DISPLAY SOLUTIONS OF OPTOELECTRONIC SYSTEMS IMAGERY

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ABSTRACT

In this paper there are presented the most used head mounted display principles by showing the particularities of the presented principles and the there are presented the functions which characterize the HMD performances, a field with high interest in military equipments.

keywords: Head Mounted Display, HMD, optoelectronic system , head mounted projective display, HMPD

This paper presents the generalities of head mounted optoelectronics systems, also known world widely as **Head Mounted Display- HMD**.

A general method of classifying HMD's is by how many images are presented and to which eyes. The three classifications are monocular, bi-ocular, and binocular (Figure 1). A monocular display presents one image to one eye. A bi-ocular display presents one image to both eyes (i.e. both eyes see the same image). Finally, a binocular display presents different images to each eye. It is only with a binocular display that true stereoscopic images can be presented.

Another method of classifying HMD's is by whether they are occluded or see-through displays. The occluded (or inclusive) display is one where only the image produced by the display is visible to the viewer. The see-through (or augmented vision) display is one where the viewer sees both the image produced by the display and the ambient scene.

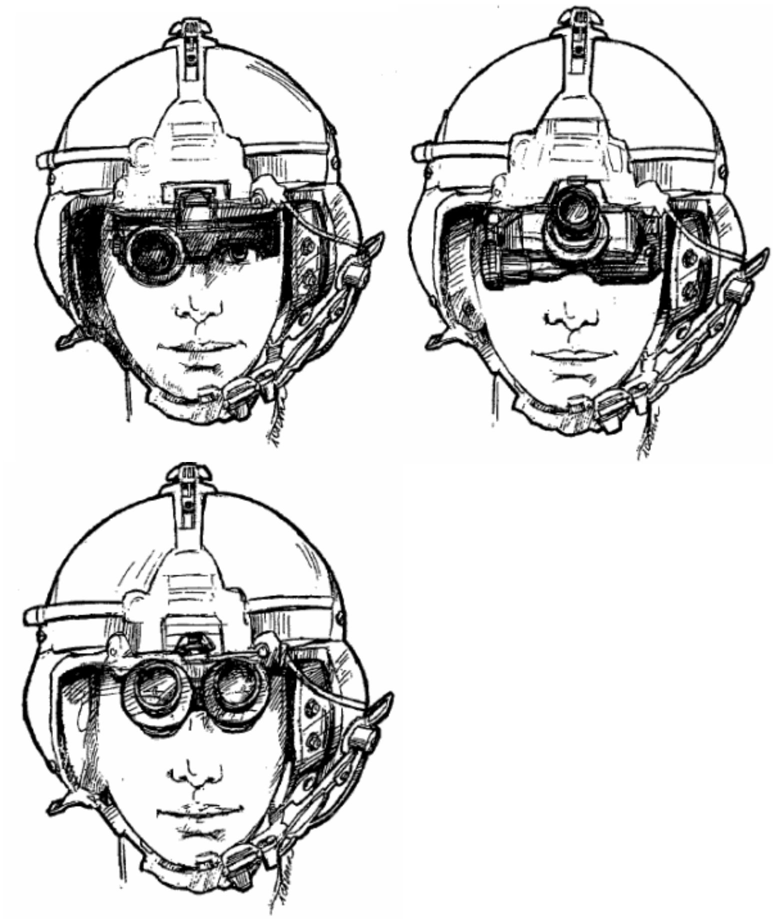

Figure 1: Monocular, bi-ocular and binocular goggle (occluded display).

Figure 2 and Figure 3 show HMDs whit see-through displays.

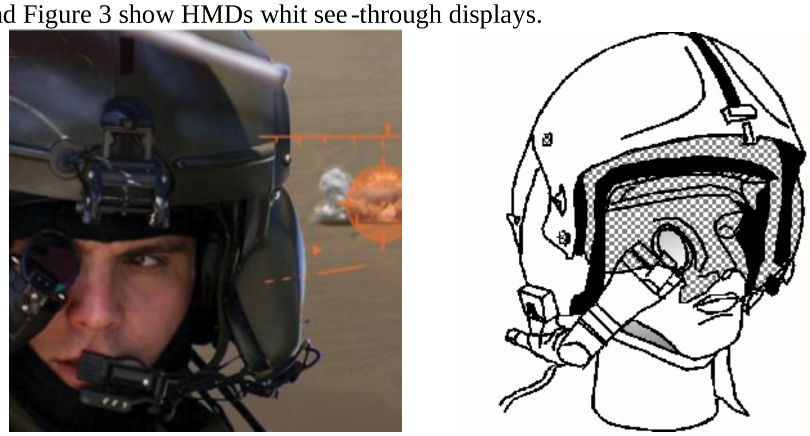

Figure 2: See-through display in monocular design.

