Standardization Activities for Head-Mounted Displays from Ergonomics Aspects

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ABSTRACT

As novel display devices, head-mounted displays (HMD) are getting popular. These devices have unique characteristics. Because of those, there are immediate requirements of having standards to evaluate those HMDs to avoid unwanted impacts to viewers. In order to answer those, ISO TC 159/SC4/WG2 and WG12 starred developing standards for HMDs.

1 INTRODUCTION

Thanks to technological evolution and huge efforts of engineers, mainly display and electronic engineers in the world, head-mounted displays (HMDs) are getting popular as novel electrical display devices. These booming devices have unique characteristics in several technological areas, such as optical, electro-optical, mechanical, and ergonomics. For example, although a viewer of a conventional display is seeing that display from relatively far position, around 20-30 cm for handle devices and 50 cm-1m for data display, a display of HMD is set very close to an eye of a viewer of HMD, 1 cm-3 cm. And, typically, HMD uses optical components such as a mirror or/and lens(es), and a viewer sees 'virtual' image by using those optical components, unlike a view sees 'real' from a conventional display. At most, in most cases, a viewer 'wears' display(s) on her/his head, unlike a conventional display is put apart from her/his body. Because of those differences, there are huge impacts onto a viewer from a HMD, which she/he is using a HMD. Because of that, there are immediate requirements of having certain standards to evaluate those HMDs to avoid unwanted impacts to a viewer. In order to answer those, ISO TC 159/SC4, human-system interaction, starts their activities in ISO TC 159/SC4/WG2, visual display, and WG12, 'image safety', to have standards for ergonomics aspects. Through this paper, we would like to explore our activities of having ergonomics standards for HMD.

2 HMDs' characteristics

HMDs have distinctive characteristics differ from most other displays. As stated before, at most, unlike most other displays, a viewer wears an HMD in most cases. And, because of that major difference, there are several characteristics of HMDs differ from other displays. Through this document, we would like to discuss the following three major categories of characteristics; i) optical, ii) contents related and iii) generic physical.

2.1 Optical characteristics

In most cases, HMD show images by putting displays(s) near a viewer's eyes and by using certain optical components, such as lens(es) and/or mirror(s)(See Fig. 1).

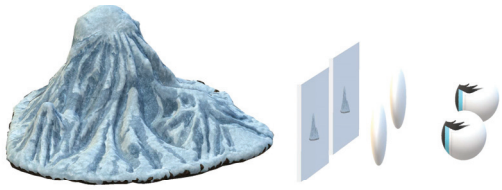
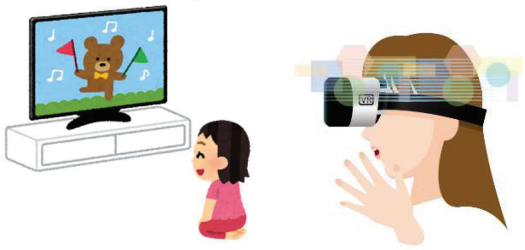


Fig. 1 an example of HMD image forming

In most cases, HMD show real images on displays for each eyes, and a viewer sees those images through optical components, and seeing a virtual image. Therefore, a display is put very close viewer's eye, usually 25-35mm, unlike conventional displays have at least 30-50cm viewing distance (see Fig 2).



a) viewing TV b) viewing HMD

Fig 2 – Viewing conditions

From ergonomics standing point of view, there are several characteristics that might affect a viewer; i) closer distance, ii) virtual image, iii) seeing one image from two separate images from two separate displays or through two separate optics. Table 1 shows examples of opt-electronic parameters those are important ones for

HMDs.

Table 1 – Examples of optical parameters

Spherical aberration	Astigmatism
Curvature of field	Chromatic aberration
Distortion	Misalignment of images

2.2 Contents related characteristics

One of the major symptom related to see VR images is called 'VR sickness', a kind of motion sickness. The major cause of VR sickness is as follows; there are several In order to obtain 3D virtual image, most HMD shows two slightly different images for each eye. And, in order to have 360 degree virtual image, most HMD have motion sensor(s) to detect the movement of viewer's head. Based upon that movement, an image generating system of HMD generates proper images for both eyes, then HMD shows those images. Because of these processes, there are several characteristics that affects viewer's experience, such as delay of showing updated image after head movement (latency) and positioning difference of 3D image rendering (stereoscopic parallax).

Another contents related major symptom related to see VR images is called 'post-VR disorientation'. It is known as an after effect of exposing VR environment. During seeing VR images, a viewer gradually gets accustom to virtually created environment. Sometimes that viewer may not come back to the real environment after stopping viewing VR images.

