

Medical Image Manipulation and the Outer-Contour Detection

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ABSTRACT

Background and purpose: The development of an in-house Monte Carlo based treatment planning system (MC TPS) for the radiation therapy applications; have being play an important role in treatment process. Our preliminary results with many techniques and its planning process; encouraged the further progress in making the Monte Carlo code more user friendly by adding more graphic interfaces. Thus in the current work we have to manipulate the medical images with some coding functions to help in design a graphical windows and aiding tools to control the contouring and planning process.

Materials and methods: The tomographic images (Medical images) are taken via the computer tomography (CT) scanners; and then the patient virtual phantom is constructed using these tomographic images (in DICOM format), and we can export it from our commercial TPS. The virtual phantom consists of CT slices; which will manipulated with some mathematical functions in Matlab program.

Results: Medical images with DICOM format; are manipulated with the functions that may help to development of a planning system. Some of these functions performed to read and show these medical images with the personal computers. Another functions performed to contrast the manipulated images, and perform auto-contouring to image, and outline the image objects and these function are the most important in planning process.

Keywords : In-house Monte Carlo (MC) Codes, Matlab program, Medical image, Graphical user interface (GUI).

I. INTRODUCTION

Imaging systems construct an (output) image in response to (input) signals from diverse types of objects. They can be classified in a number of ways, e.g. according to the radiation or field used, the property being investigated, or whether the images are formed directly or indirectly. Medical imaging systems, for example, take input signals which arise from various properties of the body of a patient, such as its attenuation of x-rays or reflection of ultrasound. The resulting images can be continuous, i.e. analog, or discrete, i.e. digital; the former can be converted into the latter by digitization. The challenge is to obtain an output image that is an accurate representation of the input signal, and then to analyze it and extract as much diagnostic information from the image as possible ¹.

Of the five senses; sight is the most powerful. Receiving and analyzing the images; forms a large part of the routine cerebral activity of human beings throughout their waking lives. A visual image is rich in information.

Confucius said, "A picture is worth a thousand words," and we shall see that is an underestimate.

On a more sophisticated level; humans generate, record and transmit images. Since the early days of science, researchers have tried to record their observations and even their conceptions pictorially.

More recently, technology has tremendously extended the possibilities for visual observation. Photography makes it possible to record images objectively, preserving scenes for later, repeated, and perhaps a more careful examination. Telescopes and microscopes greatly extend the human visual range, permitting the visualization of objects of vastly differing scales. Technology can even compensate for the inherent limitations of the human eye. The human eye is receptive to only a very narrow range of the frequencies within the electromagnetic spectrum. Nowadays there are sensors capable of detecting electromagnetic radiation outside this narrow range of "visible" frequencies, ranging from γ -rays and x-rays, through ultraviolet and infrared, to radio waves ².

Images can be formed from many kinds of objects using differing mechanisms of formation, and, consequently, imaging systems can be classified according to several different criteria, and for example; x-rays are used in medical diagnostic work.

An imaging system senses or responds to an input signal, such as reflected or transmitted electromagnetic radiation from an object, and produces an output signal or image. When this radiation is focused and then sensed by a photographic film, for example, it gives rise to an image that is recognized as analog, comprising continuously varying shades or colors. A grayscale photographic image is a two-dimensional function of optical density or brightness with position; if the object can move, the image is an average over the exposure time^{3,4}.

Any imaging system must be judged on the quality of the images it produces. For medical imaging systems the images must be diagnostically useful, that is capable of leading to the detection and identification of an abnormality and its interpretation so as to determine its cause, and obtained at an acceptable dose to the patient. An image is a spatial pattern of intensities^{5,6}.

Fundamentally, the quality of a digital image depends on the size of the pixels, relative to the size of the image, and the number of available values of gray tone that are accessible to describe the intensity range between black and white: image quality is highest for small pixels and a large number of available gray tones^{7,8,9}.

