A Decision Support System for Classification of Normal and Medical Renal Disease Using Ultrasound Images: A Decision Support System for Medical Renal Diseases

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ABSTRACT

Early detection of medical renal disease is important as the same may lead to chronic kidney disease which is an irreversible stage. The present work proposes an efficient decision support system for detection of medical renal disease using small feature space consisting of only second order GLCM statistical features computed from raw renal ultrasound images. The GLCM mean feature vector and GLCM range feature vector are computed for inter-pixel distance d varying from 1 to 10. These texture feature vectors are combined in various ways yielding GLCM ratio feature vector, GLCM additive feature vector and GLCM concatenated feature vector. The present work explores the potential of five texture feature vectors computed using GLCM statistics exhaustively for differential diagnosis between normal and MRD images using SVM classifier. The result of the study indicates that GLCM range feature vector computed with d = 1 yields the highest overall classification accuracy of 85.7% with individual classification accuracy values of 93.3% and 77.9% for normal and MRD classes respectively.

KEYWORDS

Decision Support System, GLCM Features, Man Machine Interaction, Medical Renal Disease, Support Vector Machine, Ultrasound Renal Images

INTRODUCTION

The kidney performs important functions such as removing excess water and retaining it whenever required, adjusting the levels of minerals, removing waste products such as urea and creatinine, making important chemicals called hormones (which regulates blood pressure, red blood cell production and calcium balance), which mainly involve parenchyma region of kidney. Thus, early diagnosis of medical renal disease (MRD) that hampers the normal functioning of parenchyma is clinically significant to avoid further complications such as renal cancer (Page et al., 1994; Inci et al. 2006; Viswanath and Gunasundari, 2014; Hung, 2015; Schrader et al., 2002; Chen et al., 2011; Raman et al., 2014).
The real time, inexpensive, non-radioactive and non-invasive nature of ultrasound (US) imaging modality are some of the significant advantages due to which it is considered as the primary examination for the imaging of soft tissues however there are certain associated disadvantages such as (a) inter and intra-observer variations associated with interpretation of ultrasound image, (b) motion artefacts and (c) equipment limitations (Page et al., 1994; Inci et al., 2006; Viswanath and Gunasundari, 2014; Momenan et al., 1988; Marsoursi and Plataniotis, 2015; Araki et al., 2015; Ikeda et al., 2015; Araki et al., 2014). Also, magnetic resonance imaging (MRI) and computed tomography (CT) scans provide better diagnosis for renal diseases (Renken and Krestin, 2005; Ergen et al., 2004; Sun et al., 2009; Ghalib et al., 2014; Goh et al., 2011) but the feasibility and cost-effectiveness of ultrasound imaging modality overcomes its drawbacks. These factors restrict the clarity of proper diagnosis. Thus, the researchers have shown keen interest to develop CAD systems for classification of renal diseases (Golodetz et al., 2007; Linguraru et al., 2009; Virmani et al., 2014; Raja and Madheswaran, 2007; 2008; Raja et al., 2007; 2010; Jose et al., 2012; Dhanalakshmi and Rajamani, 2010; Subramanya et al., 2015).

The brief description of sonographic appearance of normal and MRD renal ultrasound image classes is given here:

- **Normal**: A normal bean-shaped kidney has a parenchyma region which is divided into renal cortex and renal medulla. The renal cortex is the outer portion of the kidney between renal capsule and renal medullary pyramids. The centrally located hyper-echoic region is termed as renal sinus which is mainly composed of renal fat, renal vessels, calices, nerve tissue, and lymphatic channels. The differentiation between renal sinus and parenchyma region can be made easily in case of normal class as renal sinus region exhibits more echogenicity in comparison to parenchyma region and cortico-medullary differentiation can also be made as shown in Figure 1;

- **MRD**: Any acquired kidney disease may cause renal infection (destruction of kidney tissues) which may cause renal failure. Renal disorders like polyuria, pyuria, proteinuria, and hematuria may involve diseased glomerulus, nephrons and blood vessels of the parenchyma region. Such disorders form the class of MRD (Kadioglu, 2010; Hoffman and Riley, 1967; Bakker et al., 1998; Huntington et al., 1991; Rosenfield and Siegel, 1981; Quaia and Bertolotto, 2002). In

Figure 1. Normal renal US image. Note: RT kidney: Right kidney. Renal sinus region exhibits more echogenicity in comparison to renal parenchyma. Cortico-medullary differentiation can also be made.
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