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Voice Activation Visualization for Echocardiograph and 3D Angiographic Images in Surgery

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ABSTRACT

In some cases, surgeons need to navigate through the computer system for reconfirmation patients' details and unfortunately surgeons unable to manage both computer system and operation at the same time. In this paper we propose a solution for this problem especially designed for heart surgeon, by introducing voice activation system with 3D visualization of Angiographic images, 2D visualization of Echocardiography processed video and selected patient's details. In this study, the processing, approximation of the 3D angiography and the visualization of the 2D echocardiography video with voice recognition control are the most challenging work. The work involve with predicting 3D coronary three from 2D angiography image and also image enhancement which utilize the median filtering, morphological opening and contrast improvement and heart boundaries detection. With 3D reconstruction of 2D angiography images, the system was able to display 3D coronary tree, with voice activation. The system was able to rotate, zoom in and out the 3D image, the 2D echocardiography video and display patient's information that needed by the surgeon while doing heart surgery. Development of this system is useful for surgeons, where they can navigate the system using voice commands instead of keyboard and mouse. Medical practitioners also can facilitate more the angiogram and echocardiograph images. With this system, it can help and ease the work of surgeons in analyzing and processing the medical images especially in-vivo procedure.

Key words: Angiographic, Echocardiograph, Voice Activation

1. INTRODUCTION

During surgery, surgeons sometimes need to navigate through the computer system for re-confirmation patients' details. Unfortunately constraints happened on the navigation due to surgeons unable to manage both computer system and operation at the same time. We present here the implementation of a robust voice recognition algorithm for voice activated control of assistive visualization devices, which include Coronary Artery Tree Extraction, echocardiograph contour extraction and text data visualization specially design for heart surgeons. Our system was developed due to this constraint which is enabling the surgeons especially cardiothoracic surgeon to control the system through voice commands.

Our proposed system is specially designed to store patients, details including their medical images in the database so that surgeons can obtain the medical images of patients in a short period through voice commands. Enlargement, zooming, enhancement of medical images, blockage location prediction and coronary tree visualization can be performed easily through a series of voice commands.

As cardiologist and heart surgeon basically rely on echocardiography and angiography images for diagnosis and treatment, this system include medical databases, medical image manipulation and visualization which only focus to angiography's images and echocardiography's video and finally the usage of voice activation to instruct the system to visualize the text data

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and images. In this proposed system, entry data included patient's information, two-dimensional echocardiography movies and angiograph images. Other than enable the surgeon navigate through computer system while doing surgery, this system also designed for medical record documentation of the echocardiography and angiography examination, intraoperative completion of an examination database entry form, documentation of patient complications and data entry into a permanent computer database. While developing the system, we found out that Eccher *et al*. (2003) had proposed an evolution of a system of Electronic Patient Record (EPR) that allows adding automatic voice recognition functions to standard Internet browsers. Their system usages are to handle the patient admittance task by using speech recognition and allow user to easily go across a huge amount of information to find the needed one. Their proposed system defines a usual interaction based on standard devices using standard HTML documents and defines a corresponding interaction based on voice via Voice XML documents. Voice XML interpreter enables user browsing by speaking and hearing, but unfortunately does not support a graphic interface. From their modified proposed system, we come out with our interactive system and able to support processed images and graphics.

2. MATERIALS AND METHODS

As mentioned above, in this study, we proposed a voice activation system that enables heart surgeon to retrieve and visualize his/her patient's medical data including medical images while doing the surgery. The complete system was developed using visual basic 6.0 acting as an interfaces which integrate with VC++ to process the angiograph and the echocardiograph images and Microsoft Access for our databases.

We start our project with choosing the type of pc headset microphones, because the speech recognition rate is directly related to the quality of the input and trained the speech engine by using a consistent quality of speech. For our purposes we choose Microsoft Speech Engine 4.0 which is freely-redistributable component which can be shipped with any Windows application and have been designed such that a software developer can write an application to perform speech recognition and synthesis by using a standard set of interfaces, accessible from a variety of programming languages. To get better output we consult our friend, a heart surgeon, discussing what kind of image processing and visualization that he need to use for viewing a medical image. May we remind the reader that the angiograph actually a moving Jpeg. To perform any processing or image manipulation we need to extract it into bitmap images and once done, we play it accordingly so that it will looks like a real video clip. Nevertheless each image has different pixel values, thus we need to prepare a tolerance adjustment to let the user to adjust so that they can get the clear view images.

Once we successfully develop a basic voice activation visualization system with specific database design we focus on angiograph and echocardiographs images processing. **Figure 1** showed the main interface of our basic system.

