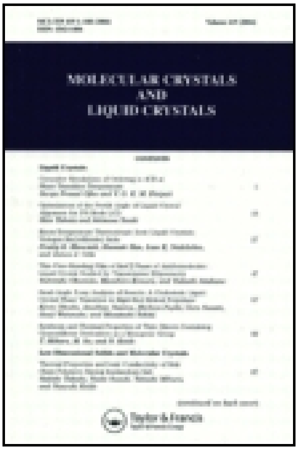

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CONTRAST ADJUSTMENT OF RADIOLOGICAL IMAGES USING LIQUID CRYSTAL DEVICES

H. F. Gleeson [a], R. Winlow [a] & R. Whitehouse [a]

[a] Department of Physics and Astronomy, Manchester University, Manchester, M13 9PL, United Kingdom

[b] Manchester Royal Infirmary, Oxford Road, Manchester, M13 9WL, United Kingdom

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H. F. Gleeson and R. Winlow
Department of Physics and Astronomy, Manchester University, Manchester M13 9PL, United Kingdom

R. Whitehouse
Manchester Royal Infirmary, Oxford Road, Manchester M13 9WL, United Kingdom

When trying to view a radiological image (x-ray) with a full range of optical densities, it can be impossible to see detail in very dark parts of the image if there are also very bright parts. A technique which uses a liquid crystal device to improve the visibility of such images by selective reduction of the optical density range in parts of the image is described. A nematic liquid crystal device (such as that typically used in an overhead projector display) is employed within an apparatus that incorporates feedback to selectively mask bright parts of a radiological image. Obvious visual improvements were obtained using the technique, presenting the potential of a device system for improved analysis of certain radiological images.

INTRODUCTION

When trying to view a radiograph with a full range of optical densities it can be impossible to see very faint parts of the image if there are also very bright parts. This is due to the potential optical density range of a radiological image being around 3.5 Optical Density Units (ODU) which is greater than the observable range of the human eye, approximately 2.5 ODU. Small images surrounded by large bright areas of a viewing box are especially difficult to view as are images such as chest X-rays with large bright areas within the image itself.

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Address correspondence to H. F. Gleeson, Department of Physics and Astronomy, Manchester University, Manchester M13 9PL, United Kingdom.

More difficulties are encountered when trying to photograph images for storage or transmission over the Internet for specialist review. The latitude of a digital camera is not large enough to ideally expose all parts of a radiograph, resulting in overexposure of bright areas or underexposure of dark areas. A suggested solution for images used as educational material, though not advocated for clinical diagnosis is a form of un-sharp masking, using masks of light grey film placed under the brightest areas of a film and blurred using a diffuse cover. This makes the presence of the mask not obvious but the effect on the final image considerable [1]. This technique gives good results but can be time consuming for an examining radiologist who will typically have around 30 seconds to spend assessing each image. This paper describes an automated feedback system employing a liquid crystal light modulator to produce a variable un-sharp mask. The mask produced has a direct correspondence to the radiograph being observed and is generated rapidly through a feedback system. The use of the tailored mask should have a more consistent effect to the technique described above in that the algorithm used to produce the mask is the same for each image. Further, use of a liquid crystal light valve to form the mask is far faster than photographic or mechanical techniques and thus allows observation of images on a time scale that is realistic in the working environment of a radiographer.

EXPERIMENTAL

The apparatus used to produce the mask is shown in Figure 1 and comprises a light box, a liquid crystal overhead projector (OHP) panel (model 3 M 6450), and a digital camera. The radiological image of interest is mounted onto the front of the liquid crystal panel. The liquid crystal OHP uses polarisers and hence absorbs much of the light emitted by the light box. In order that the overall system produced a sufficiently bright image, the light box was designed to be brighter than is normally used to view radiological images. On the front of the OHP panel four red LED's were located to allow resizing and location of the feedback image.

The camera was a JVC TK-C1381 digital colour video camera, connected to a standard video card and Hauppauge WinTV software on a PC. This combination allowed a picture of the radiograph to be taken and stored on the PC from which an un-sharp mask could be produced. The procedure for producing the mask made use of Micrografx Picture Publisher 7 on the PC by creating macros involving standard photo editor tools. The process is summarised as follows.Firstly, the "chroma mask" tool allows a colour to be detected within a variable colour range allowing the red of the LED's to be located. The picture is then automatically cropped to these positions and