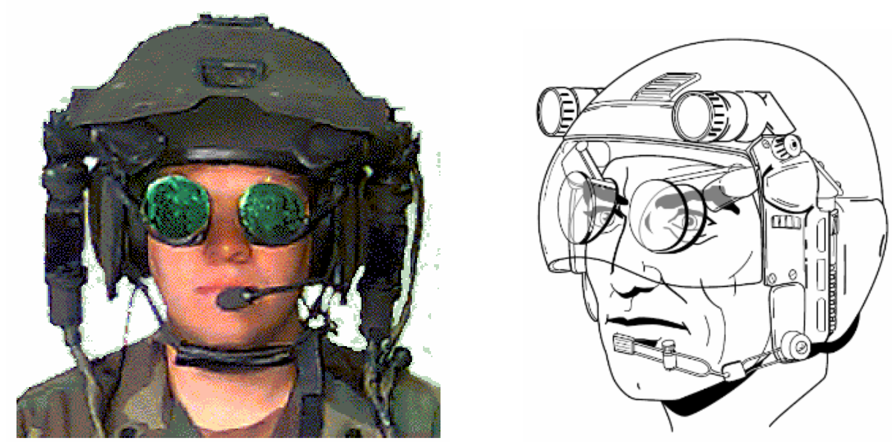

Figure 3: See-through display in binocular design

Images are the regions of concentration of light rays originating from the source, called the object. When these rays actually intersect, the resulting image is **real.** Figure 4 shows an example of real image formation by a lens. When only the extensions of the rays intersect, the resulting image is **virtual**, as shown in figure 5 and figure 6. The fundamental difference between a real and a virtual image is that a real image can be viewed at an accessible plane in space (with a screen of some sort) and a virtual image cannot.

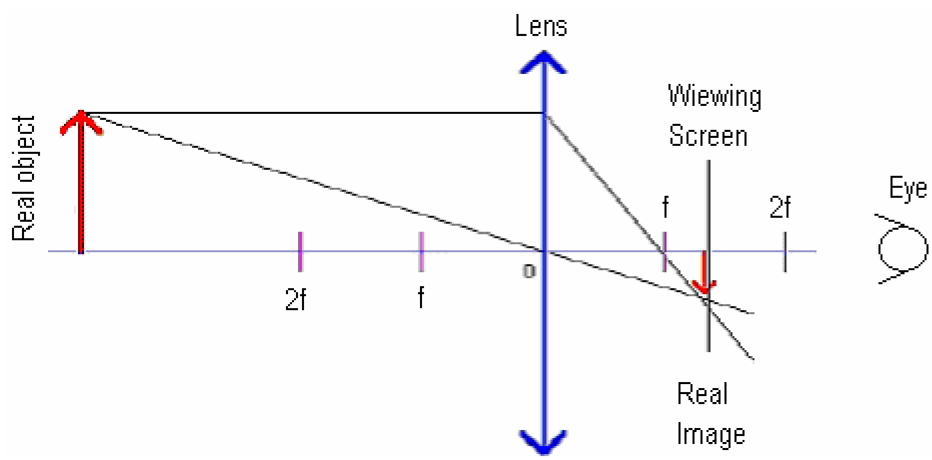

Figure 4: Formation of a real image by a lens.

Viewing a real image requires an image plane or viewing screen and defeats the purpose of a see-through display. However, real image HMD designs are rare. They would be direct view systems requiring the image source (e.g., a miniature LC display) to be located in front of the eye(s) at the typical reading distance of the eye (10 inch). This assumes a large overall size and a high deviation of mass center of the helmet which affects the capacity to sustain the helmet on the head.

