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Gabor Filter Aided 3D Ultra-Sonography Diagnosis System with WLAN Transmission Consideration

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Abstract: The Gabor filter aided diagnosis system for 3-dimensional ultra-sonography (3DUS) under the WLAN environment is introduced. Due to the important relationship between breast tumour surface features and internal architecture, we applied our system using 3D inter-pixel correlations instead of 2D features. Gabor filters provide a multi-resolution representation of texture, which increases ultrasound technology capability in the differential diagnosis of solid breast tumours. Our experiments show that the performance of the proposed diagnostic method is effective. Moreover, physicians manipulate our diagnostic system using hand-held devices in the hospital. Because WLAN is unstable, our system ensures good transmission quality. We also focus on transmission control strategies that adapt to the time varying wireless network conditions. We analyze strategies that use competitive analysis techniques. The experiments show that the algorithm's performance is effective.

Keywords: 3D ultrasound, 3DUS, breast tumour, speckle noise, Gabor filter, auto-correlation, neural network, WLAN Transmission
Categories: SD I.4.0

1 Introduction

The ultrasound (US) imaging system is widely used in hospitals, physicians' offices and clinics. Since the traditional 2D ultrasound (2DUS) cannot easily demonstrate tumour surface features and internal architecture simultaneously, the 3D ultrasound (3DUS) has been developed. The physician can now view the construction in 3D

[Chen et al. 2003a], [Chang et al. 2003], [Chen et al. 2003b], [Sallout et al. 2006]. A 3D object, such as a breast tumour, usually has volume and appears as an uneven complex shape. In 2DUS, if the 2D probe is not located at the correct location or the scanned 2D image contains only partial tumour features, it may result in a misdiagnosis. Because the 3DUS reduces the variability, it could be a potentially reliable diagnostic tool for solid breast tumour analysis. The pixel relation analysis techniques are useful in diagnosing breast lesions. Only one single 2D data slice was used for each case in the conventional 2DUS diagnostic system. When the diagnostic features come from only one slice, that slice may fail to represent all of the tumour's diagnostic features. For these reasons, 3DUS datasets are used in this paper.

Texture analysis is essential in distinguishing speckled noise from meaningful tissue texture produced by US imaging [Goncalves et al. 2006]. Texture analysis algorithms range from random field models to multi-resolution filtering techniques [Lee and Shi 2009]. We propose a multi-resolution representation method based on the Gabor filters. Gabor filters have been used in several image analysis applications including texture classification and segmentation [Bovic et al. 1990], [Manjunath and Chellappa 1993], image recognition [Daugman 1993], [Lades 1993], [Manjunath and Chellappa 1992], image registration and motion tracking [Manjunath et al. 1996]. Most of these researches are related to texture segmentation and analysis. Gabor filters are used in this research to extract textured image features using various factors, which improve image resolution, orientation selectivity and spatial frequency tuning. The Gabor approach can achieve optimal resolution in both space and spatial frequency. Using the appropriate filters with the optimal parameters to increase the computational efficiency and extract more meaningful information, we propose using the texture parameters to compute the auto-correlation matrix as the characteristic vector in our artificial neural network diagnosis models as well. The region of interest (ROI) and volume of interest (VOI) of the US images are located by physicians.

Because physicians can manipulate this system using hand-held devices in the hospital, every transmission between the system and physicians is under WLAN. Like any radio frequency transmission, wireless networking signals are subject to a wide variety of interference, as well as complex propagation effects that are beyond the control of the network administrator. The environment for transmission may be lost or produce errors within the bandwidth limits.

In order to extract the sub-images of VOI, three tumour regions need to be sketched by the physician under WLAN. The image-data quality under the wireless transmission will affect the sketch result. In other words, it may affect the diagnostic accuracy. A very reliable communication system is required to support our system. Transmission methods that avoid the failure caused by lost or errant packets are therefore very important in order to provide reliable communication. We also focus on the transmission control strategies that adapt to the time varying wireless network conditions. These algorithms can employ a number of strategies. For example, blindly estimating the channel state, employing a channel predictor to obtain information about the state of the wireless channel, estimating the probability distribution of the channel state variation, or using non-adaptive and adaptive threshold schemes to decide when to transmit and when to stop. Here we consider the last approach.

Moreover, we analyze strategies that use competitive analysis techniques. The previous proposed competitive analysis shows how good the link layer transmission control algorithms are compared with the optimal algorithm that has perfect knowledge of the wireless channel states for the entire duration of the transmission. In fact, the optimal algorithm is not practical. We assume that packet losses are solely due to physical imperfections in the wireless channel, i.e., we neglect other interferences such as multi-user interference, etc., for the sake of simplicity [Sleator and Tarjan 1985], [Chandramouli et al. 2004].

In Section 2, we introduce the computer-aided diagnosis system. Section 3 shows the transmission algorithms. Our conclusion is discussed in the last section.

2 Computer-aided diagnosis system

2.1 Materials and Methods

Speckle Noise

The speckle is a type of noise that changes the tissue parameters. It is a phenomenon caused when a coherent imaging system, such as US, is used to image a surface that is rough on the wavelength scale used. The surface produces many reflections in each resolution cell that adds constructively or destructively to produce a speckled pattern. A US speckled image has the magnitude of a complex Gaussian field with independent real and imaginary parts that are distributed identically [Czerwinski et al. 1994].

A small amount of additive noise might be shown in US scans. An image may be classified as possessing Gaussian noise with a very small standard deviation into different levels of speckled noise. The p(x) (Zero-mean Gaussian noise also represents the speckle noise) with standard deviation σ is drawn from the probability density function

$$p(x) = \frac{1}{\sqrt{2\pi} \cdot \sigma} \exp(-\frac{x^2}{2\sigma^2})$$

(1)

where x denotes the grey level of the uncorrupted image [Wachowiak et al. 2000].

Gabor Filters

2-D Gabor function is a Gaussian modulated by a complex sinusoidal plane wave of some frequency and orientation. The general form for the 2-D Gabor function is given by

$$G(x, y) = g(x, y) \cdot \exp[2\pi i(Ux + Vy)]$$

(2)

where $i = \sqrt{-1}, U = F\cos\theta, V = F\sin\theta,$ and F=1/T (T is period), g(x,y) is 2-D Gaussian function given by