Technology highlight

SmoothGray technology

Grayscale remains important

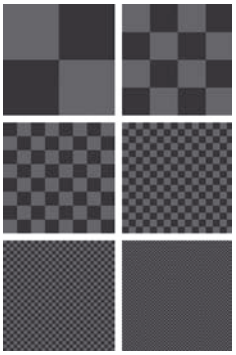
Despite the growing success of color imaging, radiology displays with the highest resolutions (i.e. 5 MegaPixel and up) are still mostly grayscale only.

In order to be approved for medical use, grayscale displays have to comply with the DICOM GSDF standard, which stipulates accurate calculations of the various grayscale levels. This is important, because the more accurate a specific grayscale level can be represented, the more conspicuous certain subtle lesions will become.

Display manufacturers are aware of this and they have engineered several techniques to increase the number of grayscales available on a display.

Dithering techniques

In order to increase the number of noticeable grayscale values, display manufacturers have developed a technique called "dithering". Dithering creates additional grayscale levels by adding small spatial patterns (e.g. for adjacent sub-pixels) or temporal alternations (e.g. by rapidly switching between two levels), or by combining both these techniques.

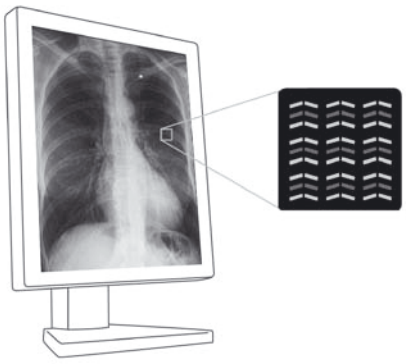


Dithering can be used to create extra visual grayscales. As can be seen in the upper left square, two different luminance levels are generated; the smaller these patches become, the more our eyes will perceive a new grayscale level (being the average of the other two) as can be seen in the bottom right square.

Spatial dithering

'Spatial dithering' is a technique in which adjacent pixels generate different luminance values to eventually create an extra visual level for the user. Spatial dithering is generally accepted and done on grayscale displays with separately addressable sub-pixels.

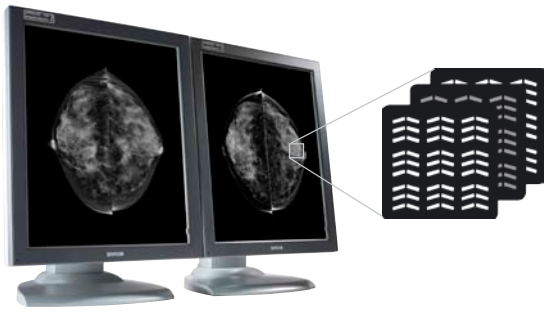
Spatial dithering might seem straightforward to implement, but on some displays it could result in image distortion, mainly because the pixel structure of the LCD panel used is unique (full pixel with 10-bit accuracy). It goes without saying that even the slightest possible distortion on full pixel level is not acceptable in medical imaging, where diagnostic accuracy and confidence are of vital importance.



Display with a zoomed patch of 9 pixels simulating spatial dithering.

Temporal dithering

Temporal dithering uses a rapid alternation of different luminance levels to create a new visual level for the viewer. The human vision system is sensitive to temporal frequencies up to 60Hz (up to 80Hz for very bright levels seen in the periphery). Because of this, simple repetitive temporal alternations will result in a visible flickering. However, with sufficient knowledge of the human visual system, you can avoid the occurrence of this artifact.



Barco Coronis 5MP Mammo with a zoomed patch of 9 pixels simulating temporal dithering over 3 frames.

Combined dithering algorithms

By combining spatial and temporal dithering, many new dithering algorithms are possible. One way of doing this is by classifying the different dithering algorithms based on the specific properties of the generated noise pattern (aperiodic, no clusters,...). Another way to do this is by their specific implementation. Some of these systems also use masking; others base their dithering schemes on error diffusion or even on spectral analysis of the image.
In order to accept a specific dithering algorithm, it is good to refer to the human visual system and try to quantify possible visible deficiencies.

SmoothGray technology

SmoothGray technology introduces a new, innovative technique which combines computation hardware with high-bit precision, a proprietary algorithm, and matching display drivers that send the analog signal to the LCD.

SmoothGray takes advantage of the precise control of the frame switching to provide steps so fine that it is difficult to measure the difference from one shade to the next. For the radiologist, this makes it easier to detect subtle details, such as pulmonary nodules or pneumothoraces.

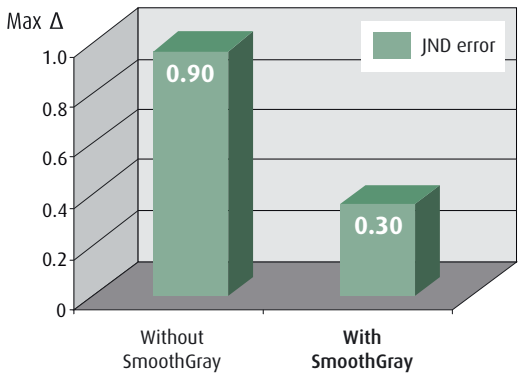
By way of example, the chart below shows a quantitative interpretation of dithering with and without SmoothGray technology. To quantify the difference, a Just Noticeable Difference (JND) metric based on the human visual system was used. JND determines whether a viewer is likely to see the effects of various processing steps on an image with a size of 5 x 5 cm from a distance of 30 cm.

When measuring multiple grayscale values on a grayscale display without SmoothGray (even a 10-bit model), the JND error can be as high as 0.9 JNDs.

This error can even be higher when considering the accumulated error margin of two succeeding grayscale steps. For example: a JND error of +0.8 in one step and -0.6 in the next step could result in an error > 1, which corresponds to a clearly perceivable grayscale step.

On a display equipped with SmoothGray, the JND deviation is significantly smaller. In fact, every sequential luminance step on the screen (JND error) is always < 0.3. This results in a much smoother representation of grayscale images.

Maximum JND error with and without SmoothGray



Maximum JND error with and without SmoothGray technology.

Conclusion

SmoothGray is an advanced, Barco-specific dithering system enabling grayscale values to be shown with perfect luminance and in sync with the human visual system.
Tests show that SmoothGray technology improves the representation of high-resolution grayscale images, which results in higher precision and diagnostic confidence for a radiologist. By incorporating SmoothGray technology into the latest high-resolution displays, Barco brings this precision to the medical studies that need it most.

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