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Proceedings of Symposium on Ultrasonic Electronics, Vol. 34 (2013) pp. 493-494
20-22 November, 2013

A study on the reconstruction precision improvement of tomographic inspection of visceral fat area with abdominal automatic mechanical scanner

腹部自動メカニカルスキャナ装置を用いた内臓脂肪トモグラフィ検査画像の精度向上

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1. Introduction

Metabolic syndrome checkup is expected to serve as preventive medical care of adult deceases. To this end, ultrasound tomographic techniques have been studied for the abdominal visceral fat area measurement from a reconstructed sound speed image. The method is based on travel time measurements of sound waves transmitted through an abdominal medium. For automatization of system being available in clinical use, an open-air type abdominal body surface scanning machinery was developed, based on a facing pair transmitter and receiver mounted on the motor actuated stages [1, 2]. In the present system, high precision movement of facing transducers as well as good acoustic contact between a transducer and an abdominal body surface becomes important. To encounter the latter problem, konjak gel coupler was used. By this means, errors due to miscalculation of coupling condition in the travel time measurement were removed. To show the feasibility of an open air automated travel time measurement machinery, experimental examination for a phantom specimen was made.

2. Method

2.1 Structure of automated body scanner

As shown in Fig.1, a facing pair of transmitter (with frequency band 10-500 kHz and aperture diameter 40 mm) and receiver are mounted on the motor actuated stages. They are moved around the abdominal body surface according to the conventional translate and rotation scanning scheme. Specifically, a pair of transmitter/receiver is translated along the lateral direction over the aperture width W=560 mm, and rotated along the circular ring with radius R=360 mm. At each observation position, the facing transducers are

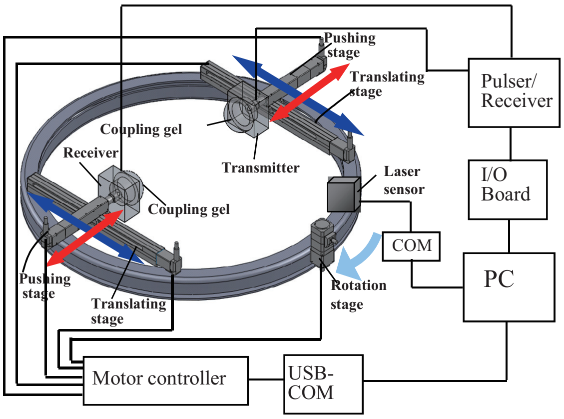

Fig.1 Body surface scanning machinery used in the experiment

pushed along to-and-fro direction to keep the close contact against a body surface. Konjak gel hemi-sphere couplers (diameter 80 mm, sound speed c_g= 1500 m/s) were attached in front of the transducers. The coupler plays a role to maintain the good contact between the transducer and the body surface, regardless of the contact angle between them. The transmitter was excited by applying an high amplitude impulse voltage. The receiver transducer was connected to the reciever amplifier. The amplified singnals were digitized and transferred to the computer. From the measured travel time data, cross sectional abdominal sound speed image can be reconstructed through the tomgraphic calculation.

2.2 Measurement procedure

Scanning of transducer around body surface and data collections are made as follows. First, contour of body surface is measured by a laser range sensor. Based on the information of body surface data and presumed backbone location, displacement values of each actuator are calculated. After the preparation procedure described above, facing transducers are moved to desired positions on the

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body surface and waves are collected for each propagation paths. In order to keep good contact between a body and a gel coupler, pushing distance was controlled by monitoring the amplitude of received wave.

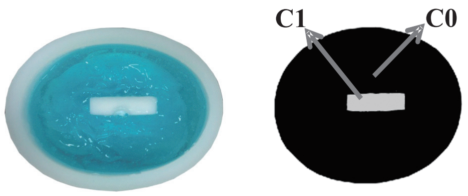

Fig.2 Abdominal phantom specimen: (a) photographic image, (b) sound speed indexed image.

Symbol	Material	Sound speed [m/s]	Mimicking target
c_0	Ultrasound gel	1500	Blackground
c_1	Polyethylene glycol+glicerin8%	1580	Muscle

Table.1 Setup sound speed of phantom specimen

3. Experimental examination

3.1 Phantom specimen

As shown in Fig.2, an abdominal mimicking phantom was prepared. A wall ultrasound abdominal phantom (OST: SB-001, 280x200 mm) was used as a container. Ultrasound gel was used to fill the container and polyethylene glycol objects were embedded with adjusted sound speed (Table.1).

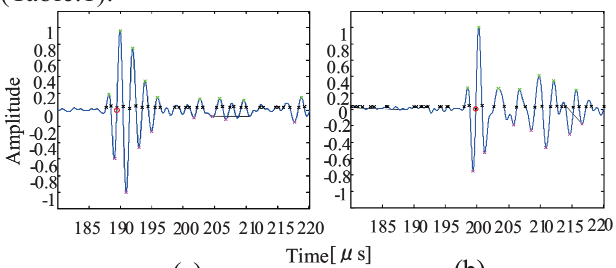

Fig.3 Examples of received wave: transmitted through (a) muscle mimicking object, (b) background region.

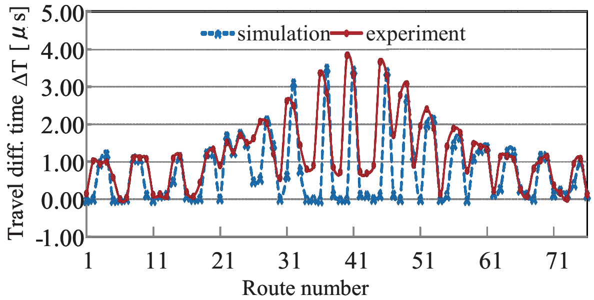

Fig.4 Comparison of travel time difference data between measured and simulated data along propagation paths.

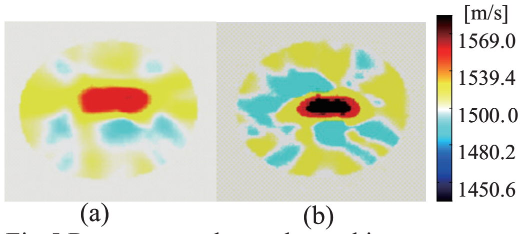

Fig.5 Reconstructed sound speed image:
(a) experimented image, (b)simulated image.

3.2 Travel time measurement

According to the procedures described in 2.2, sound wave propagation paths was determined and data were collected automatically along 76 propagation paths. Samples of received waveforms are as shown in Fig.3. Travel time was estimated from zero-cross point of leading part of a wave. Difference of travel time ΔT between measured and theoretical background medium was obtained. The results are summarized as shown in Fig.4 (red solid line). Simulated data obtained based on the straight ray propagation model were also shown (blue dot line). We can see that both results are in good agreement.

3.3 Sound speed image reconstruction

Using the measured data, the sound speed image was reconstructed as shown in Fig.5(a). In addition, the images using the simulation data as shown in Fig.5(b) were compared. We can confirm that the experimented result is close to the simulated one.

4. Conclusion

It was demonstrated that high precision travel time measurement and sound speed image reconstruction can be achieved by using developed automated body scanner machinery.

References

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