Different features in an image are displayed as different shades of gray. In medical images these differences are determined in part by the properties of the tissues, such as their thickness, density and chemical composition, and by aspects of the imaging process that are controllable, such as the energy of the x-ray photons. It is crucial to be able to distinguish parts of the body that differ anatomically or physiologically only a little from each other. This requires a sufficient number of different gray values so parts which we want to be able to distinguish are assigned different gray values^{10,11,12}.

Sharpening and edge-detecting masks:

Sharpening is used to produce a crisper image with sharper edges in order to highlight fine detail. One way of sharpening an image is by unsharp masking.

Sharpening is the reverse operation to smoothing. Detecting edges is an essential step in object detection or recognition systems; the Edge detection algorithms are used¹³.

Morphological image processing is a tool for extracting or modifying information on the shape and structure of objects within an image. Morphological operators, such as dilation, erosion and skeletonization, are particularly useful for the analysis of binary images, although they can be extended for use with grayscale images. Morphological operators are non-linear, and common usages include filtering, edge detection, feature detection, counting objects in an image, image segmentation, noise reduction and finding the mid-line of an object; there are a number of morphological operators, but the two most fundamental operations are dilation and erosion; all other morphological operations are built from a combination of these two^{14,15}.

Dilation can be used to create the outline of features in an image. If a binarized image is dilated once, and the original image subtracted pixel-by-pixel from the dilated image, the result is a one-pixel wide outline of the features in the original image. This operation tends to be more robust than most edge enhancement operations in the presence of image noise. The outline can be used in subsequent feature extraction operations to measure size, shape and orientation.

In contradistinction, erosion is an operation that increases the size of background objects (and shrinks the foreground objects) in binary images. In this case the structuring element is superimposed on each pixel of the input image, and if at least one pixel in the structuring element coincides with a background pixel in the image underneath, then the output pixel is set to the background value^{16,17}.

The development of an in-house Monte Carlo based treatment planning system (MC TPS) for the radiation therapy applications; have being play an important role in treatment process. Our preliminary results with many techniques and its planning process; encouraged the further progress in making the Monte Carlo code more user friendly by adding more graphic interfaces. Thus in the current work we have to manipulate the medical images with some coding functions to help in design a graphical windows and aiding tools to control the contouring and planning process.

So in this work, medical images with DICOM format; are manipulated with the functions that may help to development of a planning system. Some of these functions performed to read and show these medical images with the personal computers. Another functions performed to contrast the manipulated images, and perform auto-contouring to image, and outline the image objects and these function are the most important in planning process.

II. MATERIAL AND METHODS

A complete digital image processing system is a collection of hardware (equipment) and software (computer programs) that can be summarized as the following steps and procedures to perform our goal in planning process:

(i) acquire an image, using appropriate sensors to detect the radiation or field, and capture the features of interest from the object in the best possible way. If the detected image is continuous, i.e. analog, it will need to be digitized by an analog-to-digital converter (ADC); in this work the medical images taken with the CT scanner as shown in the figure 1.

(ii) store the image, either temporarily in a working image store using read/write memory devices known as random access memory (RAM) or, more permanently, using magnetic media (e.g. Floppy disks or the computer hard disk memory), optical media (e.g. CD-ROMs or DVDs) or semiconductor technology (e.g. Flash memory devices); and then the patient virtual phantom is constructed using these tomographic images (in DICOM format), and we can export it from our commercial TPS. The virtual phantom consists of CT slices; which will manipulated,

(iii) manipulation process of the medical image; via some Matlab functions (Mathematical functions), to read this tomographic image at the personal computer; this function is “dicomread” command and,

(iv) display the image, by using a function such as the function of “imshow” command to show the DICOM file (manipulated in the proviso step) on the personal computer monitor,

(v) more manipulation in a step to developing our In-house Monte Carlo based treatment planning system, and to be more easy and friendly in the use.