2.1. 3D Reconstruction of Coronary Artery Tree

For reader extra knowledge, an Angiography is the x-ray work of the blood vessels that uses a radiopaque substance, or dye, to make the blood vessels visible under x ray. Angiography is usually performed at a hospital by a trained radiologist and assisting technician or nurse or later by a cardiologist to diagnose patient's heart abnormality. It takes place in an x-ray or fluoroscopy suite and for most types of angiograms; the patient's vital signs will be monitored throughout the procedure. Most of the time the dye was injected known as Arterial puncture. The puncture is usually made in the groin area, armpit, inside elbow, or neck. Initially, a small incision is made in the skin to help the needle pass. A needle containing an inner wire called a stylet is inserted through the skin into the artery. When the radiologist or cardiologist has punctured the artery with the needle, the stylet is removed and replaced with another long wire called a guide wire (Baim, 2005). To view the area of work from different angles or perspectives, the patient may be asked to change positions several times and subsequent dye injections may be administered. Throughout the dye injection procedure, x-ray pictures and/or fluoroscopic pictures (or moving x-rays) will be taken. Because of the high pressure of arterial blood flow, the dye will dissipate through the patient's system quickly, so pictures must be taken in rapid succession. Once the x rays are complete, the catheter is slowly and carefully removed from the patient (Baim, 2005).

For the purposed of this work, all the angiograms images used were supply by Medical Centre National University Malaysia (PPUKM). By making few visits to the hospital and working the C-arm system, we managed to gather more information. **Figure 2** shows the C-arm system.

For angiography images, the most important procedure is to identify or locate the existence of lesion in any coronary artery tree branches. To visualize this, we extracted the tree from angiographies using extension work of Lin and Ching (2005) and later we decided to apply the modified Hoover *et al*. (2000) guided with Lin *et al*. (2010) proposed technique. One the vessel extraction from angiographic was done, we are able to make the last step which is reconstructing the 3D shapes (Hasan *et al*., 2009), please refer to **Figure 3**.

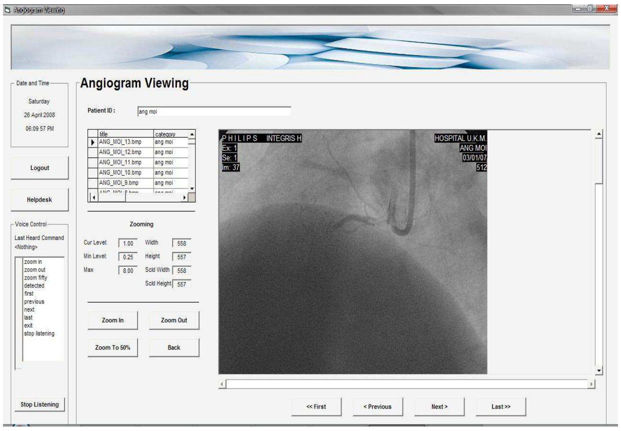

Fig. 1. System visualization and interface

Fig. 2. C-arm system

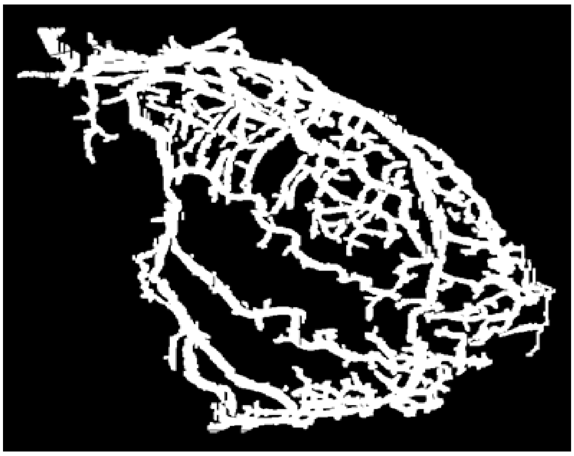

Fig. 3. 3D coronary artery

2.2. Echocardiographic Noisy Images

Once done the 3D reconstruction of coronary artery, the project proceed with processing the echocardiographic video. For this part of our proposed work it consists of two main stages:

- The image enhancement part which utilize the median filtering followed by morphological opening and contrast improvement
- The detection part which is used to detect heart boundaries and heart valves movement

