Uniform luminance technology

Non-uniformity and noise in LCDs

Although LCD technology has improved a lot over the past years, Liquid Crystal Displays still present a challenge when it comes to showing images consistently over time. Today's LiquidCrystal Displays typically suffer from non-uniform behavior across the screen area, causing arbitrary patterns that interfere with the medical image content. These patterns, also called mura or noise, can have several causes. Non-uniformity of the backlight for example is responsible for the typical luminance fall-off towards the corners of the display. Also, liquid crystal cell artifacts can cause random, high frequency, pixel-by-pixel variations in the luminance and color of the display. The superposition of all these effects results in spatial noise, which can be observed as a fixed, cloudy pattern on the LCD.

Uniform image rendering across the entire screen

To compensate for LCD non-uniformity, We have has developed its proprietary Uniform Luminance Technology. This technology reduces luminance non-uniformities and color non-uniformities and makes sure that the display is compliant with DICOM GSDF across the entire display area.

In a first step, Barco's Uniform Luminance Technology characterizes the spatial noise pattern of the display. Based on this data, which includes all causes of non-uniformity, appropriate correction values for every display pixel and all video levels are calculated. The correction data is chosen so that it will compensate for the spatial noise of the LCD panel.

Uniform Luminance Technology will digitally pre-compensate in real-time each image that needs to be displayed before sending it to the display panel. The correction data that is applied is the inverse of the spatial noise of the LCD. When this pre-compensated image is displayed, the stationary spatial noise of the LCD and the pre-correction cancel out. As a consequence, the resulting image displayed is spatially.

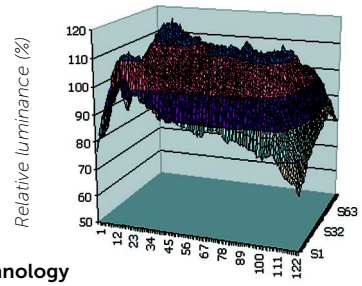
The clinical relevance of Uniform Luminance Technology

Luminance non-uniformity

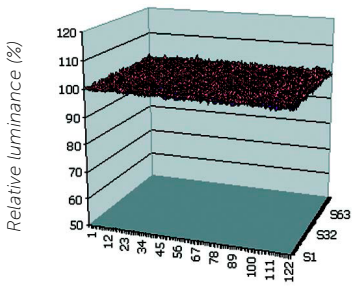
Spatial noise may have a negative influence on the accuracy of reading medical images, as the presence of noise makes it much harder for a human observer to discriminate a (subtle) image feature from the surrounding background. In other words: spatial noise increases the risk of "false negatives" (clinically relevant features that remain undetected). A spatial noise pattern can also be confused with a clinically relevant image feature. The spatial noise pattern of the display, for example, could be interpreted by a radiologist as actually being part of the medical image. Such confusion can result into "false positives".

In the adjoining graphs, we see the luminance uniformity for video level 64 (DDL 6.25%). Without Barco's Uniform Luminance Technology, luminance variations of over 40% are possible, whereas with Uniform Luminance Technology, luminance variations are reduced to less than 5%.

Without Uniform Luminance Technology



With Uniform Luminance Technology

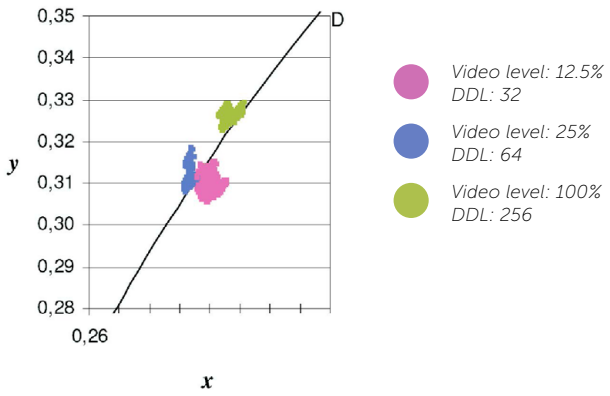


Color non-uniformity

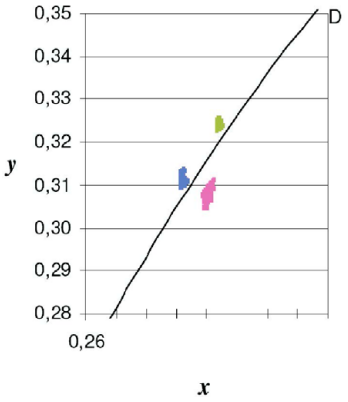
More and more, color displays are used in medical imaging. Color can convey important clinical information. Therefore, precise reproduction of these colors is absolutely necessary. However, spatial noise also impacts the performance of color displays. Compared to grayscale displays, color displays present an extra challenge with respect to uniform behavior. For color displays, the spatial noise content is different for each of the primary colors (red, green and blue). It will not only result in luminance errors over the entire display area, but also in different color reproduction over the display area. In other words: the same color will look differently depending on the exact position on the display area. It is obvious that this is not acceptable for applications where precise color reproduction is important.

Our Uniform Luminance Technology also improves color uniformity and color accuracy. To analyze the effect of Uniform Luminance Technology on color uniformity, three different colors were shown on the same display. For each of the three colors the exact color coordinates were measured for multiple positions on the display surface. The adjoining diagrams show the results. Without Uniform Luminance Technology there is a very large variation in color coordinates for the same color depending on the position on the display. This variation is much larger than the smallest color difference that a human observer can perceive. With Uniform Luminance Technology the color variation over the display surface becomes much smaller and typically will be less than 0.005 in (x,y)-space. This 0.005 variation is the smallest color difference that a human observer can perceive.

Without Uniform Luminance Technology



With Uniform Luminance Technology

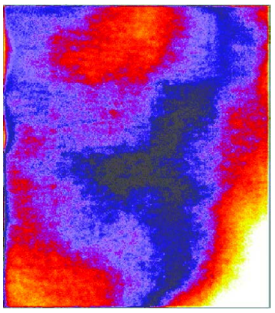


DICOM compliance

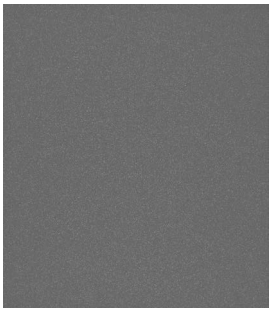
Luminance non-uniformities may also prevent a precise calibration according to the DICOM Grayscale Standard Display Function (GSDF). Compliance to DICOM GSDF is achieved by calibrating the display system. By means of a photometer the exact transfer curve of the display is measured at one point on the display.

Without Uniform Luminance Technology the display system will only be perfectly compliant to GSDF at the exact same position where the display was characterized. On a display system with Uniform Luminance Technology, the display system will be compliant to DICOM GSDF on its complete display surface. The improvement is considerable: without Uniform Luminance Technology the average distortion in Just Noticeable Differences (JND), compared to DICOM GSDF, can be over 25 JNDs. With Uniform Luminance Technology, the DICOM GSDF compliance is equally good for every location on the display surface and average distortion numbers are far below 1 JND.

Without Uniform Luminance Technology



With Uniform Luminance Technology



Not DICOM-compliant *Perfect DICOM-compliance*

Want to learn more?

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