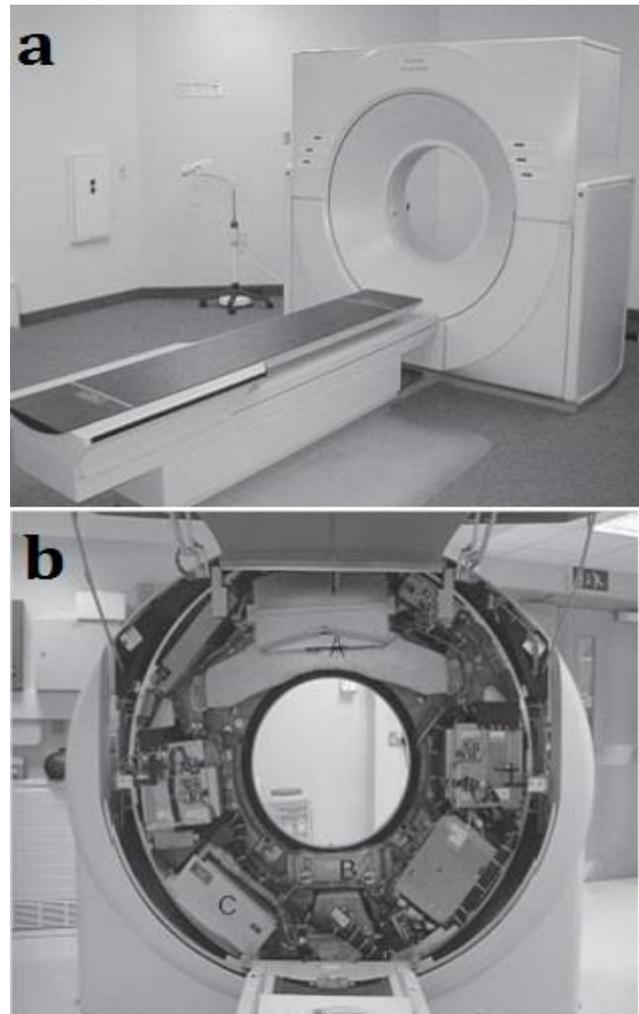


Figure 1 : (a) Outside view of third-generation CT scanner showing the patient table and gantry aperture. (b) When the cover is removed, the x-ray tube and the arc of detectors can be seen. The gantry holding the x-ray tube and detector rotate around the patient. CT scanner capture a tomographic images with DICOM format.

III. RESULTS

Matlab program functions; used to process the medical images that acquired from the CT scanners of the patient’s body.

The first one of these functions is the “dicomread” command which is able to recognizes the medical images and its informations.

The result of this command is illustrated as in the figure 2 (Original image), which show the CT slice exported of commercial CT scanner; this job is performed by using “imshow” command as another function.

But; we cannot recognize any of the patient’s body structure or features in shown slice; so we need to more

process to modify the image and became more understanding; from this point we used the contrast function to lead us to produce the Contrasted image as shown in figure 3; where the patient's body structure or features are became recognized clearly within the CT slice.



Figure 2 : Shows the CT slice manipulated with some functions; these functions to read and show the data of CT slice on the personal computers.



Figure 3 : Shows the CT slice manipulated with some functions; these functions to contrast the image to be fit the personal computers, the patient's body structure or features are became recognized clearly within the CT slice.

At this moment we success to display the Medical images (Tomographical images or CT slices), with the consideration of the whole image information or data (the patient's body structure or features) are became illustrated clearly within the manipulated CT slice.

Now; we will continue to more manipulation with the final resulted image (the Contrasted image); a set of Mathematical functions are used in this step to produces the "auto-contouring" coding of the contrasted image.

The patient's body contouring is the one of the most important and helpful steps to oncologist and medical physicist in the Cancer treatment centers; where they plan the tumor treatment on the treatment planning system with high enough accuracy plan to ensure the success of treatment process.

So; we need to develop this step and coding of the auto-contouring function, which will help and don't consume the time in the treatment planning process, and more accurate than the manual contouring. Figure 4 illustrates the result of the auto-contouring coding of the contrasted image; the body contour appears as a green line around the whole patient's body within the CT slice.

