2P5-15

Proceedings of Symposium on Ultrasonic Electronics, Vol. 30 (2009) pp. 349-350
18-20 November, 2009

Tissue Characterization Using Optically Assisted Ultrasonic Velocity-Change Imaging Method

光アシスト超音波速度変化イメージング法による生体組織診断

Hiromichi Horinaka†, Satoshi Ishibashi, Daisuke Sakurai, Hajime Sano, Tetsuya Matsuyama, Kenji Wada, Toshiyuki Matsunaka (Osaka Prefecture Univ.)
堀中博道‡、石橋　聡、櫻井大輔、佐野肇、松山哲也、和田健司、松中敏行
（大阪府立大学大学院　工学研究科）

1. Introduction

We have already proposed the optically assisted ultrasonic velocity-change imaging method for medical diagnosis.[1] Then, we got the ultrasonic velocity change images of the chicken meat phantom including Au nano-rods or the ICG (indocyanine green) which had the specific optical absorption spectra of the near-infrared region respectively.[2,3] The ultrasonic velocity change corresponded to the optical absorption properties of materials can be converted into the temperature change. This means that the optical absorption spectra of the material can be obtained from the ultrasonic velocity-change due to light illumination.

In this study, we investigated experimentally the possibilities of application of the optical assisted ultrasonic velocity-change imaging method to tissue characterization.

2. Principle of ultrasonic velocity change image

The ultrasonic pulses emitted from the linear array transducer are reflected from the boundaries of different acoustic impedance in the phantom. When the light illuminates the phantom, the echo pulses reflected at the boundaries shift owing to ultrasonic velocity change based on the local temperature rise. The round trip time τ of the echo pulse between boundaries and its time difference are denoted by τ and $\Delta\tau$, respectively. The velocity change Δv of the light absorption region is represented by

$$\Delta v = v\frac{\Delta\tau}{\tau}, \text{ where } v \text{ is the ultrasonic velocity.}$$

The process for constructing the optically assisted ultrasonic velocity-change image is shown in Fig.1. The waveform of every acoustic scan line was divided into appropriate sections with the width of transmitted pulse. The cross-correlation between the corresponding section of the waveform data stored before and after light illumination was calculated to obtain the time difference $\Delta\tau$ of the echo pulse shift induced by light illumination. The ultrasonic velocity-change image is constructed from $\Delta\tau$ and τ of every acoustic scan lines.

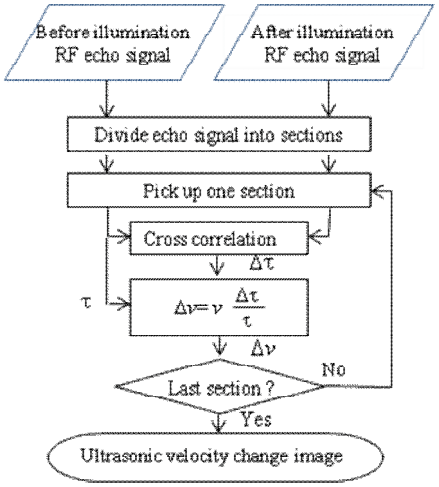

Fig 1. Process for constructing the optically assisted ultrasonic velocity-change image.

3. Imaging for tissue characterization using spectroscopic property

We have succeeded in obtaining the spectroscopic information of the Au-nano rods and the ICG contained in the chicken meat phantoms by the optically assisted ultrasonic velocity-change imaging method.[3]

We tried to emphasize the distribution area of objective material by subtracting the ultrasonic velocity-change image obtained with optical absorption wavelength of objective material from that with the different optical wavelength.

ICG has been known as the imaging agent for angiographic examination by using the near-infrared light. The agar colored by ICG was inserted into the chicken meat.

Fig.2 (a) shows the normal B-mode image of the phantom including ICG. Fig.2 (b) and (c) show the ultrasonic velocity-change images obtained under

E-mail address: horinaka@pe.osakafu-u.ac.jp

the light illumination(0.5W/cm^2) of 809nm and 913nm for 30s, respectively. The distribution area of ICG strongly absorbs the light of 809nm and weakly absorbs the light of 913nm, because the absorption spectrum of ICG used in the experiment locates around 800nm.

