Chapter 50
Segmentation of Renal Calculi in Ultrasound Kidney Images Using Modified Watershed Method

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ABSTRACT

US images are a commonly used tool for renal calculi diagnosis, although they are time consuming and tedious for radiologists to manually detect and calculate the size of the renal calculi. It is very difficult to properly segment the US image to detect interested area of objects with the correct position and shape due to speckle formation and other artifacts. In addition, boundary edges may be missing or weak and usually incomplete at some places. With that point of view, the proposed method is developed for renal calculi segmentation. A new segmentation method is proposed in this chapter. Here, new region indicators and new modified watershed transformation are utilized. The proposed method is comprised of four major processes, namely preprocessing, determination of outer and inner region indictors, and modified watershed segmentation with ANFIS performance. The results show the effectiveness of proposed segmentation methods in segmenting the kidney stones and the achieved improvement in sensitivity and specificity measures.

INTRODUCTION

The most widespread problem in the human urinary system is renal calculus which is also known as kidney stones or urinary stones (Manousakas, Lai, & Chang, 2010). Though considerable suffering and at times renal failure are caused by kidney stone diseases that occur in roughly 10% of the U.S. population affected, the mechanism for this disease is not adequately known (He, Deng, & Ouyang, 2010). The principal organ in the urinary system namely, kidney not only produces urine but it is also useful in purifying the blood. Disposing poisonous substances from the blood and maintaining the useful com-

ponents in proper balance are the two essential functions of kidney. Among the diverse types of kidney stones that exist, calcium-containing stones, Uric acid stones, Struvite, or infected stones and Cystine stones are four fundamental types (Shah, Desai, & Panchal, 2010). Kidney diseases are commonly classified into hereditary, congenital or acquired (Bommanna, Madheswaran, & Thyagarajah, 2010). The identification of calcifications inside the body is a large field of study including many dynamic areas of research, which is especially useful for diagnosing the kidney stone diseases. Prominent effects that are utilized to detect fracture in real kidney stones that can have arbitrary non-spherical shape are related to the reverberation time across the length of the stone (Manousakas et al., 2006).

Strong speckle noise and attenuated artifacts present in the abdominal ultrasound images poses a unique challenge in using these images for stone segmentation (Gupta, Gosain, & Kaushal, 2010). Accordingly, this task entails the usage of as much beforehand knowledge as possible, like texture, shape, spatial location of organs and so on. The performance of the several automatic and semiautomatic methods that have been proposed deteriorates quickly when the structures are inadequately defined and have low contrast like the neuroanatomic structures, such as thalamus, globus pallidus, putamen, etc., though it has normally a good performance when the contrast-to-noise ratio is high (Maulik, 2009). Regular clinical practice Numerous extensively available medical imaging methods like X-ray, positron emission tomography (PET), computer tomography (CT), Ultrasound (US) and magnetic resonance imaging (MRI) are extensively used in regular clinical practice (Jouannot et al., 2004). As compared to other medical imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI), the US is particularly difficult to segment because Ultra Sound is especially hard to segment because its image quality is somewhat low compared to other medical imaging modalities like computed tomography (CT) and magnetic resonance imaging (MRI) (Xie, Jiang, & Tsui, 2005). Quality of image data significantly affects the segmentation of Ultra Sound (US) images (Noble & Boukerroui, 2006). It is difficult to extract features that describe the kidney tissues by segmenting the kidney area (Bommanna, Madheswaran, & Thyagarajah, 2010). Despite this, ultrasound images are extensively used in the medical field (Jeyalakshmi & Kadarkarai, 2010). Tamilselvi (2013) proposed the segmentation method using Squared Euclidean Distance (SED) with ANFIS in supervised learning has made the technique more efficient than the previous techniques. Thus the obtained error is minimized when compared to the existing algorithm that leads to high efficiency.

As ultrasound imaging is a cost-effective and non-invasive as well as radiation-free imaging technique, it is popular in the field of medicine (Gupta, Gosain, & Kaushal, 2010). US imaging on account of its real time capabilities permits faster and more precise procedures. In addition, it is economical and user-friendly. In several applications, an important role is played by the precise identification of organs or objects that are present in US images (Xie, Jiang, & Tsui, 2005). Resolutions required by murine imaging could be achieved in ultrasonic imaging which already has a broad variety of clinical applications for human imaging, if higher frequencies (20 – 50 MHz) are used instead of the normally used frequencies (3 – 15 MHz) (Jouannot et al., 2004). The speckle noise which makes the signal or lesion difficult to detect is the main performance restricting aspect in visual perception of US imaging (Loizou et al., 2002, 2004). Diverse methodologies have been utilized in the diverse research papers that have been published on segmentation of kidney region in US images. Utilization of a-priori information may be used as an alternative in robust methods to compensate for the difficulty caused by noise and poor signal-to-noise ratio of US kidney images (Bommanna, Madheswaran, & Thyagarajah, 2006). The segmentation of renal calculi using renal images is a difficult task. Lots of researches have been performed for the successful segmentation of renal calculi using ultra sound images. However, there

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