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Ergonomics of human-system interaction —

Part 394: Ergonomic requirements for reducing undesirable biomedical effects of visually induced motion sickness during watching electronic images

Ergonomie de l'interaction homme-système —

Partie 394: Exigences ergonomiques pour la réduction des effets biomédicaux indésirables des cinétoses induites par stimulus visuel lors de l'observation d'images électroniques

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Human-system interaction*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

A list of all parts in the ISO 9241 series can be found on the ISO website.

Introduction

With the advancement in image technologies, it is now possible to experience various new types of images through different kinds of electronic displays, for example, ultra-high definition (UHD) images and virtual reality images. These technologies make our daily lives more convenient and enable different lifestyles.

The new products of advanced image technologies can be popularized both by solving technical issues and by devising countermeasures for reducing incidences of undesirable biomedical effects, such as visually induced motion sickness.

This document describes the basic and minimal conditions for reducing incidences of visually induced motion sickness. It is intended to promote an environment in which viewers can enjoy the benefits of images without the adverse effects of visually induced motion sickness. In such an environment, new technologies for images can also be actively developed and applied in various fields. This document is not intended to restrict the freedom of expression or artistic creativity in the image culture.

This document is based on scientific findings related to the possible undesirable effects of visually induced motion sickness. In the future, this document could be revised as new scientific data become available.

This document is part of the ISO 9241 series, which specifies human–system interaction standards. Readers who need guidance on other aspects of human–system interaction can therefore refer to other documents in the ISO 9241 series. See Annex A for an overview of the ISO 9241 series.

Ergonomics of human-system interaction —

Part 394: Ergonomic requirements for reducing undesirable biomedical effects of visually induced motion sickness during watching electronic images

1 Scope

This document establishes the requirements and recommendations for image contents and electronic display systems to reduce visually induced motion sickness (VIMS), while viewing images on electronic displays.

This document is applicable to electronic display systems, including flat panel displays, projectors with a screen, and virtual reality (VR) type of head mounted displays (HMDs), but not including HMDs that present electronic images on/with real-world scenes.

NOTE 1 This document assumes the images are viewed under appropriate defined conditions. See Annex B for the appropriate viewing conditions.

NOTE 2 This document is useful for the design, development, and supply of image contents, as well as electronic displays for reducing VIMS.

NOTE 3 ISO 9241-392[3] provides guidelines for stereoscopic 3D displays, of which the methods are also used in HMDs.

NOTE 4 The International Telecommunication Union (ITU) generally sets the standards for broadcasting.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9241-302 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
visually induced motion sickness
VIMS
motion sickness-like symptoms induced by perceived motion within the visual environment, such as when watching movies and screen images of video games

Note 1 to entry: The symptoms can include dizziness, vertigo, sweating, odd feelings in the stomach, and nausea, which can progress to vomiting.

3.2
dizziness
physical unsteadiness, lack of balance, or light headedness

3.3
vertigo
sensation of rotation or movement of one's self (subjective vertigo), or of rotation or movement of one's surroundings (objective vertigo), in any plane

3.4
postural instability
set of conditions in which voluntary movements cannot be well coordinated for maintaining posture

3.5
disorientation
loss of sense of direction, position, or relationship with the surroundings

3.6
visual global motion
wide spatial range of image motion in the visual field, composed of different velocities and directions that are systematically aligned in a moving image

Note 1 to entry: There are generally six types of visual global motions that correspond to the different types of motions of a camera during the capturing of images: rotation around and translation along the pitch, yaw, and roll axes.

3.7
head-mounted display
HMD
display device that is worn on the head, is integrated into eyeglasses, or is built in as part of a helmet or a hat

3.8
virtual reality
VR
set of artificial conditions created by computer and dedicated electronic devices that simulate visual images and possibly other sensory information of a user's surrounding with which the user is allowed to interact

Note 1 to entry: The artificial conditions do not reflect a user's real-time physical environment.

4 Guiding concepts

4.1 Contexts of image viewing

Two different viewing environments are defined for the contexts of image viewing to reduce VIMS. One is the active viewing environment, in which either the motion, orientation or other displayed contents of the images vary according to any viewers' actions, such as head movements or the manipulation of controllers. The other is the passive viewing environment, in which any displayed contents of the images do not vary with viewers' actions. In the active viewing environment, the changes in the displayed contents are caused by tracking the head of the viewers, or by the viewers operating the controller. In this document, the contexts of image viewing in the two viewing environments are the following:

— passive viewing environment:
  — display device: flat panel display, projector, or head-mounted display;
  — image generation: real-time rendering or playing recorded images;
  — image size in visual angle: depending on applications and display device;

- interactive type: none;

— active viewing environment:

  - display device: flat panel display, projector, or head-mounted display;
  - image generation: real-time rendering;
  - image size in visual angle: depending on applications and display device;
  - interactive type: head tracking and/or controller.