The major disadvantage in echocardiograph video image is the presence of noise; we need method to suppress this heavy noise without scarifying importance image features. In this part of work, the first step is applying median filter to each frame of echocardiograph video, to smoother the images. Simply it is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value, if the neighborhood under consideration contains an even number of pixels, the average of the two middle pixel values is used. Most of the time the smallest size of neighborhood is 3 pixels, nevertheless in the medical images often they use 5 pixel to gain better result. In this stage of work we propose a simple and effective enhancement, by increasing the size of neighborhood which used to define the size of details to 9 pixels. This step is needed because we care about the boundaries of the heart and the movement of valves and we assume that all small details that are defined as noise can be ignored. After testing different sizes of neighborhood we conclude that the size proposed give better smoothing performance while sustaining the edge preserving characteristic of the conventional median filter. After smoothing implementation, a morphological operation seems to be an effective way for more improvement in echocardiograph image. Later we apply opening operation to enhance filtering. Opening operation perform an erosion operation followed by dilation operation using a predefined structure elements. The last step of enhancement will be contrast adjustment by linearly scaling pixel values between upper and lower limits, pixel that are above or below the limits will saturated to the upper or lower limit value.

The final touch for this part of work, sobel edge detection was applied for obtaining edges from the enhanced image. Once edge has been detected by using sobel operator, the pixel values of two images will be combined to highlight selected pixels in the input image, where each pixel of the output image is a linear combination of the pixels in each input image. This overlay help in presenting better illustrative view for the anatomy of the heart, where it clarifies the boundaries of the heart and the movement of valves in interactive visualization as in **Figure 4**.

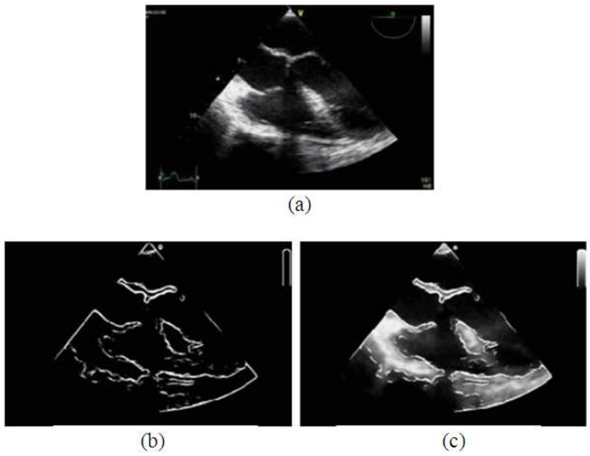

Fig. 4. Finalized Echocardiograph Image (a) Original (b) Contour detected (c) Result

The main purposed of this part of our proposed algorithm is to help the cardiologist to make their decision before any further consideration, but nevertheless, we compile the algorithm with our voice activation system and for this part proposed algorithm, the processing being done in our server before being called by the heart surgeon. If Angiographic is a series of images, the echocardiograph is a movie file. The proposed algorithm process the images frame by frame and play it back as usual once the surgeon activate the system with any chosen trained voice activation.

3. RESULTS

Validation of this work involves three parts, where we validated the processed angiography images, validated processed echocardiography images and the voice activation itself. As mentioned in Hasan *et al*. (2009) and Hussein *et al*. (2011), results for these parts has been evaluated by medical specialist and they agree the both method had achieved good performance and succeeds in presenting legible illustration for various angiography and echocardiography images. Once the medical specialists agree with the processed angiography and echocardiography processed images, we trained them on how to use the complete system and distributed a brief questionnaire to validate user acceptance and any adding requirement from their counterpart.

4. DISCUSSION

The proposed system in this work created a new and quicker method of 3D reconstruction from a single view angiogram, better illustrative view of heart and valves movement in 2D echocardiography and usage of voice activation. The idea of this algorithm came from the need of surgeons to interact with patient's data while doing his/her surgery. The system offer a good interface that any medical user can use and the output is obtained in a few seconds as it is very crucial to get information while doing surgery. One of the limitations in the work is that the 3D output is shown as points in R^3, which can cause minor disturbance in the output when we view it from the side. We still actively improvise this system where the 3D points will be connected by lines. This connected line will increase the output accuracy and the stenosis location. For the echocardiography, the usage of 2D images, limited the diagnosis or analysis of the display. For this part, we also actively improvise our work to processing 3D echocardiography images. In the meantime we actively upgraded the database design and structure, as the system should interact to the cardiothoracic database management systems and visualize the needed data in real time. As for the part of voice activation, we yet need to test it in real scenario where the surgeon most of the time wearing a mask with limited time to look into the computer screen.

5. CONCLUSION

Our proposed voice system activation still in progress, the system depended upon the constraints placed on speaker, speaking situation and message context. The navigation of voice unfortunately only limited to Microsoft applications. Even though medical images controlled by medical standard, still the images have noise distortion, this prolong the pre-processing and will take time to process image after receiving the trained voice commands. To process the images before the activation and store those in designed database will increase the size of the proposed database, in future we might need to apply image compression in this voice activation system.

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