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Screening and Manipulating Brain Medical Images on Handheld Devices

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Abstract — The prompt delivery of biomedical images for emergency diagnosis purpose is an important issue in health care organizations. This paper is aimed a developing class of algorithms to view and manipulate medical images on mobile devices and mainly PDA handhelds. We illustrate our method on human brain scans to view: 2-D single medical imaging scans, multi frames/slices medical imaging scans, internal 3-D anatomical details of a simulated straight line-cut, and the reconstruction of the original scanned object e.g. the original head image.

Keywords— Medical imaging, handheld devices, reconstruction, Telemedicine, PDA

1. INTRODUCTION

Biomedical image processing and image display techniques represent an essential factor towards an accurate and a precise diagnosis. Another essential issue is related to the continued availability of biomedical images where and when needed regardless of time and location boundaries. Handheld devices, such as PDA's and cellular phones, provide the possibility of making use of wireless networks in order to extend the availability of biomedical images for urgent diagnosis purposes [1].

Nowadays, mobile computing taking place on handheld devices is going through tremendous advancements. Such advancements in Mobile health care provide the freedom of mobility as well as faster access to patient's medical data [4].

Telemedicine is defined as the distant delivery of health care and remote sharing of medical knowledge using telecommunication means. It aims at providing expert medical care to any place, anytime. Telemedicine as a concept was introduced in the early 70's when telephone and fax machines were the first telecommunication means used [9]. In recent years, several telemedicine applications have been successfully implemented over wired communication technologies like POTS (Plain Old Telephone System), and ISDN (Integrated Services Digital Network)[9] .The traditional way of providing telemedicine services is to transmit biomedical signals from a patient to a hospital using "landlines," such as the Public Switched Telephony Network and the Integrated Services Digital Network. Most current telemedicine applications are limited to communications between fixed locations, often with conventional handsets. The adoption of mobile technology has led to new M-Health applications in health-care provision [8].

Medical applications have already been integrated into devices (e.g. Pocket PC's and PDA's) and are being used by medical personnel in treatment centers, for retrieving and examining patient data. Most of these E-Health applications are dealing with medical images, like CT scans, MRI's, and ultrasound images. The visual quality of the latter images is required to be high, in order to ensure their correct and efficient assessment, which results in significant image file sizes. Therefore, the integration of such medical applications in mobile devices has introduced several important issues relative to the image file size processing and image retrieval time from storage media like Picture Archiving and Communication Systems or Hospital Information Systems [10]. Furthermore, providing physicians with a way of viewing and manipulating 3-D internal anatomical structure improves health care practices at Emergency Telemedicine. Note that Confidentiality and the security of medical data transmission can be reached by using steganography and encryption algorithms [6].

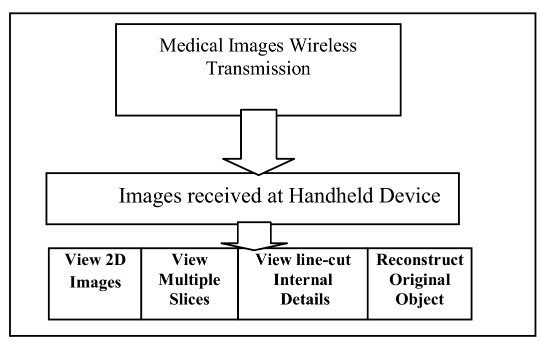

Figure (1). Block Diagram of Application Main Menu

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There are Issues concerning applications development on such handheld devices. A major issue is concerned with the limited processing speed/power of handheld devices compared to laptops/notebooks. Thus, the execution of image processing algorithms, especially for large scans, is a time-consuming process with the current processing capability. Another issue is related to the insufficient built-in memory in handheld devices. This becomes a clear obstacle when running simultaneous large applications requiring huge number of medical images data [5]. Also, the limited availability of advanced 3-D visualization and manipulation profiles in such devices may limit the capability of further medical data analysis. The developed solution, presented in Fig. 1, is expected to contribute effectively in "Emergency Telemedicine" where a solution is provided for urgent medical diagnosis. Thus, the ability of a fast decision making by radiologists/ physicians is achieved when medical scans are viewed instantly and manipulated on mobile/handheld devices.

