Chapter 2.10
Segmentation Methods in Ultrasound Images

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ABSTRACT

Ultrasound imaging now has widespread clinical use. It involves exposing a part of the body to high-frequency sound waves in order to generate images of the inside of the body. Because it is a real-time procedure, the ultrasound images show the movement of the body's internal structure as well. It is usually a painless medical test and its procedures seem to be safe. Despite recent improvement in the quality of information from an ultrasound device, these images are still a challenging case for segmentation. Thus, there is much interest in understanding how to apply an image segmentation task to ultrasound data and any improvements in this regard are desirable. Many methods have been introduced in existing literature to facilitate more accurate automatic or semi-automatic segmentation of ultrasound images. This chapter is a basic review of the works on ultrasound image segmentation classified by application areas, including segmentation of prostate transrectal ultrasound (TRUS), breast ultrasound, and intravascular ultrasound (IVUS) images.

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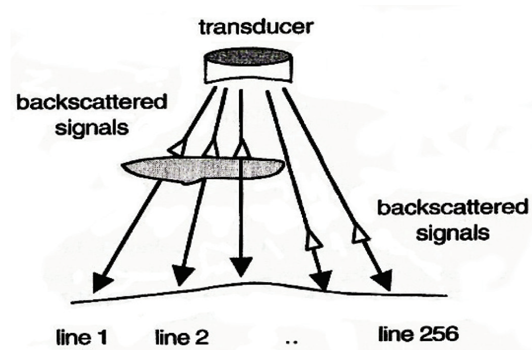
INTRODUCTION

Among different image modalities, ultrasound imaging is one of the most widely used technologies for the diagnosis and treatment of diseases such as breast and prostate cancer. Ultrasound equipment is less expensive to purchase and maintain than many other imaging systems such as X-ray, computed tomography (CT), or magnetic resonance imaging (MRI). These images are the result of reflection, refraction, and deflection of ultrasound beams from different types of tissue with different acoustic impedances. The detection of the object boundaries in such images is crucial for diagnostic and classification purposes.

However, attenuation, speckle, shadows, and signal dropout can result in missing or diffused boundaries. Also the contrast between areas of interest is often low. These obstacles make segmentation of these images a challenge. Further complications arise when the quality of the image is influenced by the type and particular settings of the machine. Despite these factors, ultrasound imaging still remains an important tool for clinical applications and any effort to improve segmentation of these images is highly desirable. Thus, there is currently an interest in understanding how to apply image segmentation to ultrasound data. Figure 1 demonstrates the basic principle of an ultrasound imaging transducer. Using an ultrasound transducer, a pulse of energy is transmitted into the body along the path shown by line 1. After this beam encounters any surface, including tissue or structures within an organ, a part of the transmitted energy is backscattered along the original trajectory and received by the transducer which now acts as a receiver. These returning waves are converted to electrical signals, amplified, and finally shown. After that, the direction of the transmitted beam changes to attain the data from the next line close to the first one. The ultrasound transducer repeats the same procedure to cover 64-256 lines and makes the entire image (Webb, 2003).

This chapter contains an overview of the ideas representing the ultrasound segmentation problem in particular clinical applications.

Figure 1. The basic principle of an ultrasound imaging transducer (© 2003 IEEE, Reprinted, with permission from IEEE Press Series in Biomedical Engineering 2003. "Introduction to Biomedical Imaging", by A. Webb).



BACKGROUND

Many methods have been introduced to facilitate more accurate segmentation of ultrasound images. The performance of these methods is generally improved through the use of expertise or prior knowledge. All segmentation methods usually require at least some user interaction to adjust critical parameters. The type of user interaction varies, depending on the amount of time and effort required from the user.

This chapter is a review of ultrasound image segmentation methods and focuses on clinical applications that have been investigated in different clinical domains. It centers on reviewing the ideas behind the incorporated knowledge of ultrasound physics such as speckle structure, as well as prior information about the intensity or shape model. We review some principal works in this area according to their applications where the majority of efforts have been focused. These include segmentation of prostate transrectal ultrasound (TRUS), breast ultrasound, and intravascular ultrasound (IVUS) images.