Improved Sensitivity and Specificity of Mammograms by Producing Uniform Luminance from Viewboxes

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RADIOLOGISTS routinely are required to view radiographs to identify the presence or absence of disease or other malady. After careful exposure from a uniform x-ray source and careful processing, the most common way of viewing a radiograph is to place it on a viewbox. Viewboxes, however, are constructed rather inexpensively using fluorescent bulbs, reflectors and diffusers to spread the light over an area the size of an x-ray. Simple electro-optic measurements show that the luminance of the viewbox varies considerably depending on position. The question is whether these variations can be lessened or removed entirely and whether doing the removal of source luminance variations would improve the decisions made by radiologists.¹⁻⁶ This paper focuses on the removal of viewbox luminance variations.

It seems to us that viewbox luminance variation can be corrected by carefully placing the proper mask over the viewbox which has the proper density of mask to adjust the luminance at a given point to the lowest luminance point.⁷ This mask can be made in several ways: (1) by analog methods, and (2) by digital methods.

METHODS

Analog Method

Currently most radiology is done with film and film produces high resolution films. Analog techniques using film can also produce a high resolution mask capable of exact registration with a fiducial mark(s) on the viewbox. One method of mask making is to simply mount a viewbox in front of a large format copy camera capable of copying the luminance pattern to produce transparent film the exact same size as the viewbox. A piece of film as large as the viewbox is placed into the copy camera, the viewbox lights are turned on and warmed up, the aperture and shutter are adjusted for the proper exposure, the film protecting cassette sheet is opened, the shutter is opened and the film is exposed. The optics of a large format camera produce a 1:1 magnification of the source onto the film which becomes the negative image. The film must be properly processed to be sure that a linear Density-Log E (Exposure = Luminance $\times$ time) curve is produced.⁸ This method of making a mask is all that is required. The mask is positioned over the viewbox in exact resolution with the fiducial marks left on the box and which appear on the film. More intense spots on the viewbox result in proportionally darker spots on the mask (it's a negative). If done carefully a viewbox with uniform luminance is produced.

Digital Method

The mask can be produced digitally as well. The viewbox to be made uniform can have its spatial luminance recorded using a digital camera. Each pixel of the camera records an intensity value giving a spatial record of the luminance at each sample point. By simple software manipulations the lowest value of luminance can be found and subtracted from all the higher values. Using programs such as MatLab⁹ or Labview¹⁰ or more highly specialized software, the computer can then calculate the density required at each point to reduce the luminance everywhere to the lowest level found. Figure 1 shows a digital plot of an uncorrected viewbox. Data from each pixel was used to generate a mask and the mask was correctly positioned over the viewbox. The viewbox was then remeasured. Figure 2 shows the mask-corrected viewbox. The results given here are low in resolution, but higher resolution is expected to come from a higher resolution camera and a higher resolution printer which will be incorporated into the mask making development as the work proceeds.

RESULTS

To test the digital method of masking a light box, we used an ordinary viewbox and divided the luminescent surface into about 100 areas. Using a visible optical detector a reading was taken at each of 100 points on the surface where the radiograph would be mounted. Luminance was determined at each of 100 points covering the entire surface. Data shows a nearly 50% difference between the center and the edges. The data from the rather large pixels was used to calculate the densities of each of the correcting pixels of the mask. The mask was printed and placed over the viewbox. The resulting correction, shown in Fig 2 has less than 22% variation over the surface of the viewbox. Current work uses a Kodak digital camera and specialized imaging software for preparation of the mask. These digitizing devices, when combined with high resolution printing, are expected to reduce the variation even more.

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Fig 1. Plot of luminance over the viewbox surface prior to correction. Note that the corners drop to nearly 50% of the center.

Fig 2. Plot of luminance over the viewbox surface with mask correction. This mask was made digitally with only 100 data points and has reduced the variation to 22% at the corners. Higher resolution should smooth the surface.

DISCUSSION

Creating more uniform sources for a viewbox can make it easier for a radiologist to detect an abnormality in a radiograph. The construction of a radiogram results in an image with a fixed signal to noise ratio and a fixed probability of detection of the target. Combining the radiogram with a light source with fewer variations reduces total image noise and thus increases the signal to noise and

increases the probability of detecting the target being sought—a cancerous tumor, for example. While the mask does lower the total luminance from the viewbox, we believe the improved signal to noise of the image, plus the capability of lowering other lights in a viewing room, and thereby increasing the contrast, will compensate for this.

REFERENCES

1. Haua AG, Gray JE, Daly TR: Evaluation of mammographic viewbox luminance, illuminance and color. *Med Phys* 20(3):819-821, 1993
2. ACR: Mammography Quality Control Manual (ed 1994) American College of Radiology, 1994
3. Smith CK, Haus AG, DeBruhl N, et al: Effects of ambient light and viewbox luminance on the detection of calcifications in mammography. *AJR Am J Roentgenol* 168:775-778, 1997
4. Robson KJ, Kotre CJ, Faulkner K: An experimental study of the effect of light-box luminance on the detection of low contrast objects in mammography. *Br J Radiol* 69(8):153-159, 1996
5. Bick U, Geiger ML, Schmidt RA, et al: Density correction on peripheral breast tissue on digital mammograms. *Radiographics* 16:1403-1411, 1996
6. Nab HW, Karssemeijer N, Van-Eming LJ, et al: Comparison of digital and conventional mammography: A ROC study of 270 mammograms. *Medical Informatics* 17(2):125-131, 1992
7. Patent pending
8. Corney GM: X-Rays and Gamma Rays, in Mees CEK, James TH (eds): *Theory of the Photographic Process* (3d ed). New York, NY, MacMillan, 1966
9. Thompson CM, Shure L: *Image Processing Toolbox*. The Math Works, Inc., 1995
10. Demonstration by Owen Golden January 1998, National Instruments, Inc.