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Procedia Engineering 38 (2012) 667 – 672

Procedia Engineering

www.elsevier.com/locate/procedia

Bio Image Processing For Cardiac Image Using Virtual Instrumentation

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Abstract

Subtraction methods in Angiography are generally applied in order to enhance the visualization of blood vessels by eliminating the surrounding tissues. First, a series of frames, referred as mask frames, are taken to represent the body anatomy in static form. Then, after the dye is injected into the human body a second series of frames, called phase frames, are acquired to visualize the blood vessel using C- arm X- ray machine along with the Digital imaging and communications in medicine (DICOM) software. In this paper, we propose a new strategy, to improve image quality by employing Digital subtraction and so called image obtained is Digital subtraction Angiography (DSA). In DSA, a mask frame and number of Phase frames are digitized and subtracted using Laboratory virtual instrument engineering workbench (Lab VIEW) software to reduce the background tissues in the image and thereby enhancing the visualization of blood vessel and the intensity distribution of the image is also analyzed. This enhancement is used to identify the lesions present in the pathway of the blood vessels.

Key words : CT Angiography ; coronary artery; digital subtraction ; Lab VIEW ;

1. Introduction

Cardiovascular disease is any of a number of specific diseases that affect the heart itself andor the blood vessel system, especially the veins and arteries leading to and from the heart. Research on disease dimorphism suggests that women who suffer with cardiovascular disease usually suffer from forms that affect the blood vessels while men usually suffer from forms that affect the heart muscle itself. Types of cardiovascular disease include, Atherosclerosis, a condition in which fatty material collects along the walls of arteries. This fatty material thickens, hardens (forms calcium deposits), and may eventually block the arteries. Ischemic heart, a disease of the heart itself, characterized by reduced blood supply to the

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doi:10.1016/j.proeng.2012.06.083

organ s[7]. The heart diseases narrow down the arteries. The narrow downed arteries can be viewed by a technique called digital subtraction Angiography, hereafter referred as DSA. Digital subtraction angiography (DSA) is a widely used imaging tool for visualization of blood vessels in the human body [1]. One of the major advantage of digital angiography is that allows angiograms to be performed without directly entering the arterial system. Intravenous administration of contrast medium enhanced by digital processing can yield high quality angiograms of the aortic, carotid, renal, and femoral arterial systems [2]. Interventional procedures require real-time high quality visualization of blood vessels in the presence of normal motion of the tissues. This is especially true during the catheterization and surgical procedures. It is a common technique to inject a contrast enhancement agent into blood stream of the patient and obtain images of the desired region of interest before and after the dye has reached the field of view. The digital subtraction angiography (DSA) image [3, 4] is computed by subtracting the structural image from the image with enhanced blood vessels. However, the subtraction images generally contain background structures due to movement of patient as well as underlying anatomy[5], results in poor quality of DSA images and in some cases, the blood vessels may even be indistinguishable from the other background structures. In addition, the contrast of the computed images further needs to be improved for better visualization. The presented work aims at removing artifacts in background structure thereby improving the DSA image quality, identifies the narrow downing of arteries and analyze the intensity distribution of the image using National Instrument LabVIEW software (Laboratory Virtual Instrumentation Engineering Workbench)

2. Problem Formulation

For digital fluoroscopy, the x-ray tube is used during standard fluoroscopy. The x-ray image are acquired from image intensifier is transformed into an electrical (analog video) signal by a television camera. The analog video signal from the television camera is sent to the image processing computer. The computer converts the analog video signal from each television frame into digits (ie number) using a matrix of small picture elements or pixels. For vascular imaging it is also necessary that this process occur in real time, preferably at a rate of 15 frames per second [6]. To preserve information about density differences in the image, in many systems, each pixel is encoded into one of eight computer binary numbers or bits which allow the encoding of the x-ray density in each pixel of the image into 256 shades of 8 bit gray scale. Thus, for cardiac imaging, it is preferable that the computer process the image so that the black and white x-ray image is digitized, into at least 262,144 pixels, each one representing one of 256 gray shades. Such a system permits image resolution that is sufficient to visualize coronary arteries and allows satisfactory quantization of the contrast densities in the image [8]. Once an image is digitized, the picture is less subject to noise interference and mathematical image processing computations can be made with the gray scale densities. Mask mode subtraction is one such image processing strategy which has been found useful for enhancing radiographic images []. During mask mode subtraction, an initial fluoroscopic or pulsed x-ray exposure is obtained, digitized and stored as a mask. After the mask is obtained, contrast media is injected intravenously.

