Two-Dimensional Vibration Scanning Method for Puncture Needle-Type Ultrasonography

Masasumi Yoshizawa\textsuperscript{1,}\textsuperscript{†}, Kouichi Karasawa\textsuperscript{1}, Mao Kurohane\textsuperscript{1}, Takasuke Irie\textsuperscript{2,3}, Kouichi Itoh\textsuperscript{4}, Tadashi Moriya\textsuperscript{5}, (\textsuperscript{1}Tokyo Metropolitan College of Industrial Technology, \textsuperscript{2}Tokyo Metropolitan Univ., \textsuperscript{3}Microsonic Co., Ltd., \textsuperscript{4}Hitachi-Omiya Saiseikai Hospital, \textsuperscript{5}Professor Emeritus of Tokyo Metropolitan Univ.)

1. Introduction

In order to establish tissue diagnosis by the endoscopic ultrasonography into, we have been developing puncture needle-type ultrasonography.\textsuperscript{1-4)} For realization of a low-cost, fast scanning rate, and high resolution system, we developed a vibration scanning method using an audio speaker and the equivalent-time sampling method. Previously, we demonstrated the performance of the vibration scanning method.\textsuperscript{4)} However, in that experiment, the vibration method was used for only one directional scanning, and an automatic stage was used for the two dimensional scanning. Use of the stage hinders to make real-time imaging possible.

In this experiment, we demonstrated a two-dimensional vibration scanning method using two audio speakers and confirmed the effectiveness of the method.

2. Principle

2.1 Puncture needle-type ultrasonography

Figure 1 shows the schematic of the equipment for the puncture needle-type ultrasonography. The measurement principle of the method was previously reported.\textsuperscript{1)}

Fig. 1. Basic concept for puncture needle-type ultrasonography.

2.1 Two-dimensional vibration scanning method

The principle of the scanning method is based on the movements of the end point of a lever.\textsuperscript{2,3}

yoshizawa@acp.metro-cit.ac.jp

Fig. 2. Schematic illustration of vibration scanning method.

(a) Two-dimensional scanning mechanism by speakers

(b) Driving voltages of speakers

Transmitted ultrasonic signals

Vertical Audio Speaker

Fulcrum

Transducer

Two-dimensional Scanning (spherical surface)

Thin rod sensor

Transmitting and receiving timing of signal

\begin{align*}
V_{\text{vertical}} & : I_1, I_2, I_3, \ldots, I_n \\
V_{\text{horizontal}} & : I_1, I_2, I_3, \ldots, I_n
\end{align*}

Time delay

\begin{align*}
\text{Time} & : t_1, t_2, t_3, \ldots, t_n
\end{align*}

Fig. 2. Schematic illustration of vibration scanning method.
obtained. If the voltage of those signals is changed, the imaged circle is changed, and then the spherical image is obtained, as shown in Fig. 2 (a).

3. Experiment

![Schematic diagram of experiment.](image1)

**Fig. 3. Schematic diagram of experiment.**

![Joint and fulcrum mechanism.](image2)

**Fig. 4. Joint and fulcrum mechanism.**

![Overview of the prototype vibration scanning mechanism.](image3)

**Fig. 5. Overview of the prototype vibration scanning mechanism.**

Figure 3 shows the schematic diagram of the experiment. In this experiment, a fused quartz rod with a diameter of 1.2 mm and length of 75 mm was inserted into an aluminum holder with a diameter of 2.6 mm and length of 73 mm. The top side of the holder was connected to a speaker, as shown in Fig. 3. Sinusoidal waves having amplitudes of 2.5, 3.0, and 3.5 Vpp with a center frequency of 10 Hz was applied to the speakers. The phases of the sinusoidal waves differ by 90 degree each other. Figure 4 shows the mechanisms of the joint and the fulcrum. The joint was fixed to those speakers by aluminum pipes with a diameter of 2.6 mm, and the fulcrum was fixed to a base, as shown in Fig. 5.

4. Results and discussion

![Motion amplitude vs. applied voltage to speakers.](image4)

**Fig. 6. Motion amplitude vs. applied voltage to speakers.**

![Photographs of end motion (1/60 sec/frame).](image5)

**Fig. 7. Photographs of end motion (1/60 sec/frame).**

Figure 6 shows the amplitude of the motion as a function of the applied voltage to those speakers. This result shows that the effectiveness of the method. Figure 7 shows an example of the end motion when those speakers drove the sinusoidal wave having amplitudes of 3.5 Vpp. From this Figs, because of the joint was fixed to those speakers, the circle of the motion was seemed a little distorted. It is need to improve of the joint mechanism for accurate circle motion.

5. Conclusion

We demonstrated the two-dimensional vibration scanning method using the audio speakers. We confirmed experimentally that the effectiveness of the scanning method.

References