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Calibration of medical displays

Effects of luminance conditions and the limitations of the human visual system

Akademisk avhandling

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I. Båth M, Sund P, Ungsten L, Månsson LG
Calibration of diagnostic monitors: Theoretical determination of optimal luminance settings
J Soc Inf Disp. 2006;14(10):905–911

II. Sund P, Båth M, Ungsten L, Månsson LG
Generation of low-contrast sinusoidal test patterns on a high-brightness display
J Soc Inf Disp. 2006;14(10):913–919

III. Sund P, Båth M, Månsson LG
Investigation of the effect of ambient lightning on contrast sensitivity using a novel method for conducting visual research on LCDs
Radiat Prot Dosimetry. 2010;139(1-3):62–70

IV. Sund P, Månsson LG, Båth M
Development and evaluation of a method of calibrating medical displays based on fixed adaptation
Med Phys. 2015;42(4):2018-2028

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ABSTRACT

Calibration of medical displays

Effects of luminance conditions and the limitations of the human visual system

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Calibration of medical displays is important in order for images to be displayed consistently. A consistent appearance ensures that all images are always perceived in the same way regardless of display device, location and time. Since a true consistent appearance requires displays with equal luminance ranges, which is neither practically achievable nor desirable, the aim of a calibration is rather to obtain a consistent distribution of perceived contrast throughout the gray-scale. An inconsistent contrast distribution may lead to an increased workload when reviewing and possibly an erroneous diagnosis. It is also important that a display calibration utilizes the luminance range of a display as efficiently as possible by avoiding gray-scale regions with low contrast. The widely used DICOM part 14 calibration method, the grayscale standard display function (GSDF), meets these necessary requirements for a large range of display settings. However, the GSDF does not account for the limited range of the human visual system (HVS) to detect low-contrast objects when adapted to a certain luminance level, so called fixed adaptation. The luminance range of modern displays is increasing, which is beneficial since the overall contrast increases, but when calibrated to the GSDF, an increasing luminance range compromises the intention of consistent contrast distribution and an effective use of the gray-scale.

The main aim of this thesis was to determine the properties of the HVS under conditions of fixed adaptation, and to use this information to derive a new calibration method that compensates the GSDF for fixed adaptation, thereby extending the original intentions of the GSDF for displays with a large luminance range. In order to study contrast properties of the HVS on medical displays under realistic conditions for a radiologist, a method using an extended image bit-depth together with a sub-pixel modulation technique, was developed to display sinusoidal test patterns close to the detection threshold. These patterns were used in several observer studies with different display luminance ranges and ambient lighting conditions.

The results show how the ability to detect low-contrast patterns, using equipment and viewing conditions typical for a radiology department, decreases when the difference between the luminance of a pattern and the adaptation luminance increases. A new calibration method is presented that compensates the GSDF for fixed adaptation, provided that the adaptation luminance is known. The new calibration method was, in an evaluation study, found to distribute the perceived contrast more consistently on high luminance range displays than the GSDF. Other results show that only the average luminance in an image, not the luminance distribution, affects the adaptation level. Also, light from outside the display may reduce the ability of an observer to detect low-contrast objects, especially when the luminance surrounding the display is greater than the average luminance of the display.

Keywords: Medical display calibration, Image perception, Low-contrast detectability, Observer studies

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