A continuous fluoroscopic image is obtained and digitized by the computer into a 512 by 512 by 8 bit deep matrix at standard television rates of 15 frames per second. Each frame is subtracted pixel by pixel digitally in real time from the stored mask. If no dye was injected and if there was no motion of soft tissues between the mask and the subsequent images, the subtracted picture will be blank with cancellation of all bone and soft tissue signals. However if contrast media iodine were injected after the mask was obtained, the subtracted image of the iodinated vascular structures which is not obscured by overlying soft tissues and bones. Because mask mode subtraction helps to eliminate soft tissue or bone densities in the image, visualization of the arterial system is enhanced. The presented work aims at obtaining the real time images, removing underlying structure and increasing the resolution of the image using Ni Lab VIEW tool.

3. Digital Image Processing and its elements

Digital image processing is the use of computer algorithm to perform image processing on digitized images. It encompasses processes whose inputs and outputs are images and, in addition, encompasses processes that extract attributes from images, up to and including the recognition of individual objects. The processes of acquiring an image of the area containing the text, pre-processing that image, extracts (segment) the individual characters, describing the characters in a form suitable for computer processing, and recognizing those individual characters are in the scope of what we call as digital image processing.
The Essential component of Digital image processing is shown in the Fig 1. The incoming composite video represents the signal from the image intensifier television chain as well as a synchronization pulse. The signal is logarithmically amplified and then converted from an analog to digital format (ADC, analog to digital converter).The Digitized signal is then sent to an Arithmetic logic unit where manipulation of the images, such as during the subtraction process can occur. The computer has a memory component (MEM) which can store several frames of Digitized information. The image in the memory can be transferred back into the ALU for image processing, as during mask mode subtraction. The resultant image after arithmetic processing is reconverted by a digital to analog converter (DAC) into a composite video signal for storage on video tape.

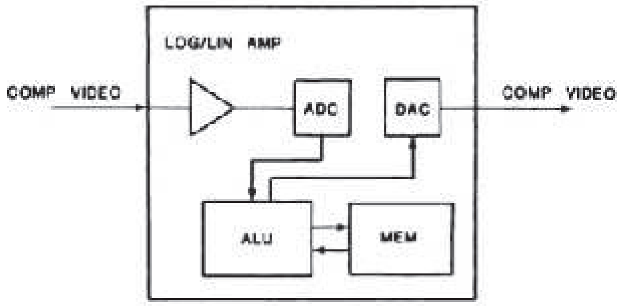

Fig .1. Essential component of digital image processing Angiography

4. Material and Methods

Using the real time DSA images that were collected, we performed a simulation using LabVIEW to test the feasibility and performance of our proposed tool. The imaging modality provides a single plane (2D) fluoroscopic cine window. The scans are generally performed at 15 frames per second(fps) and 30 frames per second(fps) with patient weight and anatomy being imaged. Furthermore the system samples the ECG signals concurrently with the X- ray imaging .The data sets were saved in the Digital Imaging and Communications in Medicine (DICOM) Format, a medical standard in most modalities for transfer of images, movies, and other diagnostic data [3]. We developed an algorithm using National Instruments' LabVIEW to analyze the extracted data. Each DICOM patient data file the information was extracted and saved as a jpeg file. The algorithm we developed using LabVIEW extracts every frame in sequence and processes these images for analysis of underlying tissues. The image obtained is a grayscale image (pixel with only one intensity value). A process called Digital Subtraction is used to remove any stationary artifacts. For example, if each pixel in the current frame is subtracted from its counterpart pixel in the mask frame, stationary objects in the sequence will be suppressed. This will increase the quality of the image and hence a high defined image is obtained. From the subtracted image, stenosis a narrowing or constriction of the inner surface (lumen) in blood vessel which leads to the restriction of blood flow is identified.

5. Experimental setup

The real time dataset used here was collected from Government Rajaji hospital, Madurai and includes the DSA images of coronary arteries. C-Arms is used as X-ray imaging system. It can be rotated to any direction by setting the corresponding angle to acquire the image .Images are obtained by passing light photons from the CRT into the patient's body and are detected by the flat panel detector. The detected photons are further processed using photo multiplier tube in the flat panel detector. These processed images are used for digitization and subtraction. The contrast agent (dose) used for the angiographic process is the iodine and the actual dose varies with patient weight and anatomy being imaged. The DSA images were acquired maximum at frame rate of 30 frames per second (fps) and sometimes at lower frame rate of 15 frames per second (fps).C-Arm machine set up are capable of producing images of higher resolution. But the cost of software employed for the image analyzing purpose is very high which limits its usage mainly in small hospitals. Our proposed tool overcomes this limitation, and when compared with the existing system set up it produces the images of the improved quality. Gray level distribution of the images is also obtained using the proposed software.