Another important function in the development of treatment planning system is the outlining of all objects presented within the patient's body; which may be help in detection of some the body's objects of the patient, such as the lung cavity and the skeleton parts, and the critical organs. The result of the "outlining" coding is illustrated in figure 5; where all objects of the patient's body is contoured or outlined with a thin white line.

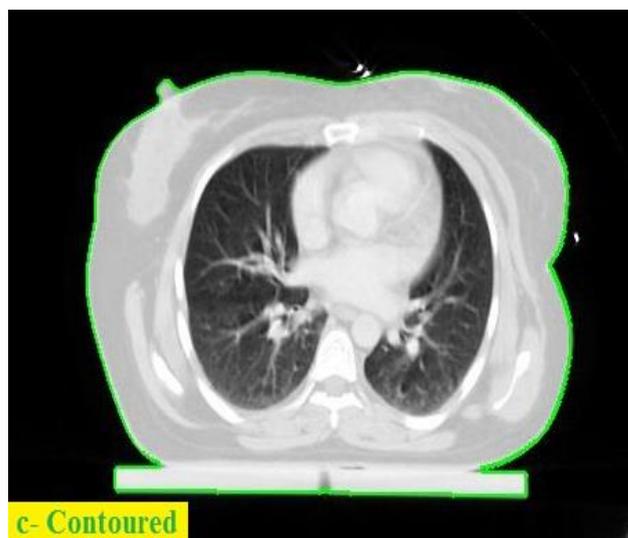


Figure 4 : Shows the CT slice manipulated with some functions; these functions to auto-contouring of the patient's body, to play the role of the medical planning system on the personal computers.

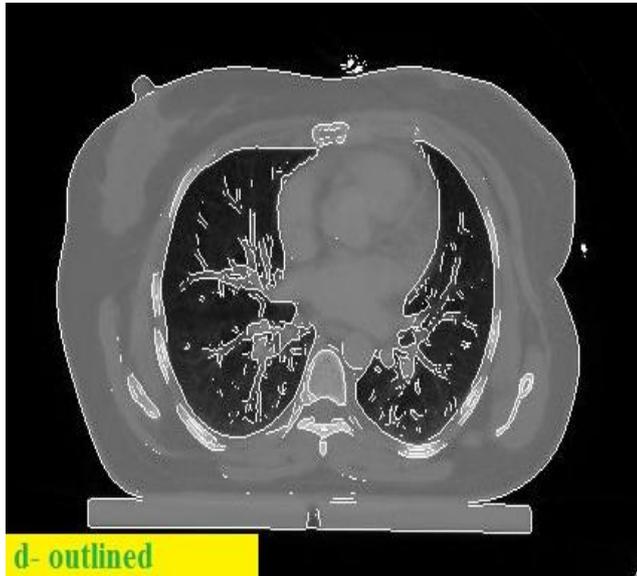


Figure 5 : Shows the CT slice manipulated with some functions; d- function to outlining of all components of the patient's body; to play the role of the medical planning system on the personal computers.

After the previous results; we work to establish a Graphical User Interface (GUI), which consists of all of these tasks, and more additional functions; such as display of multi-slices of CT in the same figure (which helps to visualize the whole tumor volume in the same figure or The three dimensional representation of the target), also auto-contouring of the whole phantom slices at the same time (to decrease the time consuming when the contouring process performed for each slice separately).

The developed GUI features allowed better control in the planning process. The implemented contouring option will eliminate our need for performing this step on the commercial TPS. The auto detection option for contouring the outer patient body and lungs was tested on patient CTs and it was shown to be successful.

IV. CONCLUSION

An in-house GUI program has being developed for more efficient radiotherapy planning. The variety of aiding tools implemented in the program is time saving and gives better control on the planning process. From the results of this work we can depend on Monte Carlo Codes for dose distribution calculations and introduce it into the established graphical user interface to construct a treatment planning system for radiotherapy techniques,

and investigate new techniques in MERT, and specially MeARC in radiotherapy.

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