Visualization Of 3-D Biomedical Imaging

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Abstract: **In the world of regular emerging technologies, medical imaging is grown. The diagnosis of a health problem is only dependent on the quality and creditability of the image analysis and preprocessing on image. It is important to process and analyze a significant volume of images so that high quality information can be produced to clinician for disease diagnoses and treatment. For this purpose 3-D medical imaging is used. Medical imaging refers to the process of creating images of human body for various clinical purposes such as medical procedures and treatment of disease. For 3-D medical imaging several techniques have been developed to enable CT, MRI and Sonography scan produced 2D static output film and then to convert it into 3D images.**

The basic task in 3D image processing is mainly classified into three parts: image registration and skew detection (preprocessing step in object identification and object classification), image visualization, image segmentation and image recognition. 3-D medical imaging enhances the quality of image. This paper gives just a brief introduction about 3-D medical images. This paper is tutorial review of 3-D medical image processing.

I. INTRODUCTION

Computer-aided diagnostic processing becomes an important part of clinical routine. Accompanied by a rush of new development of high technology and use of various imaging modalities, more challenges arise; for example, how to process a significant volume of images so that high quality information can be produced for disease diagnosis and treatment. High quality image for disease analysis 3D imaging technology is used. 3-D dimensional image processing is large field used in medical image processing that improves the patient care [2]. The new capabilities of new 3D and 4D medical imaging modalities, along with computer reconstruction, visualization, and analysis of multi-dimensional medical image data, provides powerful new opportunities for medical diagnosis and treatment [2]. MRI, CT scan are used in 3D medical image processing.

II. 3D MEDICAL IMAGING MODALITIES

Many modalities used to extract 3D medical images. In this paper we introduce some of them. Modalities we describe are MRI and CT scan. These are used to get high quality image to find out disease diagnosis and treatment.

a. MRI (Magnetic Resonance Imaging)

MRI is a tomographic imaging technique that produces images of internal physical and chemical characteristics of an object from externally measured nuclear magnetic resonance (NMR) signals [5]. MRI scanner consists of three main hardware components: a main magnet, a magnetic field gradient system, and a radio- frequency (RF) system. The main magnet is permanent. This magnet generates a strong uniform static.

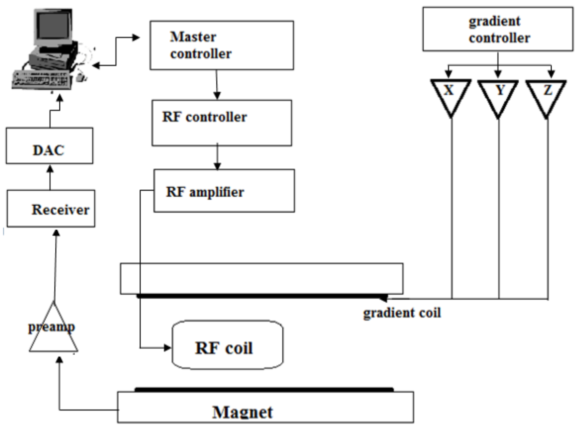

Figure 1 MRI scanner

b. Computed Tomography (CT) Scan

Computed tomography (CT) scan is used in 3D medical image processing. Computed tomography (CT) scan is a scanning technique allowing the generation of tomographic 3D images of every part of body without superimposition of adjacent structure [4]. Computed tomography (CT) is a non-invasive imaging technique where digital geometry processing can be used to generate 3D image of brain's tissues and structure obtained from a large series of 2D X-ray images [4]. It uses X-ray tube, an elaborate radiation detection system and a computer that assembles the measurement data into a series of transversal slice of the subject's body [13].

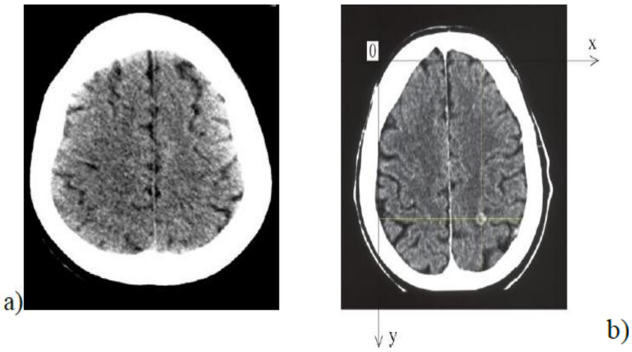

Figure 2: RGB-X-ray scan of (a) A1-normal brain (b) A2-abnormal brain

III. 3D MEDICAL IMAGES PROCESSING

3D medical image processing provides an extensive set of tools for 3D volume calculation, measurement, and quantitative analysis. 3D image processing can be classified into three parts.

