Efficient 3D Object Visualization via 2D Images

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Summary
Three dimensional (3D) image visualization is one of the important processes that extract information from the given slices. The purpose of this paper deals with the 3D object visualization via two dimensional (2D) images that included many object. The main objective of this work is to find the contour of the given object in each slice and then merging these contours to reconstruct the 3D objects. The proposed method is easy to use as well as it can be implemented on various type of images. The obtained results indicate a good resolution of the reconstruction process.

Key words:
3D visualization, 3D imaging, Volume modeling, Slice image and Image reconstruction.

1. Introduction

The growth of 3D image applications especially in medicine, industry, military, geography, satellite and remote sensing is guided the orientation of many researches and funds to go through this field.
A pair of two human eyes aimed to views images in the form of visualization multidimensional, so the images obtained from the projections of two cameras located at different positions, this situation can perform the 3D visualization of the same idea that resulted from human eyes.
A big revolution of image visualization is occurred in medical images via the introduction of new technologies in diagnosis and treatments. However these technologies depending on computer reconstruction and these devices are computed tomography (CT), magnetic resonance imaging (MIR), positron imaging tomography (PET), ultrasound (US), … etc.
3D visualization of images especially medical images gives significant information about the objects and their properties, which are very important in diagnosis and treatments. The significant potential of 3D visualization remains tell now undiscovered and undeveloped, so it is an important area of research to provide new tools, devices, procedures, diagnosis, treatments … etc.
Forming an image is mapping some property of an object onto image space, that used to visualize the object and its properties to characterize its structure or function. Imaging science is the study of mapping and development ways to understanding performance in order to improve them. The goal of image visualization is to formulate and realize concepts of an efficient architecture for productive use of image data. The needs for new approaches of image visualization and analysis will become increasingly important.
In this work we try to explain the concept of 3D visualization, in addition an efficient algorithm is presented to perform 3D image visualization.

2. Related Works

The field of 3D visualization is an important aspect of image processing, because of their huge applications in many areas of our live. Many articles and related works are published in this field and we will explain some of these works.
Carlos et al. [1] present an effective package for image visualization; this package describe a graphical tool for collaborative image analysis and visualization of model created out of slices of volume data; this package allows a number of users to simultaneously and coordinately analyze medical images. Moreover, for clinical purposes, direct measures of organs and structures on 3D space seem mandatory.
J. R. Swedlow [2] presents the development of both Open Microscopy Environment (OME) server and OME Remote Objects (OMERO) server that provide a flexible set of tool for image data management. This project have developed and released the data model that provides the description of image data acquisition structure and analysis results. This project is able to enhance the usability of its tools, as well as to extend the functionality delivered with OME.
Damini Dey et al. [3] are developed method to map intra-operative endoscopic video to 3D surface derived from pre-operative scans for enhanced visualization through surgery. This method allows panoramic and stereoscopic visualization from arbitrary perspective and navigation of the painted surface after the procedure. The validation experiments are applied on phantoms, where the pre-operative image data accurately reflect the intra-operative state.
Stephen M. Pizer et al. [4] work is a multiscale means for modeling and rendering 3D solid geometry. This work

