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Identification of chicken liver and bovine liver via novel tissue quantitative parameter

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Abstract
Frequency dependence of the tissue backscatters provides useful information about the tissue structure. Further, it has been found that structure of tissue changes due to different diseases and these alterations cause observable changes in acoustic scattering properties. Several parameters have been developed to identify these alterations and tissue identification. This study has introduced a new tissue characterization parameter, which is Full width at half maximum (FWHM) of the fitted Gaussian curve of the Fast furrier transformed back scattered signal and it has been used to identify two different tissue samples; bovine liver and chicken liver. The experiment was carried out for nine bovines and nine chicken livers and FWHM of the chicken liver 3.72±0.16 was greater than that of bovine liver 3.28±0.16 (p=2.91E-05). Hence, it can be concluded that the bovine liver and the chicken liver can be differentiate using the FWHM parameter.

Keywords: Ultrasonic spectrum analysis, Tissue backscatters, Ultrasonic tissue characterization parameters, full width at half maximum

1. Introduction

In the context of noninvasive diagnostic techniques, Ultrasonic imaging is one of the most popular diagnostic imaging techniques in broad range of medical specialties. Compared to more sophisticated approaches such as MRI, ultrasound is quite inexpensive modality, as well as widely accessible to the general population in many countries. Conventional ultra-sonic imaging (B-mode imaging) has been used to obtain Cross sectional images of abdomen, heart, kidney, prostate, eye, fetus, etc. [1].

However, due to some constrains, for example, resolution constrains; it is difficult to accurately diagnose many diseases like hepatitis and cirrhosis, [5] using B-mode images and conventional pattern recognition techniques. Further, when it comes to quantification of tissue structure of these tissues, can also not be utilized on those images due to image deration such as random speckles, artificial specular drop outs and spatially varying resolution in ultrasonic images. These derations occur due to coherent nature of the ultra sound, complex interaction of tissues and ultrasonic waves [3].

Apart from the diagnostic capabilities of conventional ultra sound images, spectrum analysis procedures can also provide useful information about the diseases [3]. In the late 1960s, scientists have realized that frequency dependence of the tissue backscatters provide useful information about the tissue structure [1]. Later, in late 1970s and 1980s it has been found that the tissue structure changes due to different diseases and these alterations cause observable changes in acoustic scattering properties [5]. Several parameters have been

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developed to identify these alterations and tissue identification. Among them, Integrated Backscatter (IB) [6], spectral slope, spectral intercept and mid-band fit [3] are the most commonly used parameters that can be found in the literature.

2. Problem definition

It has been found that the tissue structure changes due to different diseases [1]. On the other hand, if we could find a method to quantify these structural differences in tissue, then there is a possibility of identifying diseases at initial stages. In this study, we tried to understand the possibility of identifying different tissue samples from the radio frequency (RF) echo characteristics. Therefore, we tried to introduce new tissue quantification parameter using RF echo data and tried to use it to identify different tissues as an initial approach for tissue structure quantification.

3. Experimental procedure

In this study, we tried to identify different types of tissues. Hence, in our comparison we tried to differentiate chicken liver and bovine liver. In the comparison of chicken and bovine liver, we purposely selected those two types of animals as we assumed that there can be histological differentiation between mammalian and avian livers.

In the experiment, the tissue sample was completely submerged in degassed water and a 5 MHz single element 0.25 in elemental diameter; immersion transducer (Olympus-V310-SU, Band width 16–24 MHz at -6 dB) was used for scanning. Tissue samples were held stationary and the transducer was moved five-millimeter steps using a computer controlled micro position system. RF echo data was acquired at a sampling rate of 1GHz, using the same transducer. Readings were taken at fifteen distinct positions of the tissue sample and 32 echo signals at different time intervals were collected at each position. Real time signal acquisition was done by a PC oscilloscope (PicoScope 3204D). Settings were adjusted to acquire 100000 samples at a sampling interval of 1ns. Refer Figure 1 for a signal received from a single position of a bovine liver sample. One echo signal was selected per each position and a Hamming window was applied to the RF echo signal, followed by Fast Fourier Transformation (FFT). Average of all Fast Fourier transformed power spectra at fifteen different locations were calculated. A Gaussian curve was fitted on the averaged FFT data. This Gaussian curve was used to calculate full width at half maximum(FWHM). The data acquired by a chicken liver sample and a bovine liver sample and fitted Gaussian curve shown in Figure 2. Two Gaussian curves were normalized for visual comparison.

