - *customization and adaptation of tactile / haptic interfaces*
> - *temporal issues with tactile / haptic interfaces*
> - *application dependent issues with tactile / haptic interfaces*

2.3 Definitions

There is a notable lack of ISO definitions of "tactile" and "haptic" interactions. Many aspects of tactile / haptic interactions are described in the various models discussed in Section 2.1, but are not officially defined in the definition sections of applicable standards. It will be essential to provide a suitable set of definitions for the new standard.

There are relatively few ISO definitions that provide the basis for a standard on tactile and haptic interaction. ISO 14915-3 provides definitions of a static medium and a dynamic medium, which could be involved in defining tactile and haptic media. ISO 9241-9 and 9241-400 provide definitions of kinaesthetic feedback and resolution/resolving power. ISO 9241-400 provides additional definitions of tactile feedback and reach envelope.

3. DRAFT GUIDELINES

The following guidelines are based on existing guidelines we have found in major international sources. We have refrained from adding guidelines not based on major international sources, even where we clearly recognize the need for such additional guidelines.

3.1 Tactile/haptic inputs, outputs, and/or combinations

3.1.1 General guidance

3.1.1.1 Provide information on tactile elements

"Where tasks require access to the visual content of user interface elements beyond what a label provides, software should provide user interface element descriptions stored as accessible text, that are meaningful to users, whether those descriptions are visually presented or not" [14].

3.1.1.2 Provide navigation information

The system should provide navigational information support to assist users in navigating haptic space [6, 7].

NOTE: Providing navigational information keeps users from becoming "lost in haptic space".

Rationale: Different users may have differing mental models of how the virtual space is defined and what part(s) of the tactile device is "touching" a virtual object [6].

3.1.1.3 Safeguard accessibility features

"Inadvertent activation or deactivation of accessibility features should be prevented." [14]

3.1.1.4 Provide undo or confirm functionality

"A mechanism should be provided that enables users to undo at least the most recent user actions and/or confirm that action" [14].

3.1.2 Guidance on combinations of inputs and outputs

Our review of current standards did not reveal any guidance regarding combinations of inputs and outputs. Guidance on input/output combinations is considered important because of the several instances where tactile/haptic devices can be seen as both a mechanism for information output as well as input. For example, Braille personal digital assistants (e.g., BrailleNote) often combine tactile input and output.

3.1.3 Guidance on combinations with other modalities

3.1.3.1 Provide alternative text input

"Software shall enable users to perform all input functionality, including navigation, using only non-time dependent keyboard (or keyboard equivalent) input." [14]

"Exception: Input that requires analogue, timed movement (such as watercolor painting where the darkness is dependent on the time the cursor spends at any location.)" [14]

3.1.3.2 Provide alternative text output

"Electronic text should be provided explaining the pattern used for tactile output presentation" [14].

"NOTE In contrast to visual and acoustic output presentation for tactile output only a few sets of symbols are standardized (e.g. Braille-code in several versions)" [14].

3.1.3.3 Provide alternative input strategies

The system should enable users to accomplish the same function in multiple ways including at least one method not requiring fine manipulation skills on the part of the user [2].

Rationale: The most efficient, logical or effective input/control mechanism for a majority of users may be difficult, if not impossible, to use by individual users with certain disabilities.

3.1.3.4 Provide additional information to support exploring complex objects

When haptically exploring a complex object users should be enabled to explore the complex object using information provided by other media [6].

NOTE: Multimedia information may be required to give a sense of complex objects and what they mean.

Rationale: Users may not understand complex objects from purely haptic information [6].

3.1.3.5 Exploration of complex objects

Complex objects made up of component objects have very small spaces between them into which the haptic pointer may slip. The system should either: a) prevent the haptic pointer from slipping into such spaces, or b) enable users to easily move the pointer from the gap to continue to explore the next component object [6].

NOTE: Users may be confused when finding unexpected gaps in objects.

3.2 Tactile/haptic encoding of information

3.2.1 General encoding guidance

3.2.1.1 Use familiar encodings

"Well known tactile patterns (familiar in daily life) should be used for presenting tactile messages." [14]

"NOTE: A person without special knowledge in tactile coding (e.g. like Braille-code, Morse-code etc.) will be mostly well experienced in tactile patterns of daily life" [14].