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contributes that the detailing of method for 3D image segmentation that use the medial model representation (m-reps) both to capture prior knowledge of object geometry and as the basis of measurement of model to image match. M-reps based visualization of an object in both 3D and versus the 3D image relative to a medical atom were also described.
Qi Zhang et al. [5] implement a new segment-based post color-attenuated classification algorithm to address the problem of interactive 3D medical image visualization. An efficient numerical integration computation technique is applied to take the advantage of the symmetric storage format of the color lookup table generation matrix. This algorithm will facilitate the interactive visualization of the medical image database in both diagnostic and therapeutic applications.
Nicolas Herlambang et al. [6] present a real time autostereoscopic visualization system using the principle of integral videography. The system was used to visualize 4D MR image that was generated from registration of 3D MR image and 4D ultrasonic image. The evaluation of processing speed showed that GPU processing time was faster than CPU processing time for integral videography volume processing.
A.Bardera et al. [7] present a novel information-theoretic approach for thresholding-based segmentation that uses the excess entropy to measure the structural information of a 2D or 3D image and to locate the optimal threshold. The main motivation of this approach is the uses of excess entropy as a measure of structural information of an image. Experimental results have shown a good behavior of the implemented approach.
Meisam Aliroteh and Tim McInerney [8] present fast and accurate interactive segmentation method for extracting and visualizing a large range of objects from 3D medical images. This model is simply and precisely initialized with a few quick sketch lines drawn across the width of the target object on several key slices of the volume image.
Antonio Rosset et al. [9] display a design of multidimensional image navigation for display and interpretation of large set of multidimensional and multimodality images. The system is extremely fast and optimized 3D graphic standard widely used for computer games optimized for tracking advantage of any hardware graphic accelerator boards available. Radiology imaging modalities are involving from convolutional sets of 2D topographic slices to 3D volumetric acquisition extending to a fourth or fifth dimension with temporal and functional data that can be acquired with ultrafast CT and MR scanner with combined PET/CT scanners.
Lixu Gu and Terry Peters [10] propose a fast multistage hybrid algorithm for 3D segmentation of medical images. Fully 3D precise reliable segmentation approach for visualization using a fast multistage hybrid algorithm is validated. Morphological transformation is considered to extract regions of high intensity of similar size of the objects to be segmented.
Pregrage R. Bakic et al. [11] focus on a digital breast tomosynthesis combine the advantages of mammography and 3D breast images. This approach apply to facilitate the comparison of tomosynthesis images with previous mammographic exams of the same woman, there is a need for a method to register a mammogram with tomosynthesis of the same breast.
Manuel Ferre et al. [12] study stereoscopic image visualization for teleoperated robots. In which the use of stereoscopic image has been assessed to execute teleoperated robot guidance tasks. The performance of stereoscopic and monoscopic image is compared, in which stereoscopic images have shown a guaranteed depth perception.
Sun K. Yoo et al. [13] explain that widely accepted that 3D visualization of medical images helps in patient diagnosis. Optimized streaming conditions are evaluated to visualize and control the 3D medical image which has a high quality on the web. The 3D Visualization system is applied in various biomedical fields such as interactive guided surgery, computer aided diagnosis and telemedicine technologies.
K. Kerchetova et al. [14] provide the construction of 3D images based upon various medical data that trained by computer tomography, magnetic resonance imaging, scintigraphy …etc. This work describes an approach of 3D model reconstruction from medical images by using detailed initial information obtained for forming DICOM files. The proposed system describes methods to provide practical improvements to the reliability of medical diagnostics.

3. 3D Data Volume

3D data volume can be reconstructed using computer graphics, in which images are treated as digital forms. This means that images are stored in a numerical form in computer device. In general 3D volume is constructed from a series of parallel slices that contains the valuable information. Most 3D medical images are sampled anistropically, with the distance between consecutive slices greater than in-plane pixel size. So, the spatial resolution that is the size of image voxels, with a base corresponding to the pixel dimension dictated by the in-plane resolution of the scanner, and a height corresponding to the distance between consecutive slice. Figure (1) shows three different voxel size:

- First, isotropically sampled image at low resolution as shown in part (a).
- Second, anistropically sampled image with in-place resolution higher than resolution between

consecutive slices as shown in (b).

- Third, isotropically sampled image at high resolution as shown in part (c).

When voxel size is provided isotropically, 3D rendering will have the correct scale in all three dimensions. This permits it to perform measurements at any plane and to reslice the image along an arbitrary axis in3D space.

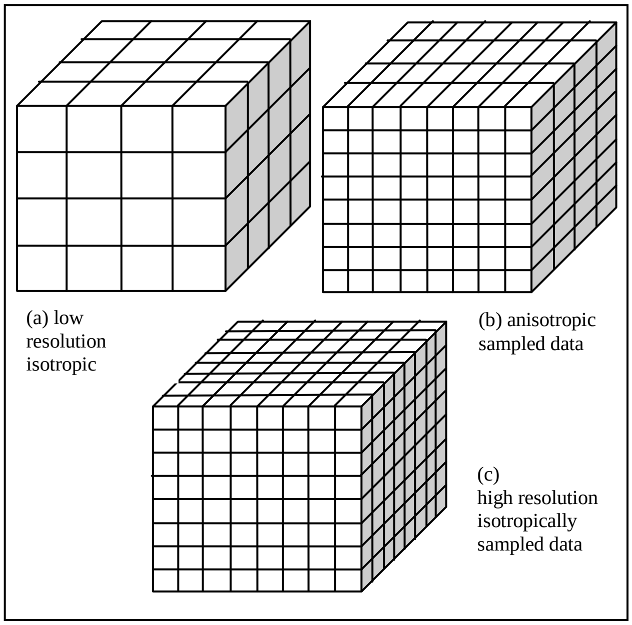


Fig. 1 Voxels size

4. 3D Image Visualization

The presentation of 2D depends on the physical orientation of the image plane with respect to the structure of interest. Most imaging systems have limited capabilities to create optimal 2D image directly. Many techniques are used to generate 2D images from 3D objects, and these techniques depend on the extraction of the important fractures.

Varity of methods and systems are developed for 3D image display and visualization, these methods normally are divided into two techniques: surface rendering and volume rendering. Both techniques produce the visualization of 3D volume images, and each has its advantages and disadvantages. The selection between these methods depends on the application and the result of the visualization [4].

