Noticeable Differences for Image Misalignment in Biocular Helmet Mounted Displays

Logan Williams[1], James Gaska[1], Marc Winterbottom[1], Elizabeth Shoda[2], Eleanor O'Keefe[2], Alex Van Atta[2], Thao-My Tran[1], Steven Hadley[1]

[1]OBVA Laboratory, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

[2]KBRWyle, OBVA Laboratory, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

ABSTRACT

Biocular/binocular near-eye/helmet mounted displays (HMDs) typically exhibit registration errors between left and right eye images due to distortions and misalignment of the individual left/right optics, or poor HMD fit. Biocular registration errors have been known to cause eye strain, fatigue, and performance loss, particularly for precision-critical applications, in both 2D and 3D applications. While various metrology toolsets have been used to precisely quantify angular registration errors, there is widespread disagreement in the literature regarding the subjective degree of human tolerance for misalignment. In this work, we investigate the just noticeable difference (JND) for various binocular registration errors, including convergence, divergence, and dipvergence conditions, in a simulated operational task. Observer performance was evaluated by estimating the JND threshold for typical Heads-Up Display (HUD) symbology under varying degrees of biocular registration error. JND thresholds were found to be statistically correlated with measurements of the each subject's stereo acuity and fusion range, allowing such tests to be predictive of sensitivity to binocular misalignment. The Psi algorithm was used to estimate psychometric thresholds using a 4 alternative forced choice scenario to detect symbol misalignment for more than 30 subjects. These psychometric thresholds were then mapped onto objective registration error maps to illustrate those regions of HMD field of view over which errors will be perceptible to the typical observer. These data and methods can be used to guide binocular HMD design for virtual or augmented reality applications to minimize perceptual misalignment while avoiding over-specification of the display optics.

BIO

PRIMARY AUTHOR

Dr. Logan Williams is a senior research engineer at the United States Air Force School of Aerospace Medicine at Wright-Patterson AFB, Ohio, and currently leads F-35 HMDS tactical vision research for the Operationally Based Vision Assessment laboratory. Previously, he has led multiple lines of research in various fields such as human effectiveness, vison assessment, immersive environment & visual display system design, holographic metrology, and distributed simulation for aircrew training. He has previously served as the lead systems engineer for F-16, A-10, and KC-135 aircrew training systems and has over two decades of experience in analog and digital circuit design, networked control systems, optical & electro-optical system design, and physics-based modeling. He has earned a PhD in Electro-Optics, ME and BS degrees in Electrical Engineering, as well as a BS in Physics.