3.2.1.2 Make tactile messages self-descriptive

Tactile messages should be self-descriptive. Self-descriptiveness is described in ISO 9241-110 [16].

Rationale: Generally, people are not familiar with the tactile signals used in human computer interaction. Most users experience low tactile continuity (i.e., they do not experience tactile signals continuously), limiting their opportunities to learn the meaning of tactile messages. This means that tactile messages must, if at all possible, be self-descriptive [6, 7].

3.2.1.3 Mimic the real world

To the extent possible, tactile messages should mimic the real world [6, 7].

NOTE: In the real world, touch is used to perceive: mass, size, structure, resistance, pressure, orientation, edges, etc.

3.2.1.4 Virtual objects need not follow the laws of physics

Where the task allows, virtual objects need not follow the same laws of physics as real objects. However, the physics utilized should a) remain consistent throughout the application and b) be made explicit to the user [6, 7, 14].

EXAMPLE Users can push through the surface of an object.

NOTE: Current technological constraints mean that virtual objects may not be able to simulate all aspects of their real world equivalents [6, 7].

3.2.1.5 Combining multiple tactile components

Well-known, meaningful components should be used when composing complex tactile messages [6, 7].

NOTE: Combining different vibro-tactile signals may unintentionally alter the percept. This is analogous in the physical world to combining two waves, as their sum is out of phase with the original waves.

3.2.2 Spatial Encoding

Spatial encoding applies to both tactile and haptic devices. Spatial encoding refers to the identity of activated sensory receptors.

Major concepts in the spatial encoding of tactile/haptic interfaces include apparent location, apparent position, and apparent motion. Tactile illusions can be used to either help or mislead users when using tactile/haptic interfaces. Each of these concepts use tactile illusions to help the user perceive information correctly.

Apparent location is a tactile illusion used to indicate direction in a tactile display [24]. It is caused when the percept of a single stimulus is induced by the simultaneous activation of two stimuli to different locations. The apparent location is perceived to be in between the two stimulus locations and depends on the relative magnitude [6, 24].

Apparent position maintains relative position within a scaled environment. This includes environments where spatial resolution is enlarged to create a more acceptable tactile illusion for the user [24].

Apparent motion refers to a set of tactile illusions that can be used to indicate movement in a tactile display. Apparent motion occurs when tactile stimuli are sequentially presented to two or more points on the skin with a certain inter-stimulus timing such that a single stimulus is perceived to move continuously from one point of stimulation to the next. One example is the tactile illusion known as the *cutaneous rabbit effect* where a properly timed and distributed train of taps creates the illusion of a phantom tap ‘hopping’ between two or more points on the skin [8].

Although perceptual illusions are used in tactile displays, care must be taken since, if stimuli are presented too closely in time and space, the intended percept may be altered and possibly result in a completely new unintended percept.

3.2.2.1 Higher resolution can be allowed for trained users

Where the task allows, displays designed for trained or expert users, may use higher density of stimuli [6, 7].

3.2.2.2 Virtual object dimensions can differ from real world dimensions

Where the task requires users to perceive size accurately, scaling may be used such that the size of a virtual object differs from its real world dimensions [6, 7].

Rationale: Research suggests that users a) perceive the sizes of larger virtual objects more accurately than those of smaller virtual objects and b) feel virtual objects to be bigger from the inside and smaller from the outside. This suggests that, if a task requires users to perceive size accurately, an object’s virtual representation may need to deviate from its real-world dimensions [6].

3.2.2.3 Virtual object shape

Our review of current standards did not reveal any guidance regarding virtual object shape.

3.2.2.4 Use distal body parts if a high spatial resolution is required

Where high spatial acuity is needed, the system should only interact with the distal body parts [6, 7].

EXAMPLE: A refreshable Braille display uses spatial location as an important parameter in design.

Rationale: Tactile display designs may rely on spatial location as an important parameter. Research suggests that where cortical representation of the skin is great, tactile acuity is fine [26]. Thus, only the distal body parts (e.g., the fingers, the toes) will suffice for designs requiring high spatial acuity.