Surface rendering techniques depend on the extraction of contours, in which the surface of the structure is defined. Then the surface batches are placed at each contour point, then using the hidden surface removal and shading to render the visible surface. The advantage of this technique speeding up the processing because of minimum data required for contours. Also this technique can take advantage of particular graphics hardware to speed the geometric transformation of rendering operations. The disadvantages of this technique based on the data required for building contours, some image information is lost in this process. Also this method eliminates any interactive dynamic construction of the surface to be rendered.

Volume rendering techniques based on ray-casting algorithms that have become the powerful method for image visualization. 3D visualization of volume images is provided without the need of prior surface of object segmentation. In these techniques, the entire image volume is required in maintaining the original volume image data. This provide the capability and powerful of rendering the actual image data. Volume rendering techniques preserve high resolution details of the displayed structures. However, these techniques suffer from high computation to implement 3D visualization system.

Normally, images are represented in 2D matrix (M*N). However objects can be represented in 3D matrix (M*N*L) which is a volumetric representation or 3D visualization. The process of creating 3D computer graphics can be sequentially divided into three basic phases: 3D modeling which describes the process of forming the shape of an object, layout and animation which describes the motion and placement of objects within a scene, and 3D rendering which produces an image of an object.

5. Volume Estimation

Volume estimation is an important issue in the field of image visualization, including medical images as well as geographical images. Volume estimation means 3D construction of image from slices. The procedure of construction depends on the following aspects as shown in figure (2) [14]:

- First, find the contour of interested area in each slice.
- Second, measure the indicated area in each slice. The calculation of the indicated area in each slice is approximately similar to the area of the rectangular.

$$S1, S2 \,\&\, S3 \qquad (1)$$

- Third, calculate the volume between two slice S1 and S2.

$$vn = \tfrac{1}{3} D (S1 + \sqrt{S1S2} + S2) \qquad (2)$$

Where D is the distance between two slices.

- Forth, reconstruct the volume of indicated areas for all slices as:

$$V = \sum_{n=0}^{N-1} vn \qquad (3)$$

Where N is the number of slices and vn is the volume between slices.

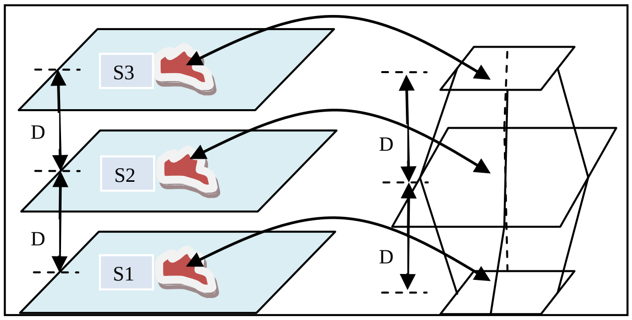


Fig. 2 volume reconstruction from slices

6. The Proposed Visualization Algorithm and Results

This proposed algorithm of image visualization is used to generate 3D objects depending on the extraction of the important features. Open image slices, then the algorithm can be implemented in four steps as shown in figure (3):

- Implement noise reduction.
- Implement edge enhancement.
- Calculate surface rendering.
- Calculate volume estimation.

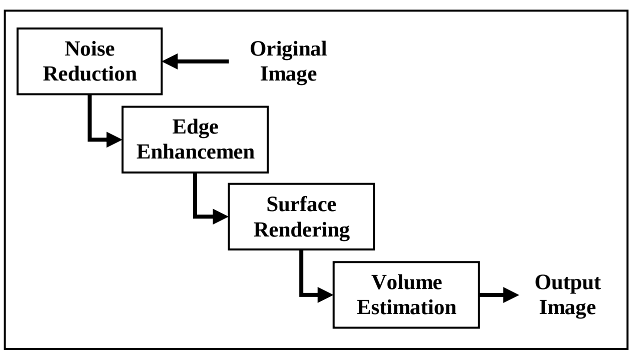
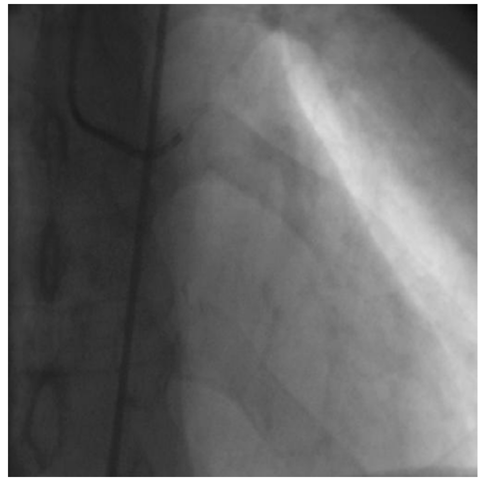


Fig. 3 Visualization algorithm steps

The following figures (4,5 & 6) shows the original image, rendering image and the contour. These figures illustrate the obtained results, starting from the original medical image, passing to all of the algorithm steps, reaching to the final step.