The ultrasonic velocity change of 0.22% is observed in the ICG distribution area in Fig. 2 (b). The ultrasonic velocity change observed in Fig. 2 (c) is lower than 0.13 %, which is thought to be caused by the biological material except for ICG in the chicken meat. Fig.2 (d) shows the image of ultrasonic velocity change beyond 0.10 %. to reduce speckle noise is reduced. Therefore, the ICG distribution area appears clearly in Fig.2 (d).

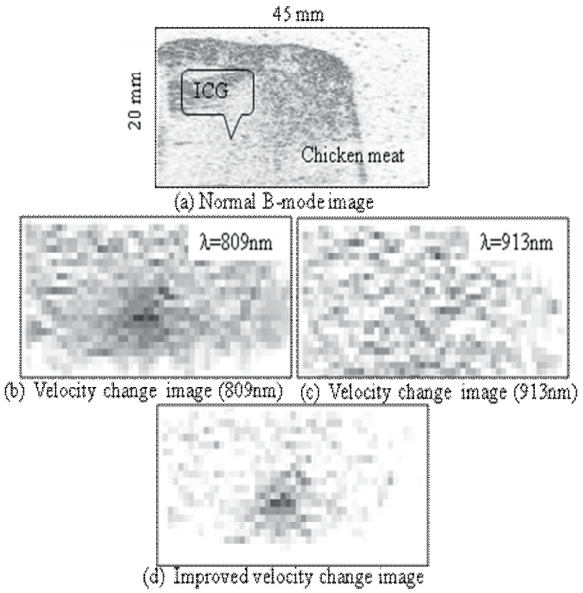

Fig. 2 Ultrasonic velocity-change images of chicken meat including ICG

4. Imaging for tissue characterization using ultrasonic velocity-change

It has been known that the ultrasonic velocity is different in each material. For example, the ultrasonic velocity in water 1483 m/s at 24°C and 1530 m/s at 37°C, and that in fat is 1476 m/s at 24°C and 1412 m/s at 37°C. The temperature change rate of the ultrasonic velocity in water is +2m/s degree and that in fat is -4m/s degree in body temperature. The ultrasonic velocity increases in muscle and internal organs with high percentage of water content and decreases in fat. It is thought that temperature dependence of ultrasonic velocity change is useful for the detection of the fat distribution in the living body.

The basic experiment for detection of the fat distribution was done by using the phantom made of chicken meat including the fat. Figure 3 (a) shows the normal B-mode image of the phantom. The fat distribution area is not indentified in the B-mode image. Figure 3 (b) shows the gray scale image of the ultrasonic velocity change obtained by light illumination (0.5W/cm^2) of the diode laser. The upper figure of Fig. 3 (b) shows the ultrasonic velocity profile across the line A-B. The ultrasonic velocity change Δv shows the negative sign in the fat region area.

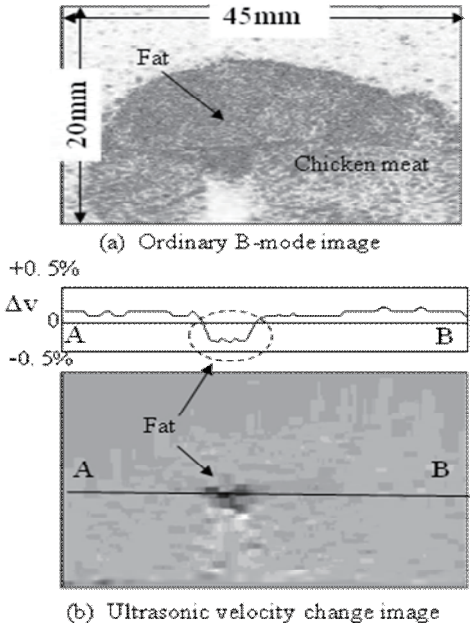

Fig. 3 Ultrasonic velocity-change images of chicken meat including fat

5. Conclusion

Two kind of methods using the spectroscopic information and the temperature dependence of ultrasonic velocity-change were investigated to indentify the distribution of objective material in biological tissue. Experimental results showed the possibility that the biological tissue could be characterized using the optically assisted ultrasonic velocity-change imaging method.

Acknowledgment

This research was partially supported by the Nakatani Foundation of Electronic Measuring Technology Advancement.

References

1. H. Horinaka, T. Matsunaka et al.:Jpn. J. Appl. Phys., **41** (2002) 3555
2. H. Horinaka, T. Matsunaka et al. : Electronics Letters, **43** (2007) 1254
3. H. Horinaka, T. Matsunaka et al. : Proc. 2006 IEEE Ultrasonic Symposium (2007) 2060