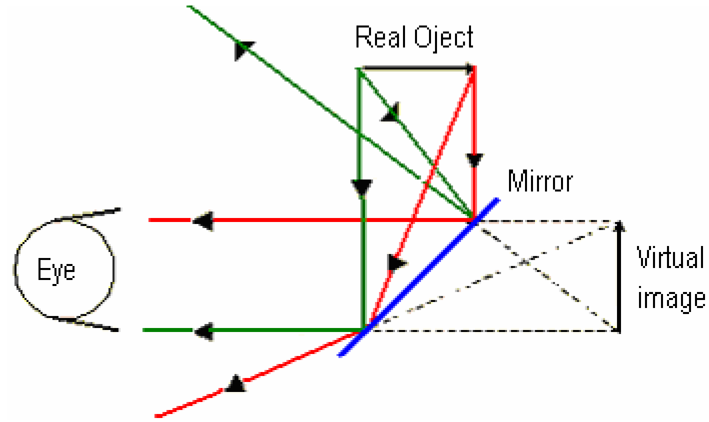

Figure 5: Formation of a virtual image by a mirror.

That's way, generally, the HMD projects a virtual image. Particularly,, in th e case of see-through display, the system is giving a virtual image viewed as being in the same plane as the terrain image.

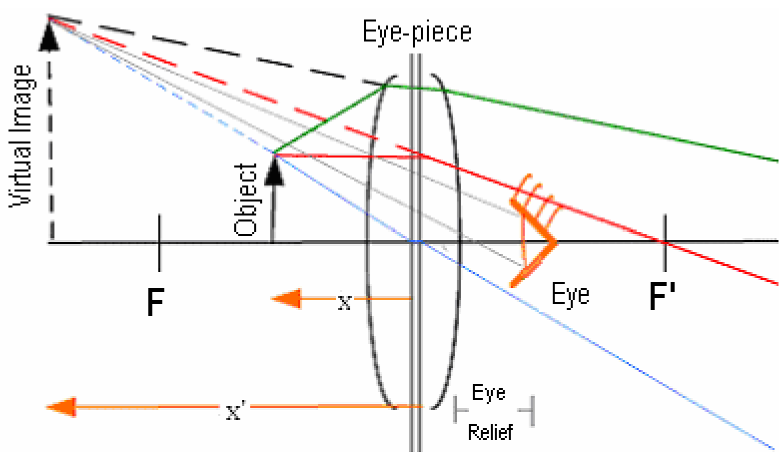

Figure 6: Formation of a virtual image by eye-piece

The principle of virtual image being formed on a reflecting surface (fig.5) is present in all see-through HMD, as shown in fig.2 and fig.3. The reflecting surface is actually an beam splitter or an see - through mirror.

The virtual image of an object located between the lenses and the font focal plane, image which is formed with the help of eyepiece, fig.6, is more far and enlarged and is rectified. This principle is the principle used in case of occluded display from the night vision goggles, fig. 1.

The principles of HMD with a see-through display with virtual image formation thr ough and partially transmissive reflector are much more complex. Figure 7 illustrates a typical approach for forming a binocular virtual image in a head mounted display. The base idea is to relay the object's image to the human visual system. Thus, between the object (the screen source for the displayed image) and a see - through mirror (also named combiner) which allow the simultaneous vision of the displayed image superimposed on the direct scene image, a collimating, transmitting and displaying system is p laced.