3.2.2.5 Use of apparent location

Where the task requires access to a greater number of stimulus sites without increasing the number of actuators, apparent location may be used [6, 7].

3.2.2.6 Keep apparent location stable

When using apparent location, both stimuli should be in phase to evoke a stable apparent location [6, 7].

3.2.2.7 Use of apparent position

Apparent position may be used to enlarge the spatial resolution [6, 7].

NOTE: Use of apparent position is questionable where the density of actuators is close to the spatial acuity.

3.2.3 Sensory Encoding

Sensory encoding applies to both tactile and haptic devices. Two major concepts in this section require definition: a) intensity and b) subjective magnitude.

Intensity refers to the magnitude of force or energy used per unit of surface, charge, mass, or time. It is analogous to the acoustic notion of volume — the greater the intensity, the “louder” the experience of the stimulus.

Different users have different experiences of magnitude. The concept of *subjective magnitude* captures this. Subjective magnitude is a “scale” based on a user’s estimation of their experience of actual magnitude. It can be defined as a non-linear function of amplitude [6]. For a given individual, this scale may change with each experience of the tactile device as well as over the duration of the device's use.

3.2.3.1 Enable users to easily discern different simulated textures

The system should enable users to easily discriminate between different simulated textures [6, 7].

NOTE 1: Different users have different experiences of a tactile texture, physical variations in roughness are not always easily detected or discriminated from one another.

NOTE 2: Different users have different experiences in their perception of texture, both in the degree of the differences they can detect and in the way they feel textures (e.g., what is rougher, what is smoother).

3.2.3.2 Using frequency to encode information

No more than nine (9) different levels of frequency should be used for coding information [6, 7].

Rationale: Since the capacity of short term working memory is around seven items plus or minus two [22], the effective channel capacity of a number of human cognitive and perceptual tasks is between 5 and 9 items. This suggests a maximum of nine different levels of frequency can be used such that a user is able to distinguish one from the other in task memory.

3.2.3.3 Maintain suitable distanced between frequency levels

Each frequency above the lowest frequency should be at least 20% higher than the previous frequency [6, 7].

3.2.3.4 Use a frequency between 50 and 400 Hz

When encoding tactile messages, tactile output should be kept at frequencies between 50 Hz and 400 Hz [6, 7].

NOTE: There is great variability in how different users experience the sensitivity of the human tactile channel. While, the human tactile channel is typically only sensitive to frequencies between 10 Hz and 600 Hz, these thresholds are high with some users experiencing their lowest threshold at 250 Hz. Limiting frequencies between 50 Hz and 400 Hz ensures access for a large range of users [6].

3.2.3.5 Encoding using pressure / force / temperature

Our review of current standards did not reveal any guidance specific to pressure, force, or temperature. These areas are important because they are used in tactile/haptic device design. Guidelines relating specifically to pressure, force, and temperature would encompass concerns that are unique to these areas.

3.2.3.6 Avoid using too many levels of intensity to encode information

Since, the number of intensity levels available to encode information is limited, not more than four (4) different levels should be used between the detection threshold and the pain/comfort threshold [6, 7].

3.2.3.7 Encoding physical entity properties via intensity differences

Where the task requires, intensity differences to encode information should be dependent on the physical entity, at least 10% for force and mass, and 100% for stiffness and viscosity [6, 7].

Rationale: When using a tactile / haptic device, one's kinaesthetic system uses signals about force, position, and movement to derive information about the mechanical properties of objects in the virtual environment (e.g., stiffness and viscosity) [20].

3.2.3.8 Using subjective magnitude to encode information

Subjective magnitude of a stimulus can be used to encode information.

NOTE: Research suggests that there are two ways of enlarging the subjective magnitude of a stimulus: a) enlarging the intensity for intensities near the threshold, and b) enlarging the area of stimulation [6, 7].

3.2.3.9 Limit acoustic output of tactile display

The system should be designed to prevent unintentional acoustic energy emissions or acoustic energy emissions that could interfere with tactile/haptic interactions [6].

Rationale: In some environments acoustic output may interfere with nearby equipment and/or persons not using the tactile display.

