A low-cost, color-calibrated high dynamic range display
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High dynamic range (HDR) displays are enabling new advances in visual psychophysics, but commercial HDR displays are both expensive, and difficult to calibrate colorimetrically. Homebrew HDR displays incorporating LCD panels and digital projectors are relatively inexpensive and can be calibrated, but building such displays requires sophisticated technical skills. We have developed a low-cost, color-calibrated HDR display for vision research that can be constructed and used by researchers without the need for specialized equipment or advanced engineering abilities. Inspired by the work of Bimber et al., this print-based HDR display incorporates an inkjet printer, a digital video projector and a digital camera. To display an HDR image, the image is first processed through the iCAM06 color appearance model to produce a standard dynamic range (SDR) image that is sent to the printer. The digital video projector is then roughly positioned so its image field covers the print. Custom camera-based structured-light image registration software then automatically aligns the projected and printed images. A separate camera-based color calibration module then measures the print colors and determines the values to send to the projector to achieve the best possible reproduction of the original HDR image. This iCAM-based approach to HDR color reproduction goes substantially beyond prior work in terms of its colorimetric accuracy. With respect to intensity and dynamic range, because the print area is substantially smaller than a projector’s typical field size, the maximum intensity in the combined image can be quite high, and the current display has a peak luminance over 2000 cd/m² with a dynamic range of 20,000:1. While the print-based nature of this display does limit its usefulness for interactive studies, its low-cost, do-it-yourself design, and ability to be calibrated should make a valuable addition to the vision researcher’s laboratory.
A low-cost, color-calibrated, reflective high dynamic range display

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• Background / motivation:
  • images taken at different exposure times can be merged into a single HDR image
    • 10,000 to 1,000,000:1 dynamic range
    • impossible to view HDR images on standard displays
    • typically 30:1 – 100:1 usable dynamic range
  • High dynamic range (HDR) display (Seetzen et al. 2003):
    • dual image plane design
    • transparent LCD front plane with DLP backlight
    • image values multiply to produce HDR output

• New Approach:
  • calibrated print-based HDR display
  • new appearance-based HDR image splitting algorithm
• Geometric registration:
  • custom structured light (checkerboard) image registration software measures misalignment of projector and print
  • affine transform is calculated to register the images

• Colorimetric characterization (projector):
  • luminance/color stability of DLP projector is measured
  • output is linearized through calculated LUTs

• Colorimetric characterization (printer):
  • color output managed through custom ICC profile
  • paper type affects color gamut volume
    • mesh: HP satin matte photo; solid: HP canvas

• Display performance:
  • ~2000 cd/m² peak lum., ~20,000:1 dynamic range

• Impact:
  • low-cost, off-the-shelf, DIY HDR display
  • color calibrated output suitable for image perception/quality research
  • integrated with PsychToolbox
  • additional applications: radiology, astronomy, virtual museums

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