i. 3D image restoration and basic image segmentation.
ii. 3D image visualization.
iii. 3D image registration

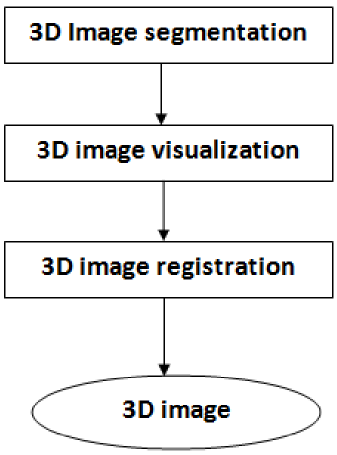

Figure 3: 3D medical image processing steps

a. Image Segmentation

Image segmentation is the task of partitioning the data into contiguous regions [1]. In 3D medical image processing the aim of segmentation process is to extract a 3D surface of each object from data.

The main problem with 3D image processing is distinguishing objects from background or different objects in a complex scene. This problem is due to the characteristics of image process and gray-value mappings of the object. In segmentation of medical image is presence of gray scale in-homogeneities[12]. By in-homogeneities intensity variation occurs which can be solved by anisotropic filter. Anisotropic filter is used as pre-processor in 3D medical image processing.

IV. ANISOTROPIC FILTER

Anisotropic filter is used to smoothing medical image. Smoothing is used as pre-processing step in medical image processing to reduce the noise in image [1][11]. Anisotropic filter works in a different way on different region of the image. Smoothing as a diffusive process that is stopped at boundaries by selecting proper spatial diffusion strength. Depending on the values assumed by diffusive strength, the filter is able to realize intra region smoothing without smoothing across boundaries [11].

The non linear diffusion algorithm is:

$$\frac{\partial}{\partial t} I(x,t) = c(x,t)\Delta I(x,t) + \nabla c(x,t).\nabla(x,t)$$

Δ = gradient operator
∇= laplacian operator
c(x,t) = diffusion function
I(x,t) = image intensity

The diffusion must be reduced or even blocked when close to discontinuity. The diffusion function c(x,t) was chosen as a non linear function of gradient image intensity ∇I (x,t), as follows:

$$c(x,t) = g(|\nabla I(x,t)|) = e - \frac{|\nabla(x,t)|^2}{2M^2}$$

M= diffusion constant

Note: c(x,t) diffusion coefficient c(x,t) monotonically decrease with increasing gradient ∇ I.

i. Images flow strength is dependent on the relationship between M and ∇ I.
ii. The maximum flow is produced at image location with$\nabla I = M$. When ∇ I is below M, the flow function reduced to zero because in most homogeneous regions the flow is minimal. For ∇ I larger than M, the flow function again decreases to zero, halting diffusion at locations of high gradients.

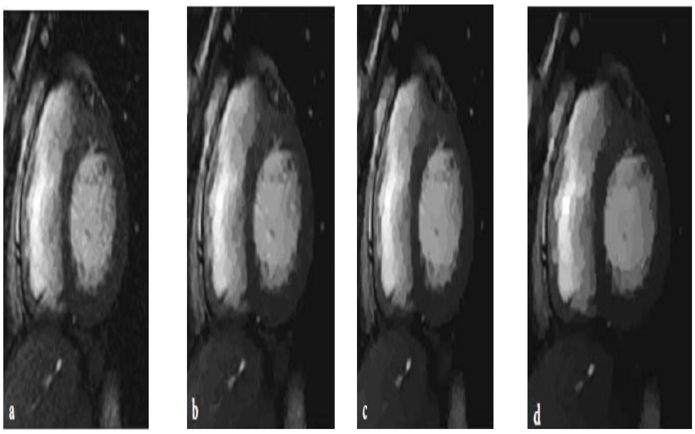

Figure 4 Anisotropic filtering of MRI cardiac image. All (a-to-d) cardiac images from left to right shows the effects of different (different M values) sthenghts of the filtering operation.

V. 3D IMAGE VISUALIZATION

In this process surface rendering is used.

a. Surface Rendering

Surface rendering is process in which apparent surface are produced from the data volume and an image of the extracted surface is suitably visualized. Surface contours are modeled with bi-dimensional primitives, as triangles or polygons, in order to represent a 3D object [2]. Basic process of surface rendering is to extract a surface from the 3D data volume as a collection of adjacent polygons and to visualize the appropriate algorithm.