3.2.3.10 Prevent vibration of non-activated vibrators

Prevent non-activated vibrators from vibrating due to activation of a nearby vibrator [6].

NOTE 1: There is an especially high risk of unintentional vibration where the nearby actuator vibrates at the same resonance frequency.

NOTE 2: Installing a rigid surround is one way to reduce the spreading of vibration.

Rationale: The occurrence of unintended vibration can mislead the user with an unintended percept and/or irritate the user with an unexpected stimulus.

3.2.4 Temporal Encoding

Temporal encoding applies to both tactile and haptic devices. For tactile devices, temporal encoding refers to the timing between tactile signals. For haptic devices, temporal encoding refers to the real time use of the device. Two major issues in tactile/haptic interfaces are temporal enhancement and temporal masking.

Generally, "masking" is the reduced ability to detect a stimulus in the presence of a background stimulus [25]. *Temporal masking* occurs when two stimuli are presented to the same location asynchronously [7]. The onset of the target (i.e., "masked") stimulus is typically within -100 ms up to +1200 ms from the onset of the "distracter" stimulus [6].

Generally, "enhancement" occurs when the presence of a brief stimulus causes a second stimulus to appear to be of greater intensity than when it is presented alone [25]. *Temporal enhancement* occurs when two stimuli in the same frequency band are separated by a short duration, typically 100ms to 500ms [6], such that the they are perceived to be one longer, stronger stimulus.

3.2.4.1 Temporal enhancement affects the subjective magnitude of separated stimuli

Where the task requires, prevent unintentional temporal enhancement of a second stimulus [6, 7].

NOTE 1: Temporal enhancement of a second stimulus occurs when two stimuli are separated by 100ms to 500ms.

NOTE 2: Temporal enhancement typically occurs when the stimuli are in the same frequency band.

Rationale: Temporal enhancement can result in a higher subjective magnitude of the stimulus. In situations where the desired effect is for the user to experience two different stimuli, then an inter-stimulus interval greater than 500ms will be needed.

3.2.4.2 Provide user control of temporal presentations

"Whenever moving, blinking, scrolling, or auto-updating information is presented, the user shall be enabled to pause or stop the presentation." [14]

3.2.4.3 Provide pauses between consecutive signals

Where the task requires a single actuator of a tactile display be used to encode information in a temporal pattern, there should be at least 10 ms between consecutive signals of the temporal pattern [6, 7].

3.2.4.4 Prevent temporal masking

The system should prevent the occurrence of temporal masking [6, 7].

Rationale: Temporal masking can distort the perception of multiple stimuli.

3.2.4.5 Use frequency to prohibit temporal masking

The system should use low and high frequencies to encode temporal patterns to prevent temporal masking [6, 7].

3.2.4.6 Use stimulus location to prohibit temporal masking

The system should present stimuli to different loci to prevent temporal masking [6, 7].

3.3 Content-specific Encoding

3.3.1 Encoding and using textual data

Our review of current standards did not reveal any guidance regarding encoding and using textual data. Guidance on textual data encoding is of interest to support devices such as Braille displays.

3.3.2 Encoding and using graphical data

3.3.2.1 Provide exploring strategies

The system should provide the user with methods for exploring virtual objects [6, 7].

3.3.2.2 Simulating actual motion

Apparent motion may be used to simulate actual motion [6, 7].

EXAMPLE: Tracking displays

NOTE: When using apparent motion, the most important parameters are the duration of bursts (minimum 20 ms) and the interval(s) of time between the onsets of the consecutive stimuli.

3.3.3 Encoding and using controls

3.3.3.1 Use size and spacing of controls to avoid accidental activation

The system should provide buttons and controls sufficiently large and sufficiently spaced, to reduce the likelihood that a user will accidentally activate an adjacent control [2].

3.3.3.2 Usable controls

The system should avoid using very small controls or controls which require rotation of the wrist or pinching and twisting [2].

3.3.3.3 Allow users to adjust time required for activation of controls

To help separate between inadvertent motions or bumps and desired activation, the system shall enable the user to individualize the delay during which a control is activated before the input is accepted [2, 14].

