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3D ultrasound imaging: applications in image-guided therapy and biopsy

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Abstract

The use of conventional 2D ultrasonography to view 3D anatomy limits our ability to plan and guide interventional procedures. CT and MRI have been used in planning and guiding these procedures due to their ability to provide 3D images with accurate depiction of anatomy. Recent development of 3D ultrasound imaging techniques that are capable of acquiring B-mode, color Doppler and power Doppler images, has allowed the development of image-guided therapy and surgery approaches. Because ultrasound imaging is an inexpensive and compact imaging modality, it is particularly suited for applications in prostate therapy, breast biopsy and monitoring of disease progression in response to therapy.

Keywords: 3D ultrasound; 3D imaging; Image-guided surgery; Minimally invasive surgery

1. Introduction

Since the early days after the discovery of X-rays, visualization of the interior of the human body has been particularly important in interventional applications. Developments of computed tomography (CT), ultrasound (US), positron emission tomography (PET), and magnetic resonance imaging (MRI) have revolutionized diagnostic radiology, as for the first time, 3D information of the interior of the human body was recorded. Since interventional application require at least near real-time planning and guidance in 3D, the use of medical imaging approaches for these applications were slower to develop primarily because of the demanding computational requirements for 3D reconstruction and visualization. Typically, the acquired 3D information was presented as 2D images, requiring the physician to assemble the 3D information in their mind.

Advances in the past decade in computer technology and computational techniques now allow real-time reconstruction, visualization and manipulation of 3D images on inexpensive desktop computers. It is only in the past few years that we have began to explore the full potential of 3D visualization for medical interventional applications.

US imaging is an inexpensive and compact imaging modality readily available in hospitals and clinics. Medical US image quality has advanced steadily, making it an indispensable tool in obstetrics and in the diagnosis and management of many diseases. Nevertheless, use of US in interventional applications still suffers from several disadvantages related to its 2D image presentation. Despite decades of exploration, it is only in the past 5 years that 3D US imaging has advanced sufficiently to make it useful for medical interventional applications [1–4].

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