Figure shows a wire-frame representation of the heart (right) and the resulting 3D visualization (left). And the original data were acquired by cardiovascular MRI.

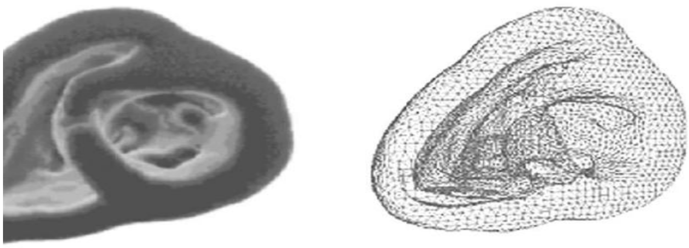

Figure 5: Surface Rendering of Human Heart

b. Triangulation Method

In triangulation approach contours defined on two adjacent slices are divided into the same number of equiangular sectors the points corresponds to neighbors are connected by obtaining a series of triangles that will define the surface. The marching-cube algorithm works on 3D mask that defines the object of interest obtained by a threshold based algorithm.

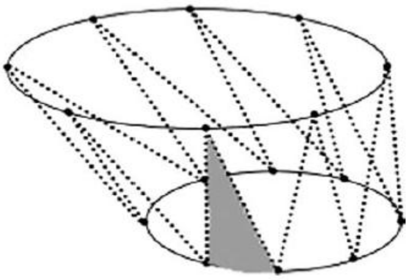

Figure 6: Triangular Method

c. Volume Rendering

Volume rendering is a process that visualizes sampled function of 3D data volume by computing 2D projection of a semi-transparent volume from a desired point of view without the use of any segmentation procedure, that is ,it preserve any information contain in a data volume. In volume rendering algorithm ray tracing is used. The data volume is scanned by one or more light ray source.

Ray emitted by light source (B) are reflected or diffused by each voxel in the data volume (C). The information available to data volume is gray level associated to each voxel, which reflect some tissue properties according to the type of energy used during image acquisition. Reflected rays travelling towards the observer (A) will produce an image (D) of the 3D data volume as seen by an observer from a particular point of view.

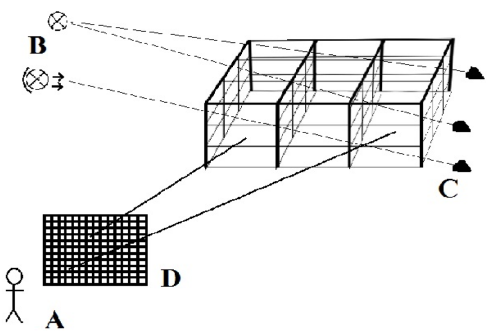

Figure 7: Volume Rendering Algorithm where A is Observer, B is Light Sources, C is Data Volume and D is Reconstructed New Image

d. 3D Visualization Tools

3D rendering algorithm is not able to fully exploit its potentialities when the support for visualization is a bi-dimensional screen [1]. Thus, number of tools available, based on 3D glasses, for increasing the illusion of three dimensionality. The basic principle consists of supplying the two eyes of the observer with two slightly different images, exploiting what happens in the real word. The eyes-brain system integrates the two images in order to derive the three-dimensionality of the object.

In glasses supplied with optical filters, each lens is constituted by an optical filter i.e. red or green, in order to supply each eye with light of only one color. Through this optical filter two superimposed images are visualized, one is red and other is green. Using optical filter it is now possible to observe different images with each eye, thus creating the illusion of 3D in brain.

In shutter glasses ach lens is constituted by crystal liquid lens, which has the property to block the light when suitable polarized. The two images, left-eye image, right-eye image, used alternatively projected on a screen. When left image is projected, the shutter will switch off the left eye lens, and vice versa during right image projection.

VI. 3D IMAGE REGISTRATION:

3D Image registration is a pre-processing step in object identification and object classification [1][10]. Medical image registration is the process of combination the different set of the same object, which comes from different modalities (CT, MRI, SPECT, PET etc.) [1]. 3D Image registration algorithms improves image quality and 3D image registration algorithms transforms the object of image into one ordinate system [1] and as result, registered image would be more informative than original images [6]. 3D image registration mainly involves non-rigid mapping scheme.

If the registration procedure involves image coming from different modalities, it is define as multimodal registration. When the registration involves images produced by the same modalities, it is define as uni-model.

3D image registration according to interaction can be categorized as:

i. Automatic: This is when the user only supplies the algorithm with the image [2].
ii. Semi-automatic: This is when the user only supplies the algorithm with the image data [2].
iii. Interactive: this is when the user does the registration himself, helped by the software [2].

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