II. BACKGRAOUND

Hardware: Display Device: Portable image display devices include variety of devices, ranging from Pocket PCs (PPC), Personal Digital Assistance (PDA), and cellular mobile devices. In this application, PDA handhelds are considered. They are chosen due to their popularity in medical fields, as they integrate several functions such as wireless connectivity's for sending/ receiving images, Pocket PC functionality, and working as mobile phones. Also, medical applications of PDAs have grown as PDA's allow writing prescriptions, managing patient information and performing administrative functions [2].

Software:

1. Java Micro Edition Software Development Kit (J2ME Wireless SDK): provided by Sun Microsystems is used to provide the application development environment [3].

2. Run-time Environment: -J2SE (Java 2 Standard Edition) provides software development kit as well as Java platform for runtime on desktop PC`s. In addition, J9VM (IBM Java 9 Virtual Machine) provided by IBM, provides the java runtime environment for mobile devices and PDA`s.

III. IMPLEMENTATION

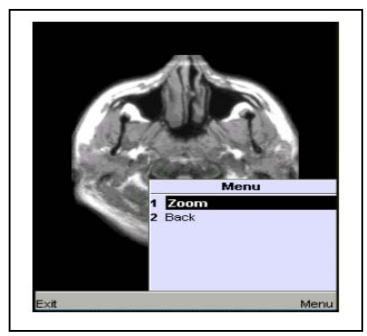
In this section four main parts to view and manipulate human brain scans will be highlighted. The used images are 46 slices of MRI Brain scans converted from DICOM to *.png image format. They have a standard resolution of 320 x 240.

A. *Visualization of a Single Image*

Using the PDA touch-pad, the associated java code loads the entire scanned slices of the brain, and lists them for viewing. Images are smoothed using Gaussian smoothing function as follows:

$$G(x,y,\sigma) = \frac{1}{2\pi\sigma^2} e^{\left(\frac{-x^2+y^2}{2\sigma^2}\right)} \tag{1}$$

The loaded image is expected to match the resolution of the display screen of the PDA. However, in case the loaded image is smaller or larger than the specified screen resolution capabilities, the user has an option to zoom-in or zoom-out the image. Zooming-in functionality re-scales the image on a larger scale when small pictures are downloaded, and/or to view little image details. On the other hand, zooming out an image results in scaling it down, to view the entire image on the PDA screen enabling diagnosing medical images having the standard CT/MRI scan size.



Figure(2). Zooming Option Menu

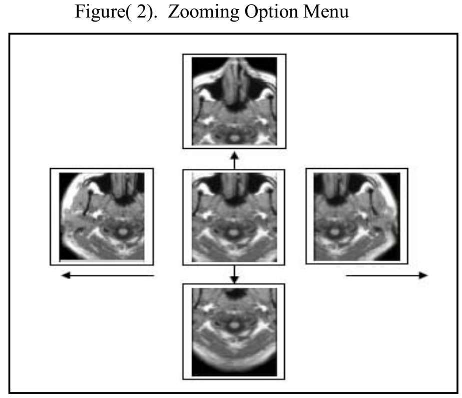


Figure.(3) Image Scrolling Option using touch-pad

B. Visualization of Multi-slices Biomedical Image

Using the PDA touch-pad, the user chooses the 2nd option listed on the main menu:" View Multiple Frames". The purpose of this part of the application is to display a sequence of 2-D images. In medical imaging, it is often needed to develop multi-frame/slice scanned images of the same organ. This part of the developed application enables the user to view a sequence of 2-D medical frames at different user-defined speed rates. A list showing different display rates (seconds/frame) are shown to the user for selection.

The application makes use of the animation functionality in J2ME technology, used mainly to develop mobile games application. Before this part is triggered, a list for frames speed is displayed where the user has to choose the desired speed. Fig. 4 illustrates the display sequence.

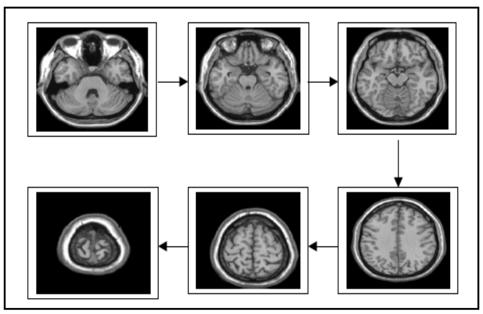
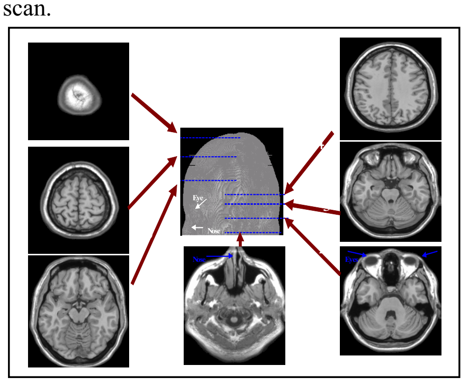