2.3 Generic physical characteristics

In addition to above mentioned characteristics, there are generic physical characteristics such as weight, physical size and shape, those were not major issues for conventional display devices from ergonomics standing point of view. Table 2 shows examples of generic physical characteristics.

Table 2 – Example of generic physical characteristics

Weight	Weight balance
Gravity center	Rotational moment
Heat	Contact heat

3 Requirement of International Standards

Since there is no recent International Standards covers most of above mentioned characteristics of HMDs, it is required to develop International Standards to cover those.

3.1 IEC, International Electrotechnical Committee

Within IEC, International Electrotechnical Committee, IEC TC (Technical Committee) 110, Electronic Displays, covers all display related technologies. Since HMDs are kinds of displays under a category of electronic displays, IEC TC 110 covers HDMs. Within IEC TC 110, there are several WGs (Working Groups) handles all kinds of electronic displays (see Table 3). Among those WGs, there is WG12, Eyewear Displays, covering HMDs. Within IEC TC 110 WG12, experts from all over the world discussed a lot to put proper title of this working group, WG12, handling HMDs, and they put EWD, Eyewear Displays for HMDs considering standardization activities in IEC.

Table 3 – WG structure under IEC TC 110

WG 6	3D Display Devices (3DDD)
WG 8	Flexible display devices (FDD)
WG 9	Touch and interactive displays (TID)
WG 10	Laser display devices (LDD)
WG12	Eye-Wear Display(EWD)
WG13	Optical measurements of electronic displays (OPT)
PT 62341	Organic light emitting diode displays (OLED)
PT 62595	Display lighting unit (DLU)
PT 63211	Durability test methods for electronic displays (DTM)
MT 61747	Liquid crystal display devices (LCD)
AHG 16	Electronic displays for special applications (SPA)

3.2 Standards by IEC TC 110 WG12, EWD

IEC TC 110 WG12, EWD, has already established the following standards for HMDs (see Table 4) and is developing the following standards (see Table 5) (dated 2019/09/03).

Table 4 – Published standards by IEC TC 110 WG12

IEC number	Title
IEC TR 63145-1-1:2018	Eyewear display - Part 1-1: Generic introduction
IEC 63145-20-10: 2019	Eyewear display - Part 20-10: Fundamental measurement methods - Optical properties

Table 5 – Standards under development in IEC TC 110 WG12

IEC number	Title
IEC 63145-1-2 ED1	Eyewear display - Part 1-2: Generic – Terminology
IEC 63145-10 ED1	Eyewear display - Part 10: Specifications
IEC 63145-20-20 ED1	Eyewear display - Part 20-20: Fundamental measurement methods - Image quality
IEC 63145-21-20 ED1	Eyewear display - Part 21-20: Specific measuring methods for VR type - Image quality
IEC 63145-22-10 ED1	Eyewear display – Part 22-10: Specific measurement methods for AR type – Optical properties

For measurement methods, WG12 proposed newly developed measuring method simulating eye movement during seeing an image on a display through optical component(s), such as lens and/or mirror (see Fig. 3).

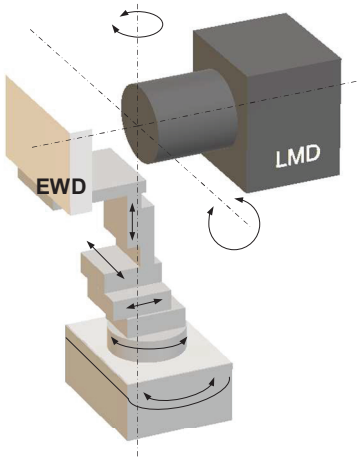


Fig 3 – an example of measuring method

By using this measuring method, it is possible for us to measure the quality of an image for each eye.

3.3 ISO, International Organization for Standardization

Other International Standardization body handles HMD is ISO, International Organization for Standardization. Within ISO, there is TC (Technical Committee) 159, 'Ergonomics', handles all ergonomics related standards. Within ISO TC 159, there is SC (Sub-Committee) 4, 'Ergonomics for Human-System interaction', handles all ergonomics related standards for interactions between human being and system, including computer system. Under SC4, there are 2 WGs related to HMDs, one is SC4, there is WG2, 'Visual Display Requirements', and the other is WG12, 'Image Safely.

WG2 has developed ISO 9241-300 series standards related to displays (see Table 6).