3.3.3.4 Avoid simultaneous activation of two or more controls

The system should enable users to avoid the use of control combinations requiring simultaneous activation of two or more controls [2, 14].

3.3.3.5 Allow users to sequentially activate composite controls

Where the task requires the use of control combinations, the system shall enable users to lock or latch each control such that multiple control combinations can be entered sequentially rather than by simultaneously pressing multiple controls [2, 14].

EXAMPLE: For keyboards, chorded key-presses can be sequentially enabled using StickyKeys.

3.3.3.6 Allow users to reposition controls

The system should provide a control option that moves all of the controls for the product such that it can be positioned optimally for the individual [2].

3.3.3.7 Allow users to re-map controls

The system should enable users to re-map all controls [14].

EXAMPLE: As an analogy, a keyboard user who has a left arm and no right arm might switch frequently used functions from the right to the left side of the keyboard.

Rationale: The ability to re-map controls allows the individual to reposition the most used controls in a way that favors their environment and mobility. This strategy may reduce repetitive strain injury.

3.3.3.8 Allow users to use a remote control

The system should provide a remote control option that moves all of the controls for the product together to a separate unit that can be positioned optimally for the individual [2].

NOTE: The “Universal Remote Console” is a proposed standard communication format that may allow the use of alternate remote controls for those who cannot use the standard remote control [17].

Rationale: The use of a remote control allows the individual to operate the product without having to move to it.

3.4 User Individualization of Tactile / Haptic Interfaces

3.4.1 Intentional Individualization

3.4.1.1 Enable user to change modalities

The system should enable the user both to disable tactile output and/or to reroute output to another modality [6, 7].

NOTE: Tactile stimuli may annoy users, as they are hard to ignore if the user does not want to use them.

3.4.1.2 Enable user to individualize tactile parameters

The system should enable users to adjust tactile output parameters, including:

- stimulus intensity,
- timing,
- frequency,
- location, and
- size/dimension

[6, 7, 14].

3.4.2 Unintentional User Perception

3.4.2.1 Beware of adaptation

Where the task allows, the system should avoid situations where user adaptation to stimuli might occur [6, 7].

NOTE: Adaptation effects only occur for stimuli within the same frequency range.

Rationale: Adaptation occurs as a result of prolonged tactile stimulation. Adaptation can decrease a user’s absolute threshold and change their experience of subjective magnitude. This is a gradual process caused by prolonged stimulation and can take up to 25 minutes to occur [6, 7, 25].

3.4.2.2 Recovery from adaptation

The system should enable the user to recover from adaptation to stimuli [6, 7].

NOTE: A user’s recovery time is about half as long as the adaptation time [6, 7, 25].

3.4.2.3 Use frequency to prevent adaptation

Adaptation to stimuli may be prevented by using different neurophysiological channels (i.e., different frequencies) [6, 7].

NOTE: One approach to preventing adaptation is switching between a frequency below 80 Hz and one above 100 Hz.

3.4.2.4 Be aware of the occurrence of perceptual illusions

The system should avoid the occurrence of unintended perceptual illusions [6, 7].

NOTE: Pauses between percepts is one strategy to avoid perceptual illusions.

4. CONCLUSION

Our collection of guidance shows that several potential candidate guidelines exist that can be used in a proposed ISO standard on tactile/haptic interactions. Of note, ISO 9241-171 contains several candidate guidelines that with, in some cases, no modification may apply to tactile/haptic use. However, there remain several areas where our search for relevant guidelines revealed little.

Although, our research found several guidelines that apply in general to tactile/haptic interactions and the use of vibration in particular, there is little guidance specific to other modes of tactile/haptic interaction such as the use of temperature or force.

Our research found no guidelines that were specific to the tactile encoding of text. It is quite likely that there are international or other guidelines on the design of tactile devices such as Braille displays. However, it is also important to note that there are other ways to tactilely encode text than the use of Braille. For example, the Moon alphabet is a system of embossed type that is often taught to people who have become Blind later in life and/or cannot master the small dots system of Braille [23].

This paper provides a beginning to a potential international standard on tactile/haptic interactions. The new standard will need to go beyond this collection of guidance to incorporate information from other available research, including the research presented at GOTHI-05.

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