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Procesado de Imágenes Médicas e Inteligencia Artificial

Medical Imaging Processing and Artificial Intelligence

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Evaluation of optical readers for X-rays

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Abstract

Various low cost optical readers of X-ray films were compared. Both a CCD and a photomultiplier are capable of capturing X-ray images but many of the scanning devices available are not. The optical readers examined were a video camera, a flatbed scanner, a Logitech hand-held scanner and a Logitech Fotoman digital camera, the best results being obtained using the video camera.

Introduction

The objective of medical imaging is to obtain information relevant to the detection, diagnosis, treatment and monitoring of disease. In radiodiagnosis, much effort is spent in reducing the radiation dose and improving the information obtained with radiographs. Computer technology has the potential to significantly impact radiography in medicine and in dentistry to achieve these goals (1). For example, orthopaedic research often involves angular and linear measurements from plane radiographs. However the accurate standardisation of such radiographs is difficult. Manual techniques of measurement are also found to be time consuming, tedious, highly subjective and seldom defined objectively. Even if the collected data is reliable, further time is required to transfer the information into a database for statistical analysis. In theory digital imaging systems are capable of acquiring imagery that has a wider dynamic range than the human eye or photographic film and a single digital image can present large amounts of information in a compact and easily interpreted form. This paper describes analysis of X-ray films with a view to introduction of a low-cost digitisation method.

Analysis of radiographs was one of the first applications of digital image processing, including enhancement, signal averaging and differencing, geometric transformation, edge detection and digital filtering. The major elements present in every system are: acquisition of a digital representation; processing; display; storage in an efficient manner.

Several types of image acquisition system are possible: image sensors (eg. *Charge Coupled Device*); film scanners which transmit light to a transparency (eg. *laser scanner*); video digitisers, which either "freeze" a single analogue video frame and digitise it point-by-point or else scan the camera field for a few seconds, digitising point-by-point as sequential imagery is acquired. All such acquisition devices provide a range of discrete digital intensity levels that corresponds to the brightness of the image. A fundamental parameter which determines the accuracy or precision is the number of bits per picture element or *pixel*. In an eight-bit system each pixel is assigned to one of 256 different gray levels. However this may be overkill as the human eye is only capable of differentiating between 64 grey levels.

Diagnostic images are often obtained without further processing eg Xrays examined using a light-box. However, following digitisation, several important techniques are available to assist the user:- image enhancement (eg. adjust contrast or brightness, suppress noise); compression where areas of little interest or low variation are treated differently in order to save space; arithmetic and processing with mathematical transformations (eg. addition, subtraction, multiplication, inversion, square-rooting, normalisation, logical manipulation); manipulation of several images, eg. to generate a three-dimensional model, from which slices can be taken (2,3). These all depend on an accurate digitisation method and a good quality Xray image to start from.

Method

Athough systems are in place for digital generation of radiographs, the large quantity of film in file storage and the fact that the majority of radiographs are still rendered onto film led us to take analogue X-ray film as our starting point. The film was converted to a digital image with the use of:- a video camera inputting signal to a frame grabber in a PC; a flat-bed scanner attached to a PC; conventional photography of the film, followed by use of a flat-bed scanner and a hand-held scanner; lastly, a digital camera.

Results

The first image examined was an Xray of a hip joint on Cronex 10S film. Digitising the Xray film using the video camera and frame grabber was rapid and efficient. Focusing and alignment were easy and the analogue image was visualised prior to digitisation.

It was not possible to scan the Xray images using a flat-bed scanner which depends for its operation on light being reflected off the subject to produce the image. A photograph of the image printed on glossy paper produced a brighter and contrasty image- however this introduced distortion. The hand-held scanner also depends on reflection from the subject and so suffered from the same drawbacks. The digital camera was easy to use, allowing images to be viewed almost immediately and saved for further editing. Lighting conditions were found to be critical partly due to an automatic flash light.

Discussion

The video camera and frame grabber combination provided a reliable and efficient method of digitising the Xray film as only the focus required adjustment. Lighting conditions had only a small effect. The CCD in the camera gives a linear response over a wide dynamic range of intensities including the range obtained from the film. For further work we recommend a high resolution solid-state CCD monochrome camera with manual gain and black level (rather than automatic). The backlight source should provide uniform illumination, as well as a stable output.

The flatbed scanner was not flexible enough to permit digitisation of dark film. It generated just 32 grey levels and was incompatible with other viewing software. The method of conventional photography of the film onto dull (not glossy) paper improved the situation- but not to the standard of the CCD. The automatic digital camera also gave poor results because of inflexibility.

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