4.2 Basis of guiding concepts

This document provides the basic and minimal conditions for reducing incidences of VIMS primarily from the viewpoint of nauseating symptoms, such as dizziness, sweating, headache, stomach awareness, nausea, and vomiting. In this subclause, the references are verified as the bases for the guidelines from literature and summaries, and also from their reported scores from the simulator sickness questionnaire (SSQ).

Nauseating symptoms are reflected in the drop-out rates in various experiments of VIMS and simulator training. The relationship between drop-out rates and SSQ total score (SSQ-TS) has been clarified[4]. The drop-out rates were also reported to be correlated with the nausea subscore of SSQ (SSQ-N)[4]. The conditions for reducing VIMS can be considered in terms of lowering SSQ-TS (and/or the SSQ-N) to some extent. In fact, the severity index of VIMS described in C.4 is based on SSQ-TS.

Meanwhile, another aspect related to VIMS has been reported in the literature, i.e. disorientation induced after exposures to VR. Disorientation is different from nauseating symptoms in that it affects the equilibrium of the body. While postural fluctuation during exposure to VR is an adverse effect from the viewpoint of physical safety during a VR experience, disorientation after exposure to VR is paramount to be considered as an after-effect from the viewpoint of physical safety after returning to the real environment. The disorientation after exposures to VR can be reflected by the disorientation subscore of SSQ (SSQ-D)[5].

The different characteristics of the nauseating symptoms and disorientation after exposures to VR are also to be considered in terms of temporal courses. When viewers are repetitively exposed to the environments that easily induce VIMS, nauseating symptoms are known to be reduced significantly by the habituation to the environments. Moreover, when viewers are repetitively exposed to virtual environments, disorientation occurring every time after the viewers return to the real environment has been reported to increase. In other words, postural fluctuations increase. Consequently, it is paramount to consider this type of undesirable effect, i.e. disorientation, as well as nauseating symptoms. To reduce disorientation, general methods described in D.1 and D.2 can be useful as countermeasures.

4.3 Major factors of VIMS

VIMS is known to be affected by various factors. Among them, the major factor is visual motion within images. It can be either enhanced or attenuated by visual image factors, visual environmental factors, and individual viewer factors.

VIMS can be reduced, to some extent, by considering other major factors such as those shown below, depending on the context of image viewing. Therefore, to control VIMS, those different major factors need to be simultaneously considered with an appropriate balance.

Passive viewing environment:

— amount of visual global rotation:

  - different types of visual global rotations;
  - velocity of visual global rotation;

  - viewing period;
- image size in visual field;
- fixation-point/visual-target;
- navigating velocity;
- predictive information of self-motion;
- independent background from visual motion.

Active viewing environment:

- amount of visual global rotation;
  - different types of visual global rotations;
  - velocity of visual global rotation;
  - viewing period;
- image size in visual field;
- fixation-point/visual-target;
- navigating velocity;
- predictive information of self-motion;
- independent background from visual motion;

  (for the environment especially by head tracking)
- match in visual field between virtual camera and display (especially for large visual field images or VR type of HMD);
- match of head motion and visual motion (especially for large visual field images or VR type of HMD);
- delay in head tracking.

5 Ergonomic requirements and recommendations

5.1 General

To obtain the condition that sufficiently reduces the possibility of VIMS, visual image factors, visual environmental factors, and individual viewer factors shall be considered. However, in this document, the following are of principal concern:

- visual image factors, such as velocity and types of visual global motion and viewing period; and
- visual environmental factors, such as image size in visual field, fixation-point/visual-target, luminance level of images, illuminance level of environment, image resolution, and delay of head tracking.

For individual viewer factors, information can be found in Annex G.

NOTE The principles in 5.2 are easier to apply in the case of pre-recorded contents, which can be analysed frame by frame. Interactive media, such as video games, can afford essentially limitless sequences throughout the game, depending on the user's actions. In the case of video games, the requirements and recommendations apply to typical sequences of play but cannot cover every eventuality of play.

5.2 Images presented in passive viewing environments

5.2.1 Potentially unwanted conditions of visual rotation

Potentially unwanted conditions of visual rotation shall be avoided.

