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Basic Study of Ultrasonic Positioning Sensor for Sensor Network Assuming Actual Model
センサネットワーク用超音波位置センサの実モデルを想定した基礎研究

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1. Introduction

A new concept called "sensor network" has been proposed recently by combining sensor technologies with wireless communication medium. In this network, a lot of sensors distributed in a certain area such as home, office and public place are connected via rather simple private radio communications means. It is also thought to contribute to future energy saving, environmental preservation and health/nursing care. In this paper, we studied a novel ultrasonic positioning technique for sensor network. We assumed such actual model as living and care environments.

2. Fundamental procedure of proposed Method

Power consumption is the most important characteristics for sensor network. Our propose method can achieve low-power consumption compared with the conventional pulse-echo method.

(1) Sensor nodes alternately transmit and receive continuous ultrasonic waves (CUWs), whose frequencies are determined by IFFT.
(2) Relative amplitudes and phases between the received CUWs and the transmitted CUWs from a certain sensor node are measured in other sensor nodes. They send these data to the center node.
(3) Finally impulse responses which include distance information among the sensor nodes via reflected objects can be obtained using IFFT in the center node.
(4) Accurate distance measurement can be achieved without increasing power consumption, because the center node operates by another power supply.

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3. Fundamental experiment to measured distance

The transmitter and receiver are arranged in a straight line with distance of 50 [cm] as shown in **Fig.1**. Relative amplitudes and phases between the transmitted and received CUW at frequencies around 40[kHz] are sent to PC, where IFFT is conducted using gathered data. Impulse response characteristics calculated by IFFT are shown in **Fig.2**. The measured length of 49.64[cm] between the transmitter and receiver can be achieved, which is very near to the distance between them.

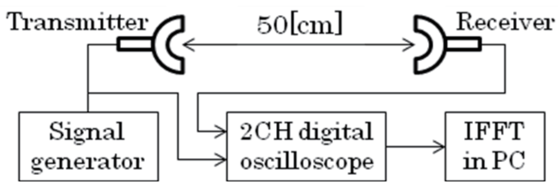

Fig.1 Experimental set-up with transmitter and receiver.

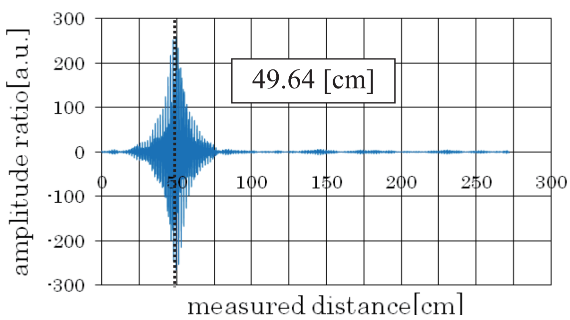

Fig.2 Results of IFFT. (The transmiter and the receiver are apart by 50[cm].)

4. Experiment based on actual model

4.1 Experimental set-up

We conducted experiment arranging two reflecting objects as shown in **Fig.3**. One object marked with "a" has a round-trip distance of 200[cm] between the transmitter and the receiver, the other marked with "b" has that of 300[cm]. Assuming actual model such as home and office, we also arranged a wall with a round-trip distance of 340[cm].

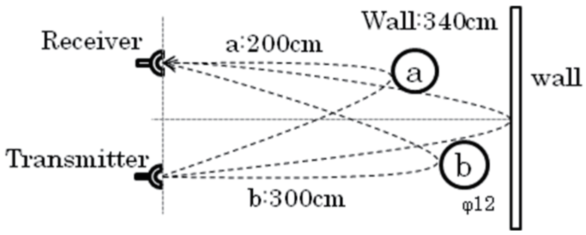

Fig.3 Arranged two objects and a wall

4.2 Distance measurement using Fig.2's condition

First we measured distance using same procedure as used in sec.3's fundamental experiment. Measured characteristics, i.e. the results of IFFT, are shown in **Fig.4**. The object, a, is measured by 199[cm], which is almost same as actual distance. However, unknown responses at 22[cm] and 68[cm] are also observed in Fig.4. In this experiment, we used resolution frequency of Δf =0.125[kHz], which corresponds to the maximum measureable length of L=272[cm]. Because the repetition period, T, in IFFT is given T=$1/\Delta f$, and T provides the maximum length L=T ×V=272[cm], where V(sound velocity)=340[m/s]. The object, b, and the wall are far apart from the distance of 272[cm]. Therefore, due to the folding effect of FFT, the unknown responses are generated. The relations of 22+272=294[cm] and 68+272=300[cm] also illustrate the results.

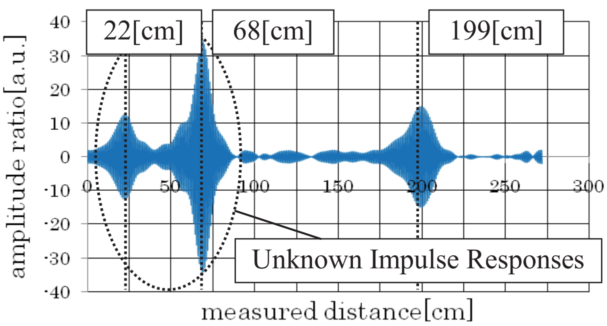

Fig.4 Results of IFFT. (Some procedure as used in Sec.3's fundamenral experiment.)

4.3 Folding-effect improved measurement

From Fig.4's results, in order to eliminate unknown responses, i.e. folding effect of IFFT, we must increase the repetition period, T, in IFFT. In the Improved experiment, we set Δf to be 0.0625[kHz], which corresponds to the T value twice larger than that used in the previous experiment. So, the maximum measurable length L=544[cm] was also achieved. Measured characteristics are shown in **Fig.5**. In this case, the objects, a and b, and the wall are clearly measured.

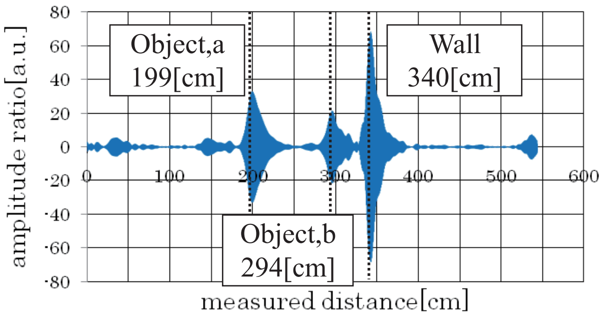

Fig.5 Results of IFFT. (Improved measurement with maximum distance of 544[cm].)

5. Conclusion

We proved the validity of our proposed new ultrasonic measurement method by the fundamental experiment. This method was applied to the model with two objects and a wall. From the experimental results, we obtained the possibility to adapt this method to monitor living and care environments.

Reference

1. T.Watanabe, M.Hikita: proc of symp. on Ultrasonic Electronics, vol.30, 2009, pp.225-226.