6. Results

The acquisition of digital fluoroscopic images can be combined with injection of contrast material and real-time subtraction of pre- and post-contrast images to perform examinations that are generally referred to as digital subtraction angiography, DSA. The result is an image of only the contrast material-filled vessels since the images were formed by detection of x-rays that had been attenuated exponentially in the body, subtraction of pre- and post-contrast images must take this exponential attenuation into account by subtracting, pixel by pixel, the logarithm of the respective images. Consider subtracting two corresponding pixels: one from the mask (pre-contrast) image shown in Fig. 2.(a) resulting from a signal of 10 000 (±100) photons, and one from the live (post-contrast) image shown in Fig .2.(b), resulting from a signal of 9900 (±100) photons. The subtracted image has a pixel value corresponding to 100 ± 141 photons,ie the pixels are subtracted. Therefore the subtracted angiographic images shown in Fig. 2.(c)are useful because they make the small differences between the two original images, pre- and post-contrast, very noticeable or conspicuous and the small contrast-laden vessels are easily seen. The arrow mark shows the lesion present in the pathway of blood vessel.They are said to have high conspicuity. Fig. 2.(d) shows the subtracted image using C-Arm unit setup. From the analysis it is found that the image obtained using our proposed tool posse's high definition image. Thus the mask is subtracted from the contrast image; this way, the structures that are common to both images (fixed anatomy) are suppressed, leaving only the enhanced image of the contrast-filled structures.

Fig. 2. (a) Mask or pre-contrast image; (b) Live or post-contrast images

The gray-level histogram is a concise initial characterization of an image, which can be used to assess its overall qualities and determine the appropriate processing steps required to enhance it [09]. The histogram is a plot showing the number of pixels, anywhere in the image, that displays each of the possible discrete pixel values and Fig 2.(e), Fig 2.(f) shows the numeric (quantitative) information about the distribution of the number of pixels per gray-level value for mask and Phase image.

Fig 2 .(c) DSA image using Lab view software ; (d) DSA image using C-Arm unit setup

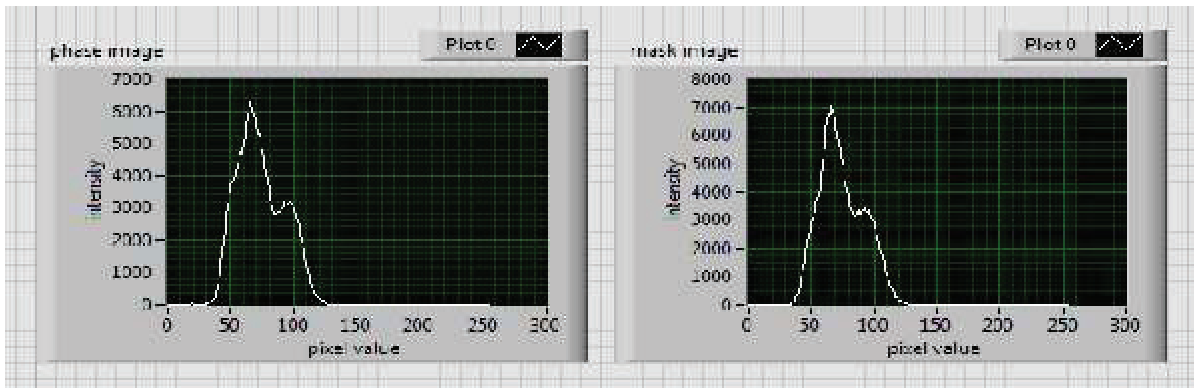

Fig . 2. (e) Gray-level distribution for mask image ; (f) Gray-level distribution for phase image

7. Conclusion

The presented algorithms were implemented and tested on coronary angiograms using Lab VIEW Software. This subtraction algorithm is a promising step in enhancing subtracted image quality by increasing SNR and highlighting iodine contrast injected areas and thereby identifying the lesions in the pathway of the blood vessels. The Performance can be further improved by enlarging the image, improving the frame rates (upto70 fps) and carrying out the digital subtraction for all the frames.

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