Potentially unwanted conditions of visual rotation are defined as those satisfying any of the following conditions.

a) Total amount of yaw rotation within a 20-minute period at any time of images is more than 17 280° (or 48 rounds).

b) Total amount of pitch rotation within a 20-minute period at any time of images is more than 15 120° (or 42 rounds).

c) Total amount of roll rotation within a 20-minute period at any time of images is more than 14 400° (or 40 rounds).

NOTE The criterion values above are applied while the image size in visual field is assumed as in the range of 30° × 17° to 70° × 40°.

5.2.2 Potentially unfavourable conditions of visual rotation

Potentially unfavourable conditions of visual rotation should be avoided.

Potentially unfavourable conditions of visual rotation are defined as those satisfying any of the following conditions.

a) Total amount of yaw rotation within a 20-minute period at any time of images is more than 12 960° (or 36 rounds).

b) Total amount of pitch rotation within a 20-minute period at any time of images is more than 11 520° (or 32 rounds).

c) Total amount of roll rotation within a 20-minute period at any time of images is more than 10 800° (or 30 rounds).

NOTE 1 The criterion values above are applied while the image size in visual field is assumed to be 30° × 17° or larger.

NOTE 2 Visual images can be enlarged in certain use cases, such as in the medical field. In such cases, the amount of rotation can be underestimated, if it is obtained by the actual camera rotation.

5.2.3 Basis of the requirements and recommendations

In 5.2.1, 5.2.2 and 5.3.2, the numerical criteria were set based on the relation between the dropout rate and total amount of rotation presented in the images on electronic displays in the experiments of VIMS[6]. In this process, the dropout rate was obtained by transforming the experimentally obtained SSQ-TS using Formula (1) (see Figure C.1):

$$Y = 0{,}0057X^2 + 0{,}744X - 3{,}973\ 9,\ R^2 = 0{,}352\ 4 \quad (1)$$

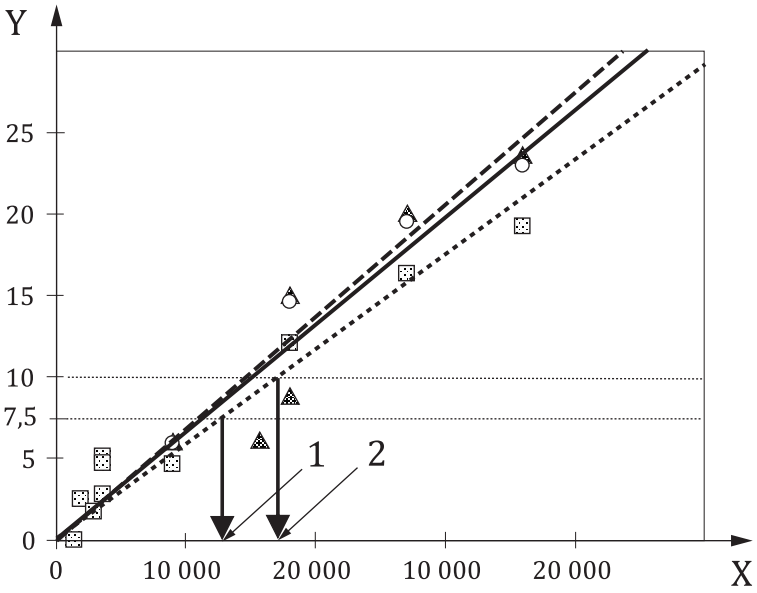
where

X is the averaged SSQ-TS;

Y is the dropout rate (%).

Those relations between dropout rate and total amount of rotation are shown in Figure 1, with fitted linear lines for each data of pitch, roll, and yaw-axes rotations. As shown in the graph, the criteria for

the requirements are set in terms of 10 % of the dropout rate, while those for the recommendations are set in terms of 7,5 % of the dropout rate.



Key

X total amount of rotation around a single axis within 20 min (°)

Y dropout rate (%)

yaw

pitch

roll

1 criterion for recommendation of yaw

2 criterion for requirement of yaw

Figure 1 — Relation between dropout rate and total amount of rotation around each of three axes

5.2.4 Reference information on effects of visual motion combination

For considering the effects of visual motion combination, see C.3.

5.3 Images presented in active viewing environments

5.3.1 General

For images in the active viewing environments, the major factors to be considered are those of visual motion described in 5.2 as well as those specific to these environments, such as:

— the time delay of changing images yoked to the signals from the head tracking or controllers;

— the consistency of visual field between virtual camera and presented images especially for large visual field images or VR-type HMDs with head tracking system; and

— the consistency of direction and amount of head movements with image motion.

5.3.2 Potentially unfavourable conditions of visual rotation

Potentially unfavourable conditions of visual rotation, not caused by head movements, should be avoided.