Nine chicken liver samples and nine bovine liver samples were used for the data acquisition. All liver samples were taken from the local meat market and the animals were slaughtered few hours before the collection of samples. Since the chicken liver is small, whole liver was used for the experiment, where a piece of a bovine liver was used. Liver samples were washed using water to eliminate blood as much as possible and submerged in the glass vessel which was filled with degassed water. Immersion transducer was lowered and the data acquire in a straight line at five-millimeter intervals. For the experimental set up refer Figure 3 and Figure 4.

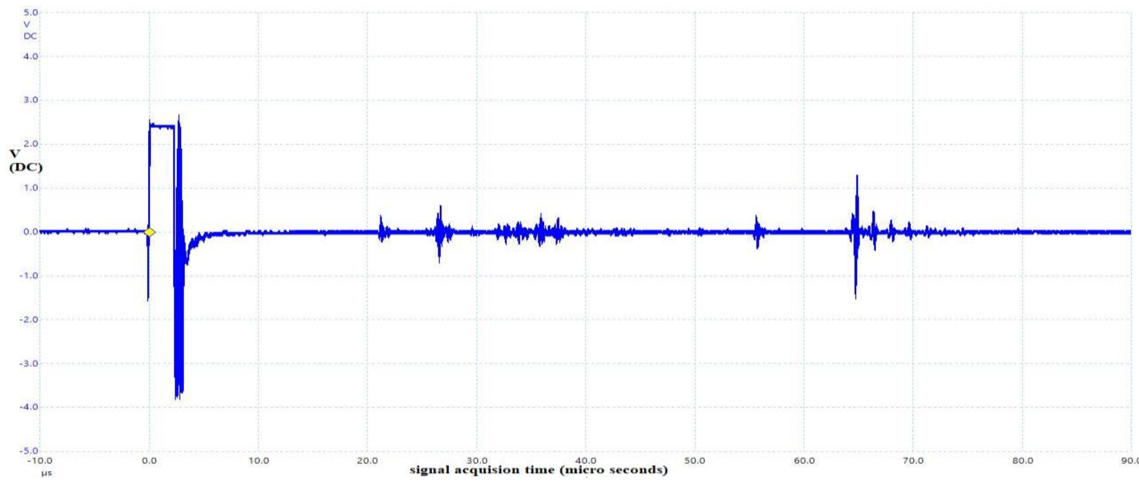

Figure 1: RF echo signal received from a single position of a bovine liver sample

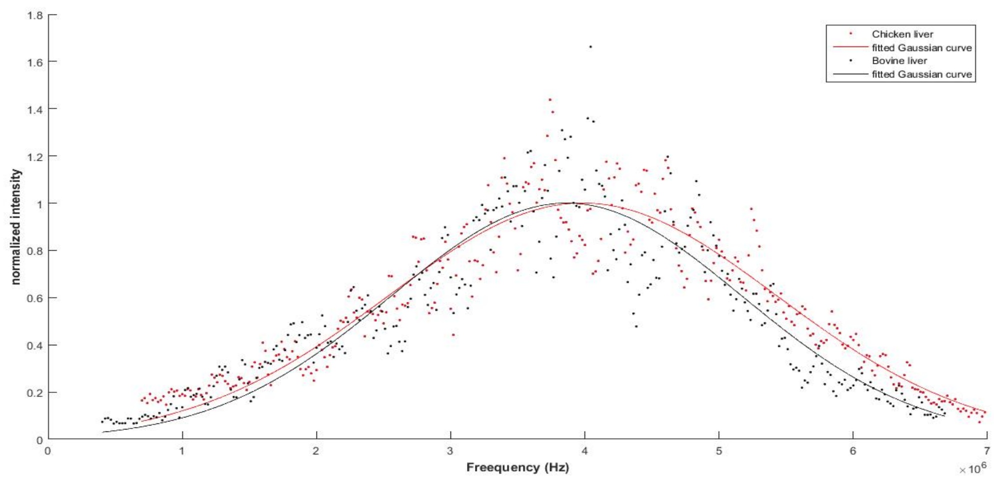

Figure 2: Normalized Gaussian curves fitted for intensities form chicken and bovine kidney