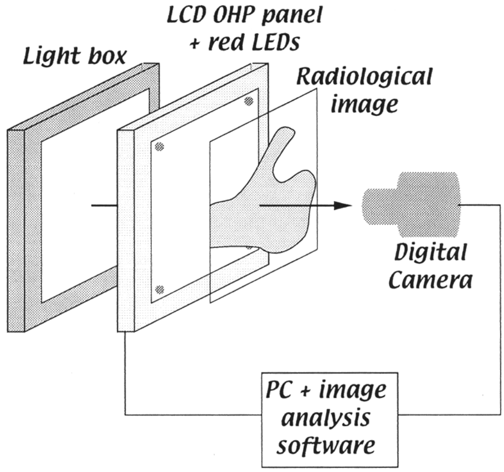

FIGURE 1 A schematic of the apparatus used for producing the un-sharp masks using a LCD.

resized to correlate the image on the projection panel with the radiological image. The "convert to" and "invert" tools are then used to convert the picture into a negative, 8-bit greyscale of the original. These two procedures comprise the first macro that was defined for image manipulation. The second macro is run after the area of interest is highlighted using the "mask" tool. Everywhere outside this area is filled with black and tone adjustments made to the area inside. These include making the lightest areas white and setting a maximum darkness for the rest so that the final mask is not too dark. The final "effect" tool is used in "Gaussian blur" mode to remove sharp edges from the image. Figure 2 shows the stages of the process from the initial picture to the final mask. The effect will be to dim the very brightest areas of the radiograph allowing more detail to be seen by the eye.

RESULTS

The effect of the masking is very noticeable to the eye and is also captured well on camera. Figures 3 and 4 show the difference between the radiological images with cropping only (macro 1) and with the introduction of an unsharp mask (macro 2). The photographs are taken with a Sony DSC-D700 digital still camera. The most striking effect on the thumb image is the visibility of the flesh surrounding the bone. Without the mask this is barely visible as it is very dark and there is a lot of peripheral light from the view box. Similar detail on the hand becomes apparent at the end of

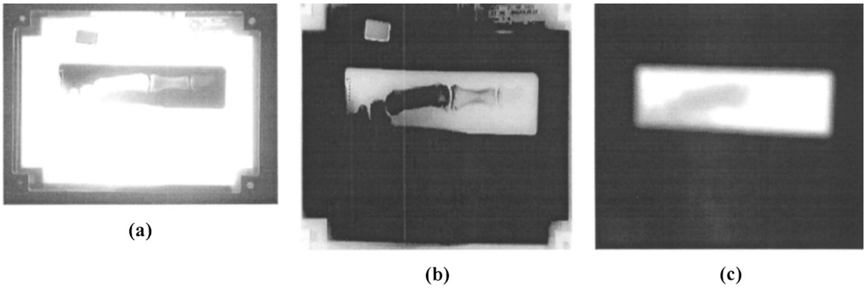

FIGURE 2 (a) The initial picture from the digital camera, (b) after running the first macro to crop to the image size, (c) after running the second macro to produce the final unsharp mask.

the fingertips and the thumb. A significant improvement in the detail that can be observed is achieved with masking only around the edges (macro 1), however the effect of the additional grey mask can best be seen on the hand images. Comparing Figures (b) and (c) it is obvious that the central bright area of the hand is overexposed without the presence of the mask.

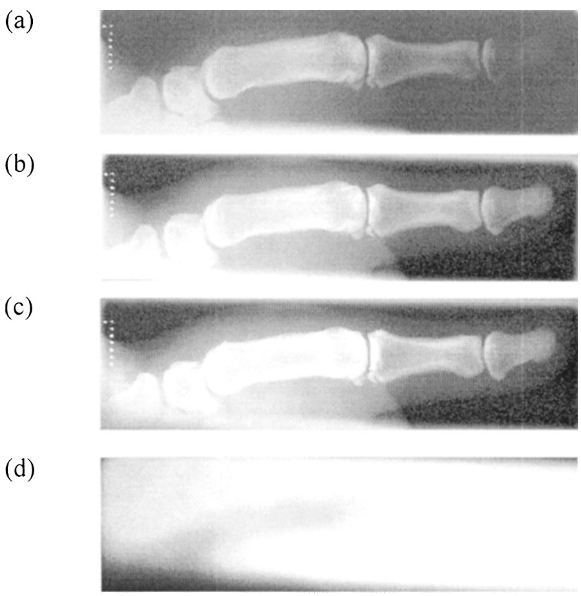

FIGURE 3 Radiograph of a thumb with (a) no masking, (b) edge masked only and (c) fully masked using the mask in (d).