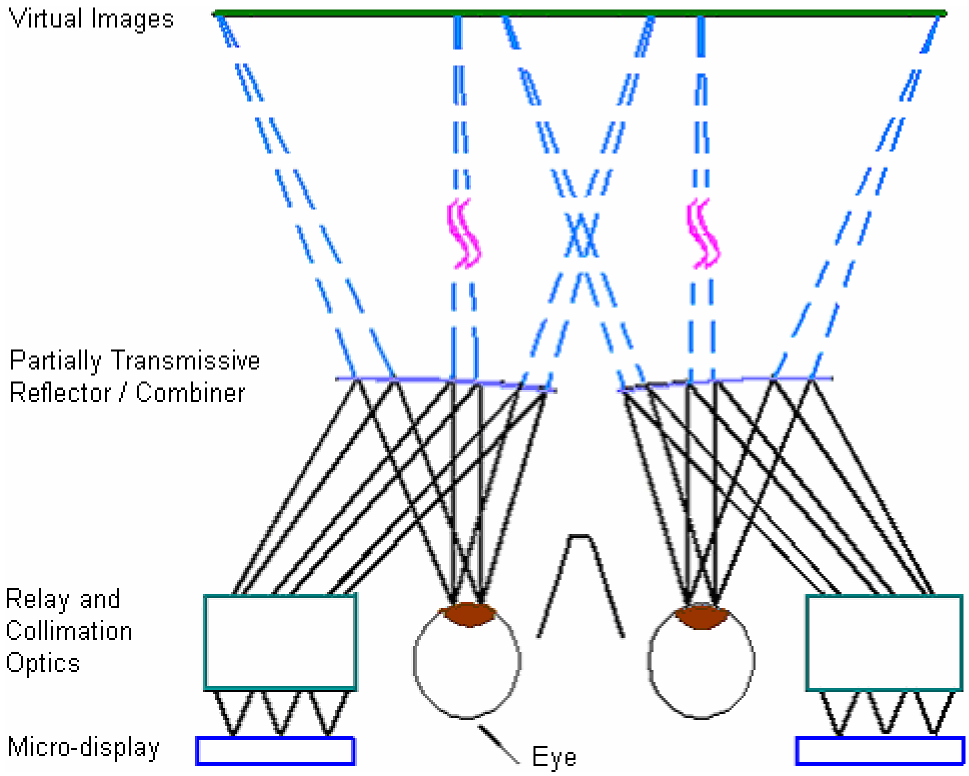

Figure 7: A general approach for imaging in a binocular see-through HMD

Typically, binocular HMDs fully overlap the images in each eye. In such HMDs, the FOV is limited to the FOV of the display optics. However, in order to achieve larger FOVs, recent HMD designs partially overlap the images from two optical channels. This results in a partially overlapped FOV consisting of a central binocular region (seen by both eyes) and two monocular flanking regions, each seen by one eye only (Figure 8).

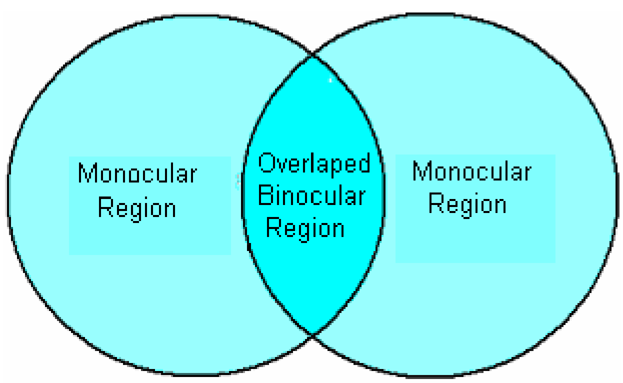

Figure 8: Partially overlapped FOV with a central binocular region and two monocular regions.

Virtual image displays offer several advantages. At near optical infinity, virtual images theoretically allow the eye to relax (reducing visual fatigue) and provide easier accommodation for older aviators. The collimated image also reduces effects of vibration producing retinal blur.

Another type of HMD system uses the projection of the image on a combiner. This system is called HMPD, fig. 9.

Figure 9: Examples of head-mounted projective display (HMPD)

The concept of head-mounted projective display (HMPD) has been recently proposed as an alternative to conventional eyepiece-type head-mounted display (HMDs). An HMPD, conceptually illustrated in Fig. 10, consists of a pair of miniature projection lenses, beam splitters, miniature displays mounted on the head, and a supple and non-distorting retro-reflective sheeting material placed strategically in the environment. An image on the miniature display, which is located beyond the focal point of the lens rather than between the lens and focal point as in a conventional head-mounted display (HMD), is projected through the lens and retro-reflected back to the entrance pupil of the eye, where the exit pupil of the projection optics is conjugated to through the beam splitter, so the eye can observe the projected image. The retro-reflective screen allows the direct vision, being transparent, and also the viewing of the displayed image by having retro-reflective proprieties. Another advantage of the HMPD principle is that the retro-reflected beam forms the exit pupil diameter with the dimension given by projection optics.

Two major components, the projective optics rather than an eyepiece as used in conventional HMDs and a retro-reflective screen rather than a diffusing screen as used in other projection-based displays, distinguish the HMPD technology from conventional HMDs and stereoscopic projection displays as CAVEs. The usage of projection optics allows for a larger field of view (FOW) and less optical distortion, compared with conventional eyepiece-based optical see-through HMDs. Furthermore, the combination of projection and retro-reflection makes the HMPD intrinsically provides correct occlusion of computer-generated virtual objects by real objects. Ideally, the perception of image shape and location is independent of shape and location of a retro-reflective screen.