Table 6 – ISO 9241-300 series by ISO TC 159/SC4/WG2

ISO number	Title
ISO 9241-302	Terminology for electronic visual displays
ISO-9241-303	Ergonomic requirements for electronic visual displays
ISO 9241-305	Optical laboratory test methods for electronic visual displays
ISO 9241-306	Workplace test methods for electronic visual displays
ISO 9241-307	Analysis and compliance methods for electronic visual displays

Among those standards, ISO 9241-305 set measuring methods for HMDs, called 'Near-to-eye display'. However, this standards was established in 2008, based upon HMDs available at that time. Therefore, those measurement methods are needed to be updated. And, there is no requirement for HMDs in ISO 9241-307 Analysis and compliance methods for electronic visual displays. That means at this point, there is no standards defines ergonomics requirement related to HMDs. In order to develop a standard handles ergonomics requirements for HMDs, WG2 started new activities to develop new standards for HMDs.

WG12, Image Safety, are developing standards related to HMDs in ISO 9241-391 series (see Table 7).

Table 7 – ISO 9241-391 series by ISO TC 159/SC4/WG12

ISO number	Title
ISO 9241-391	Requirements, analysis and compliance test methods for the reduction of photosensitive seizures
ISO 9241-392	Ergonomic recommendations for the reduction of visual fatigue from stereoscopic images
ISO 9241-393 (Under development)	Structured literature review of visually induced motion sickness during watching electronic images of human-system interaction
ISO 9241-394 (Under development)	Ergonomic requirements for reducing undesirable biomedical effects of visually induced motion sickness during watching electronic images

Among those standards, ISO 9241-393 and -394 are closely related to contents showed on HMDs. ISO 9241-393 tells us scientific back ground information about visual induced motion sickness, VIMS. It tells us the theories of VIMS, measurement methods and what kind of image factor would affect a viewer, such as visual motion, constant rotation of global image motion. And, ISO 9241-394 tells us requirements and recommendation for image contents and electronic display systems to reduce VIMS. Within this document, major factors related to VMIS [1], such as visual motion within images, for example amount of visual global rotation, image size in visual field and navigating velocity. This also tells us some information about delay of image generating, based upon head tracking. Fig 4 shows schematic system structure of measurement process for estimating time delay of HMD for head tracking.

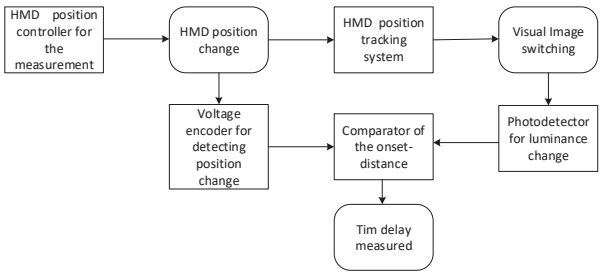


Fig 4 – schematic system structure of measurement process for estimating time delay of HMD

3.4 New characteristics of HMDs

As stated, some of characteristics of HMDs are well covered by existing standards. However, there are some

more characteristics that affects viewer's experience of using HMD(s), such as weight, weight balance and wearing characteristics. Although those are important characteristics, since HMDs are recently got popular, and the interest of this kind of fundamental physical parameters is not that high, there is no much research done for this area. As stated before, those very general physical characteristics of HMDs would affect a viewer directly, since she/he wears a HMD, it is obvious that some standard would be required to ensure safe, comfortable use of HMDs.

4 Experiment

In order to answer that requirement, AIST started their activities to investigate ergonomics aspect of weight and weight balance of HMDs [2]. In addition to that experiment, they have investigated viewers' performance and subjective evaluation based upon weight and weight balance of HMDs [3]. This report shows subject sense of burden is related to weight and weight balance. It shows that the burden is almost same if the product of weight and weight balance (distance from gravity center). This product of weight and weight balance means the torque to support an HMD on the head of a viewer. This means that the torque based upon weight and weight balance would shows parameter of conformity assessment for physical fitness of a HMD to a viewer.

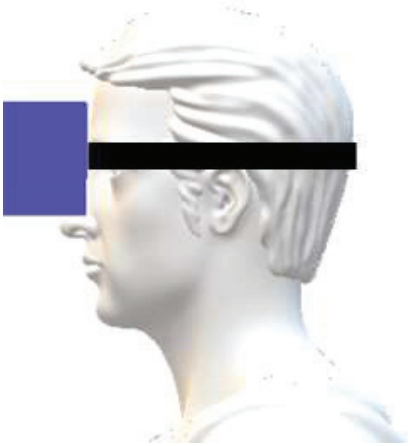


Fig 5. – 'wearing' display

5 CONCLUSIONS

Recently, use of HMDs is getting popular in business area to have virtual experience without having actual risk, such as risk assessment of hazardous situation. However, as stated, using HMD may affect a viewer by that HMD, since a viewer is going to wear 'display', itself. Needless to say, it is import to have certain guideline to avoid unwanted effect by HMDs.

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