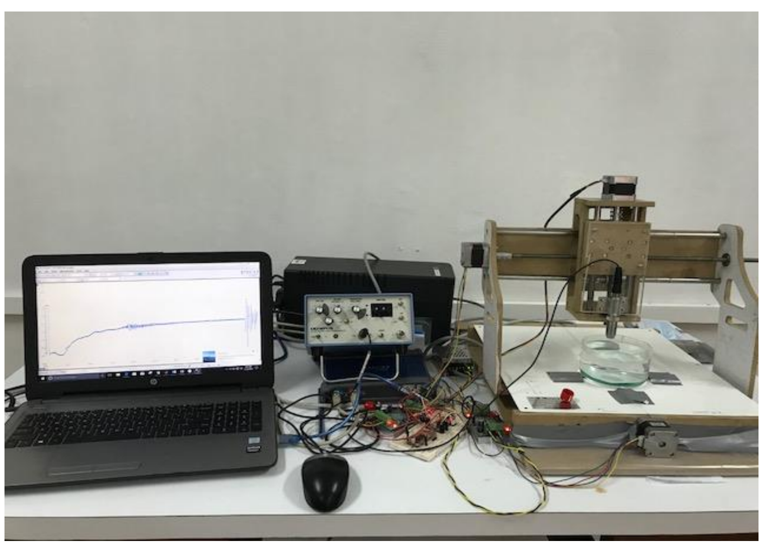

Figure 3: Experimental set up

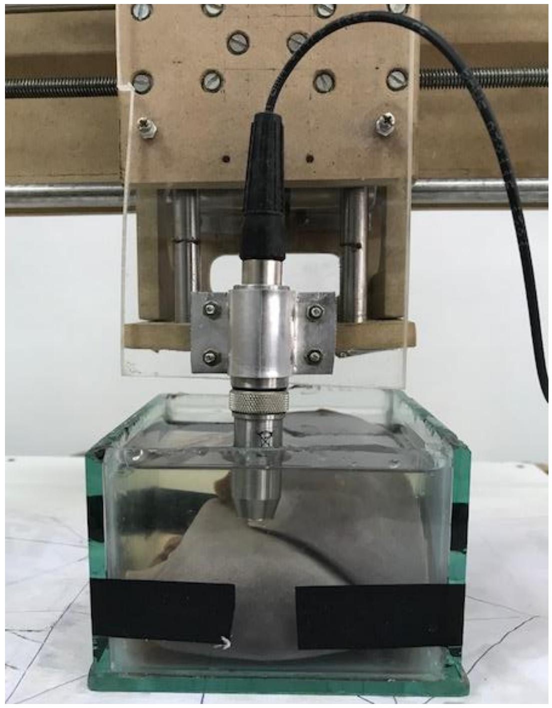

Figure 4: Experimental set up; close up of transducer and bovine liver sample

4. Results and discussion

In this study, we introduced full width at half maximum (FWHM) of the averaged FFT signals as a novel parameter to characterize the tissue. Hence, our main objective was to differentiate chicken liver and bovine liver using this new tissue characterizing parameter. Full width at half maximum data for nine different chicken samples and nine different bovine liver samples were calculated and compared, refer table1. Application of T-test for the two data sets, the p value (two tailed) appeared as 2.91E-05. This p value emphasizes that there is a significant difference between the two samples.

Table 1: Mean, Variance and P value for bovine liver and chicken liver

	Chicken liver	Bovine liver
Mean value of FWHM	3.72±0.16	3.28±0.16
P	2.9113E-05	

As mentioned above, spectral slope, spectral intercept and the mid-band fit are the most favorite quantitative descriptors to identify key features in tissue [3]. However, these descriptors were calculated using a region of interest (ROI) selected by the researcher. Where in this case, we directly used the reflected intensity signals for the data processing. Hence, there can be pros and cons in this approach. The reflections at the boundaries are not perfectly understood and as to how these reflections affect the result is yet to be identified. Where, in the ROI approach such a problem will not occur since the boundary reflections will not come in to play as the ROI selection done as per the researcher's interest. On the other hand, blood clots or air bubbles could be trapped inside the liver veins. These discrepancies could be visualized in the reflected signals as abnormal peaks, where such data can be manually excluded in the data processing. Further, this study is one successful step towards the process of constructing a simple ultrasound system capable of RF echo signal acquisition and spectral analysis, explained in Hewadikaram et al. [6]

5. Conclusion

Differentiation of two distinct tissue samples using the proposed novel tissue characterization parameter was the main target of this study. Since the p value appeared as 2.91E-05, which is a much lower value than 0.05, therefore the null hypothesis will be rejected for the two samples and it can be concluded that the two samples are separable. Hence it can be concluded that the bovine liver and the chicken liver can be differentiated using the FWHM parameter. Hence, RF echo data can be used to identify different tissues and can be used for further expansion of this study.

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