Inter-and intra-variability assessment of common technical specifications of consumer-off-the-shelf (COTS) displays

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Abstract

Background: The display (monitor) is currently defined and included as an integral part of the digital pathology pixel pathway. Medical grade (MG) displays were chosen over consumer-off-the-shelf (COTS), or professional-grade (PG) displays to be used within FDA validation studies. We present data comparing the technical criteria (to date) for multiple displays, including two FDA-cleared MG display and three sets of COTS displays as follows: 1) Dell MR2416 x 1 (Leica, MG), 2) Philips PP27QHD x 1 (PIPS, MG); 3) HP 1FH49A8#ABA x 4 (COTS, 24", 1080p); 4) LG 27BN88U-B x 4 (COTS, 27", 4K), and 5) LG 32BN88U-B x 4 (COTS, 32", 4K).

Methods: Absolute luminance, luminance uniformity, and color measurements were taken with an X-Rite PANTONE i1Basic Pro2 spectrophotometer using DisplayCAL software. Display types (3-5) were calibrated to 250 cd/m^2, and 10-12 sets of luminance measurements were taken. Delta E-2000 values were calculated to assess uniformity, which measures the luminance difference between the display's outer edges and the center. A 490-color test panel was used to assess calibrated color accuracy measurements. For context, these data were compared to 12 sets of measurement data taken for MG displays (1 & 2) in a previous study. Statistical analysis was conducted with Tableau.

Results: The boxplots and the 95% confidence intervals for median luminance deviation from 250 (not shown), uniformity (Figure 1A), and color accuracy (Figure 1B) were calculated and visualized. An ideal measurement for all characteristics is close to 0. Luminance on the Dell MR2416 and LG 27BN88U-B tended to be more uniform, while the LG 32BN88U-B and Philips PP27QHD were less uniform (e.g. higher Delta E-2000). All calibrated monitors had a median Delta E-2000 value < 1 in terms of color accuracy, which is generally considered to be indistinguishable by a human observer.

Conclusions: The COTS displays of the same model series, but with different sized display panels, showed significant variation in uniformity and luminance, demonstrating that one cannot assume equivalence based on a vendor's model series/branding and that there is value in taking empiric measurements prior to display acceptance. An alternative hypothesis is that larger panels tend to be less uniform than smaller panels. Calibration has a marked effect on color accuracy differences between displays. Further evaluation of how these factors may affect a pathologists' performance in a clinical setting may be warranted.