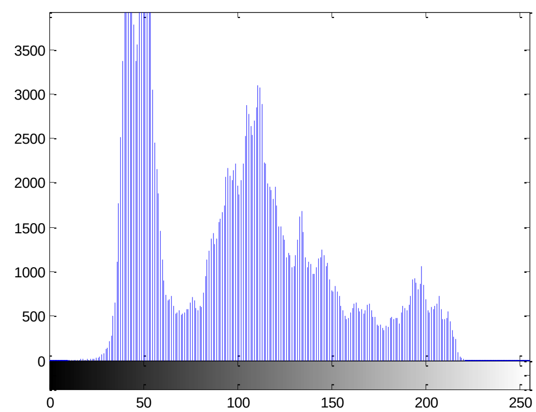
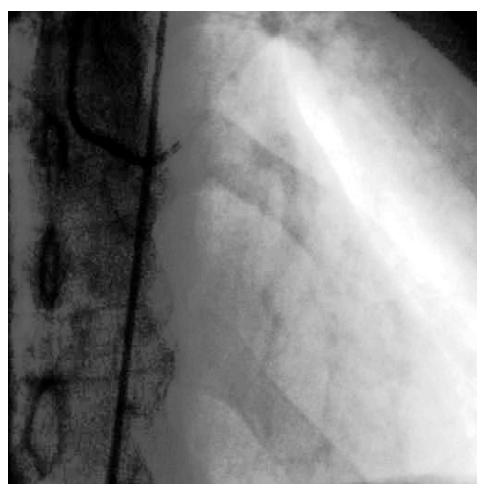


Fig. 4 Original image and its histogram



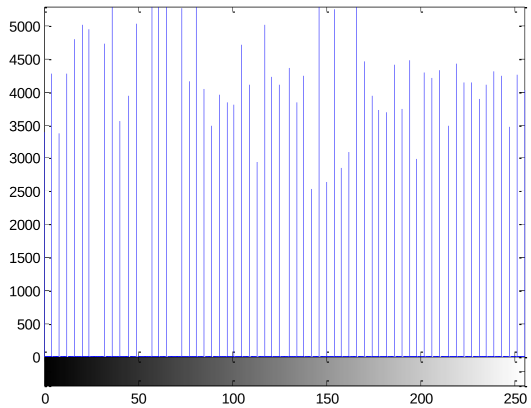


Fig. 5 Edge enhancement image and its histogram

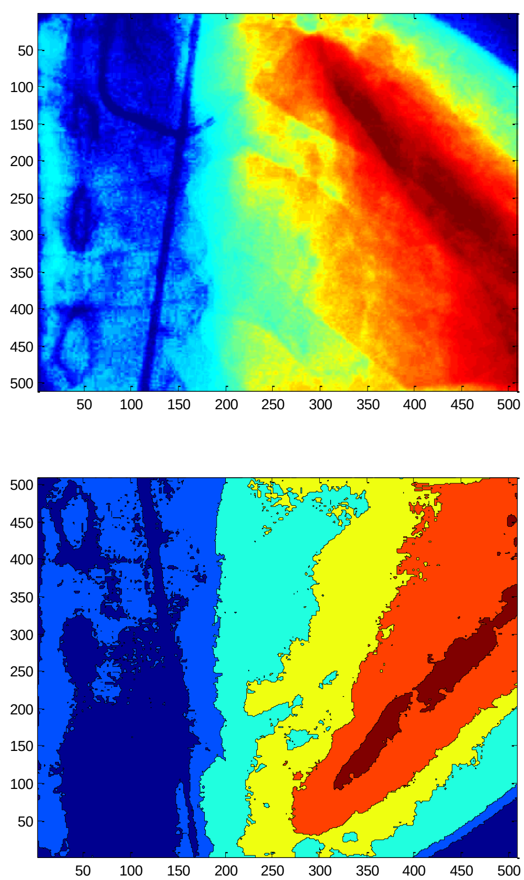


Fig. 6 Surface rendering and its contour

7. Minimum System Requirements

The minimum system requirements for this software are listed below:

- Windows 2000/XP/Vista or later.
- Pentium 3 CPU/4 CPU or better.
- 512 MB RAM or more to adapt large images.
- Sufficient hard disk space to store software and images.
- High resolution screen to display images.

8. Conclusions

Imaging deals with many problems such as low resolution, high level of noise, low contrast and geometric deformations. The merging of image slices to construct 3D image graphic representation is an important issue that opens new and wide fields of applications. This paper presents a proposed algorithm for 3D visualization via the extraction of the third dimension from 2D image. This algorithm is implemented on medical images and also it supports different forms of image format.

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