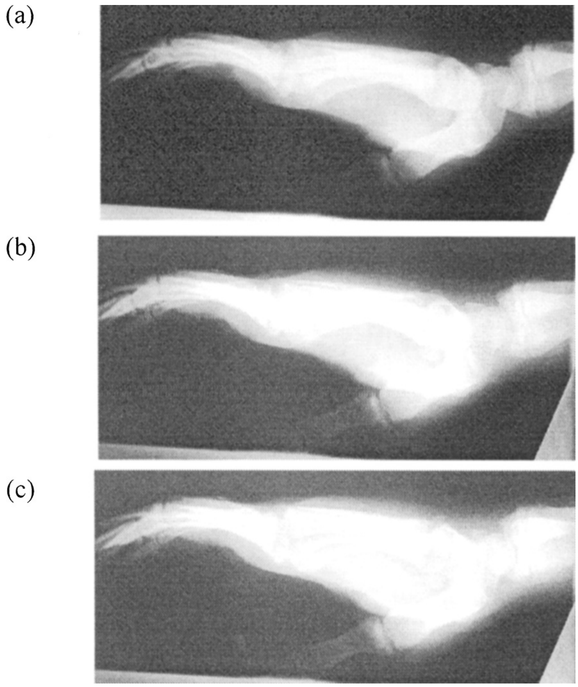

FIGURE 4 Radiograph of a hand with (a) no masking, (b) edge masked only and (c) fully masked.

DISCUSSION AND CONCLUSIONS

The results indicate a significant improvement in the visibility of detail in radiographs using both types of mask. A comparable improvement could also have been achieved had the un-sharp mask been produced using conventional means such as photographic film or mechanical shutters. However, in actual use of a device such as this, the time it takes to produce a mask specific to each x-ray image is extremely important and a limit of around a few seconds can be defined. This means that although the optics described above could readily be applied to several types of mask production, the key to the success of this system is the liquid crystal display which can be updated dynamically by the computer. The computer system allowed the mask to be produced and used in the projection system in a matter of seconds, a time scale that would be acceptable to professional radiologists.

There are of course possible variations in the method described, producing the same effect with similar basic modules (a digital camera, a PC with image grabbing and manipulation software and a light box with a wide viewing angle LCD on the front). The limitations on the technology are mainly related to the size of available LCD displays, typically around twenty inches in diameter. This is somewhat smaller than standard radiological images, but the size is not a limitation in certain specialist areas including mammography where the radiological images are smaller and contrast improvement would significantly improve the assessment of the images. Several companies are developing larger displays that are likely to be better suited to the standard size radiological images. For example, Fujitsu has developed a 90-inch screen using multiple LC panels projected onto a common screen [2]. Investigations by Rainbow displays of Endicott in New York State are also looking at a novel way of stitching panels together with seamless joints [3]. An alternative to the full-sized liquid crystal panel is to use a digital projector to illuminate the viewing screen from behind.

One problem incurred during the investigation was that of viewing angle. The observer has to be in direct line of the mask, the radiograph and the camera, to view the effect of the masking. This was partly due to the parallax introduced by the LC modulator being within the overhead projection panel and thus a short distance away from the radiograph. This could be avoided by having the LCD placed directly onto the front of the viewing box in contact with the radiograph. The second viewing angle problem is intrinsic to twisted nematic (TN) LCD's as in the overhead projection panel. However new developments in vertical alignment [4] (VA) and in plane switching [5] (IPS) systems have seen improvements with viewing angles of up to 160 degrees.

Liquid crystal displays are usually designed to work in monitors with low temperature back lights. The viewing box will have to be much brighter than standard monitor back lights as these are not bright enough to illuminate the darkest details of a radiograph. Low temperature output bulbs must be used in the viewing the box for the comfort of the operator and because LC devices are temperature dependant, though high temperature range devices are now being produced.

In order to capture the initial image, a low-resolution camera is adequate and easily affordable, especially where the sole function of the camera is in the production of the final mask where low resolution is all that is required. In a more complicated system, which may include the possibility of transmitting a picture of the resultant image over the Internet, or retaining it in an archive, a higher resolution camera will be needed. Finally, for practical applications such as in hospitals or less developed countries there may not be space or availability for an external PC or camera. It may be more useful to have an in built processor to control the unit and the possibility of using scanner technology to replace the camera. The relatively simple image acquisition and manipulation should lend itself readily to such miniaturisation.

REFERENCES

[1] Whitehouse, R. W. Use of digital cameras for radiographs: how to get the best pictures. *Journal of the Royal Society of Medicine*.
[2] http://pr.fujitsu.com/jp/news/1995/Sep/13-e.html
[3] Picture Perfect, New Scientist, pp. 16, 11 Dec 1999.
[4] *FUJITSU Sci.Tech. J., 35*, pp. 221–228, Dec 1999.
[5] Masahito, O. H.-E., Masuyuki Ohta, & Katsumi Kondo (1997). Physical behaviour of nematic liquid crystals using the in-plane switching mode. *Mol. Cryst. Liq. Cryst.*, *299*, 401.