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Intelligent Techniques in Medical Volume Visualization

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Abstract

Visual representation of the interior body is a key element in medicine. There are many techniques for creating it; such as magnetic resonance imaging, computed tomography, and ultra-sound. The past few decades have witnessed an increasing number of new techniques being developed for practical clinical image display. Medical visualization brings profound changes to personal health programs and clinical healthcare delivery. It's seeks to reveal internal structures hidden by the skin and bones, as well as to diagnose and treat disease. This paper presents the recent intelligent techniques and algorithms used for medical data visualization. These techniques cover filtering, segmentation, classification and visualization. Additionally, this paper discusses state-of-the art toolkits and software supporting medical volume visualization.

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1. Introduction

Regarding physician diagnosis and therapy monitoring, medical imaging is one of the most important tools in the field and it also comes up handy in other fields like remote emergency assistance and surgical planning. Medical images can be obtained through different image modalities such as Ultrasound, X-ray, Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Positron Emission Tomography (PET) or Single Photon Emission computed Tomography (SPET) [1]. The main problem with this large number of medical images lies in processing the enormous amount of obtained data (slice resolution with 16 bits/voxel precision can be provided by modern CT scanner). One approach is to render the data interactively using a specialized multi-processor hardware support. Since these devices are not cheap, they are not widely used in practice. Another alternative is to use volume visualization [2].

Volumetric medical image rendering is a method of extracting meaningful information from a three-dimensional (3D) dataset, allowing disease processes and anatomy to be better understood, both by radiologists as well as physicians and surgeons [3]. As for healthcare, the visualization impact is increasing rapidly in society. Medical imaging is fundamental for healthcare since the depiction of the body interior is crucial for the diagnosis of countless diseases and injuries [4]. For that purpose vast research and industry efforts have been put into the development of

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imaging devices scanning the patients and producing high-precision measurement data. Capturing the data is only the first step followed by the visualization step which is an essential link that presents this data to the physician as the basis for the diagnostic assessment.

The paper is organized as follows. Section 2 presents a brief explanation of volume visualization pipeline. Section 3 discusses the different Medical image techniques and the available databases for research. Section 4 represents the most commonly techniques for filtering medical images. Section 5 illustrates the available techniques used to segment medical image. Then, we elucidate the approaches used in classification in section 6. Sections 7 and 8 discuss both the medical image classification and volume image visualization techniques, respectively. Finally, section 9 presents the currently available toolkits used for medical image visualization.

2. Volume Visualization Pipeline

Following [5,6,7], the five processes used to preform volume visualization on medical image are shown in Figure 1. The first process is the acquisition of dataset, after that dataset filtered for enhancing the quality of the medical image, then segmentation step done to locate objects of interest for the medical image. After the possible selection of a sub-range of the voxels, the normal of the voxels are computed. For the last step before the actual rendering, the voxels are classified. Finally, the voxels are visualized.

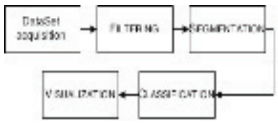

Figure 1: Volume visualization pipeline

The following sections highlight more details about each step of the above pipeline from the perspective of medical images.

3. Medical Image Technologies

In 1895 Wilhelm Roentgen discovered a new form of radiation called X-ray, and that was the beginning. Since then medical image endure continuous innovation. Nowadays most of the images are digital. Medical imaging is the process of capture image by an acquisition system of the interior of a body for the physical attributes and clinical analysis. There are techniques used to display medical images; such as x-ray, CT, MRI, ultrasound, PET and SPET.

Table 1 shows the available techniques for acquisition the medical image with a comparison between them to illustrate the advantage and disadvantage for each on [8,9,10,11,12,13] which will help to determine the best techniques in the diagnosis. For example, CT images help doctors to get 3-D view of certain parts of the body, such as soft tissues, the pelvis, blood vessels, the lungs, the brain, the heart, abdomen and bones [14,15]. CT is the preferred method for diagnosing liver, lung and pancreatic cancers and evaluate bone injuries, presence, size and location of tumors and Cardiovascular disease [16,17,18]. On the other hand, MRI used for the diagnosing a number of conditions by showing the difference between normal and diseased soft tissues of the body [19,20,21]. PET often used to evaluate Neurological diseases such as Alzheimers and Multiple Sclerosis, Cancer, Effectiveness of treatments and Heart conditions [22]. Ultrasound preferred for Pregnancy, Abnormalities in the heart and blood vessels, Organs in the pelvis and abdomen and Symptoms of pain, swelling and infection [23,24,25,26], and last but not least, X-ray is used to show Broken bones, Cavities, Swallowed objects, Lungs, Blood Vessels and Breast (mammography) [27].

Table 1: Advantage and Disadvantage of Medical Image Technologies

Technology	Advantage	Disadvantage	Example