Figure (4). Sequence of image frames/slices display

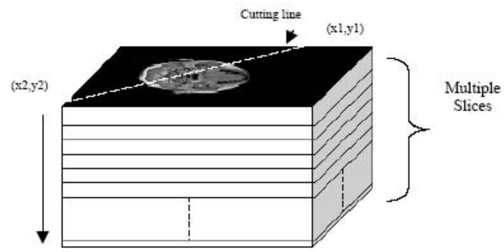
C. Visualization of Internal Details of Stacked I mages

This option is triggered when a user chooses the 3rd option from the main menu: "View Internal 3-D line-cut details". Before this part is introduced, it might be needed to highlight the positions of images in a 3-D stack of images. The following figure shows an example of selected slices from a head scan.



Figure(5). position of multiple scans of the brain

The first step in this part is to stack all slices together the opposite way, from bottom to top. In case of an urgent emergency diagnosis, physicians may need to view the internal anatomical details caused by a certain injury. For instance, how deep it penetrates.



Figure(6). A penetrating-cutting line simulation

The application allows the user to use a stylus to draw a simple straight cut- line, to simulate a cutting tool that penetrates all the stacked images as shown in Fig. 7.

Figure (7). Cut simulation on a handheld device

Once the user draws the desired cutting-line the application shows the internal anatomical details of the stacked slices. The result of the previous cutting-line in fig. 7. is shown in Fig. 8.

Figure(8). Internal details of a 2-D cut-line

D. Volume Reconstruction of the Original Object

In this part, the user chooses the 4th option of the main menu "View Object Reconstruction". The resulted image displays the original object/organ that was scanned. Fig.9. shows an example of the applied scanning pattern on the left side of the first slice.

Figure(9). Image Reading Pattern, from left

As a preparation stage, images are filtered using 3 x 3 median filter in order to avoid the detection of any false edges. An additional smoothing kernel is applied and convolved with the entire image in this part as follows:

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & \alpha & -1 \\ -1 & -1 & -1 \end{bmatrix}, \begin{bmatrix} 0 & 0 & -1 & 0 & 0 \\ 0 & -1 & -2 & -1 & 0 \\ -1 & -2 & \alpha & -2 & -1 \\ 0 & -1 & -2 & -1 & 0 \\ 0 & 0 & -1 & 0 & 0 \end{bmatrix} \qquad (2)$$

Where α is an image dependent factor .

Canny edge detection algorithm is utilized to detect edge location coordinates and map them to the original slices.

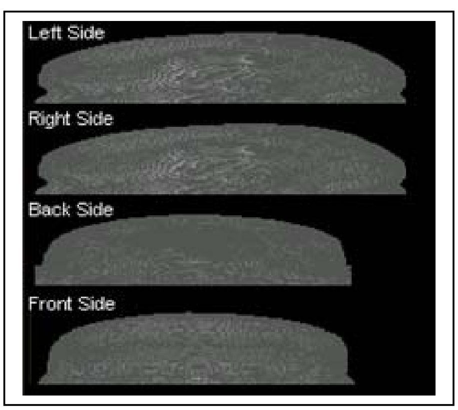


Figure (10). The reconstructed head image

The magnitude of the convolution of Canny kernels is calculated in a different way for faster implementation and less processing time as follows:

$$\text{Magnitude}= \cos\theta \frac{\partial G}{\partial x} + \sin\theta \frac{\partial G}{\partial y} \qquad (3)$$

$$\text{Where Direction: } \theta = \arctan \left(\frac{\partial G / \partial y}{\partial G / \partial x}\right) \qquad (4)$$

And $\frac{\partial G}{\partial x}, \frac{\partial G}{\partial y}$ are the gradients at each direction

An example of the reconstructed object is shown in Fig.10, where the image of the head is reconstructed

IV. CONCLUSION

In this paper, an application to view and manipulate brain medical images on handheld devices was considered. A brief background on "Emergency Telemedicine" was presented. The application's four main parts to view and manipulate human brain scans were discussed along with image snapshots for each part of the application during the running process.

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