Effects of display pixel pitch and antialiasing on threshold vernier acuity

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The term “eye-limited” resolution (ELR) has seen significant use in recent years within the simulation training and related industries. Results of a literature review revealed several distinct definitions of ELR and a range of estimates of the pixel pitch required to achieve it. Many authors simply assert that ELR corresponds with 20/20 vision which is produced with a pixel pitch of 1 arcmin and provide no supporting discussion or citations. Others have explained that 1 arcmin is the stroke and gap width for the symbols on Snellen acuity charts for 20/20 vision. Spencer (2013) concluded that image artifacts can be visible for pixel pitches finer than 0.3 arcmin for images that have not been properly band-limited prior to spatial sampling. Hopper (2000) and his colleagues have theorized that a display resolution as fine as a few arcSeconds should be required because humans are capable of achieving hyperacuity thresholds in this range.

Given that resolution is a primary driver of the performance, cost, and complexity of training display systems, a practical definition and a defensible estimate of ELR are needed. In this paper we assert that defining ELR using asymptotic visual performance is the most practical method from the perspectives of display system designers and acquisition professionals. With this definition, ELR is determined by measuring task performance as a function of many levels of display system resolution, and finding the resolution where visual performance is at some standardized level (e.g., 90 or 95%) relative to asymptotic performance.

This paper describes an evaluation of the effects of display pixel pitch and antialiasing filter width on observer performance for a vernier acuity task. This task was selected because it was identified as one of the hyperacuity tasks expected to require a very high display resolution if performance is to be limited only by the observer’s visual system. For this evaluation a pair of offset vertical lines was presented on 20 inch diagonal LCD monitor positioned 3.5 m (11.5 ft) from the observer producing a native pixel pitch of 0.25 arcmin. Vernier acuity thresholds were measured using a two-alternative forced choice psychophysical procedure that was controlled using the Quest algorithm set to measure thresholds with an 81% correct response rate. Data were collected for 57 combinations of pixel pitch and antialiasing filter width. Pixel pitches ranged from 0.25 to 3.0 arcmin and (half max) filter widths ranged from 0.01 to 2 pixels. A multiple regression model fit to the preliminary results from two observers indicates that a vernier acuity threshold of 6 arcsec was obtained using a combination of fine pixel pitch and wide antialiasing filter. Threshold performance degraded with increasing pixel pitch and more steeply with decreasing filter width. With insufficient antialiasing (filter width <= 0.5 pixels), 90% of asymptotic performance requires a pixel pitch <= approximately 0.35 arcmin. With sufficient antialiasing (filter width >= 1.2 o 1.6 pixels), a pixel pitch in the range of 0.6 to 1.0 arcmin produces 90% of asymptotic performance.

Biography

Dr. Charles J. Lloyd is president of Visual Performance LLC where he addresses research and development challenges relating to training display system requirements. He has 29 years of experience in display systems and applied vision research at such organizations as Honeywell's Advanced Displays Group, The Lighting Research Center, BARCO Projection Systems, FlightSafety International, and the Air Force Research Laboratory. Charles has published 75 papers in this arena.