Also, HMPD systems are more lightweight, robust, with lower aberrations than ey epiece optics design (relay and collimation optics) of HMDs. Thus, the technology has been pursued an alternative to stereoscopic displays for a variety of 3D visualization application.

The quality and properties of the retro-reflective material play critical roles in the overall imaging quality of HMPDs. The retro-reflective sheeting material is commonly used in traffic control and photonic lighting systems, rather than optimized for imaging purpose as in the HMPDs.

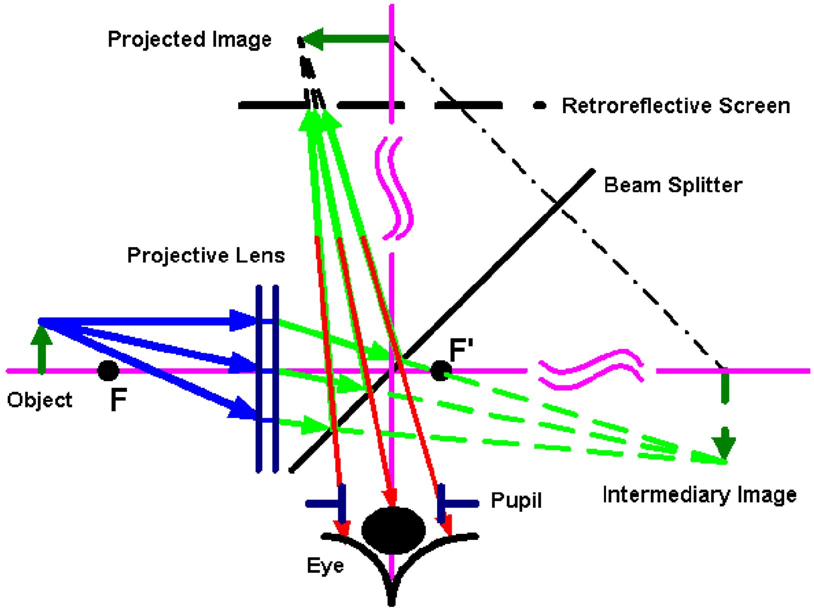

Figure 10: Imaging concept of HMPD.

Regardless of the actual optical approach used, an HMD also must include an image source, a head/eye tracker (if sensor is remotely located), and a helmet platform. An HMD system provides one or more of the fallowing functions:

- the displaying of the flaying parameter or the weapon system parameter, given by the imaging sensors (FLIR or image intensifier tube);
- to display, when needed, strategic, tactical and operational information (used as a information management system);
- to capture the head and eye movement for choosing the target, directing sensors and armaments by activating the intended commands.

Lately, the interaction of HMD subsystems is analyzed by using functions of merit (FOM). These FOMs are grouped into natural performance categories: optical system, visual, helmet (with tracking system), and human factors engineering. In the table presented bellow parameters for analyzing HMD system performance are shown.

Optical system	**Visual**	**Helmet**	**Human factors**
Prismatic deviation Residual refractive power FOV Percent overlap Extraneous reflections Biocular channel disparities and misregistration Chromatic aberrations Exit pupil size and shape Image overlap Static and dynamic MTFs Distortion	Visual acuity Visual field See-through luminous transmittance See-through color discrimination Ocular responses Depth perception and stereopsis Illusionary effects Visual problems	Head supported weight CM offset Impact attenuation Shell tear resistance Fitting system characteristics HMD breakaway force Anthropometric fitting range Visor optical characteristics Tracking accuracy Tracking resolution Tracking system update rate Tracking system motion box size	Interpupillary distance range Physical eye relief User adjustments-selection and range Equipment compatibility Training requirements Egress characteristics Fit procedure

Spherical/astigmatic aberrations		Tracking system jitter Real-ear attenuation Speech intelligibility	

Simply, an HMD projects head-directed sensor imagery and/or fire control symbology onto the eye, usually superimposed over a see-through view of the outside world. As such, HMDs offer the potential for enhanced situation awareness and effectiveness. However, their design and implementation are not without problems and limitations. Virtually every HMD, concept or fielded system, suffers from one or more deficiencies, such as high head-supported weight, center of mass off-sets, inadequate exit pupil, limited FOV, low brightness, low contrast, limited resolution, fitting problems, and low user acceptance. Of the potential problems with HMDs, none are more troublesome than those associated with the interfacing of the system with the human user. The wide variation in head and facial anthropometry makes this a formidable task, requiring HMD designs rich in flexibility and user adjustments.

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