Visualization of Focal Point of Airborne Ultrasound with Temperature Sensitive Sheet

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Abstract. The spatial distribution of airborne ultrasound is often observed by scanning microphones and time consuming. Visualization of spatial distribution by optical methods has also been attempted, however requires the installation of special optic equipment. In this paper, we propose a simple visualization method using a temperature sensitive sheet for high-intensity airborne ultrasound.

Keywords: ultrasonic mid-air haptics, visualization, thermoacoustics

1 Introduction

Development of applications for high-intensity airborne ultrasound is underway. As a result of the development of ultrasonic phased arrays such as used for mid-air haptics [1], it is expected that high-intensity ultrasound will become more familiar and the application fields where the nonlinear phenomena will be utilized will expand.

The spatial distribution of airborne ultrasound is often observed by scanning a microphone with an XY-stage or a robot arm. This method has the disadvantage of being time consuming. As alternative observation methods, the spatial distribution of the refractive index [2-4] or thermoacoustic effect [5] has been attempted to be measured by optical methods. Although these methods provide visualization as images, they require the installation of special equipment such as optical setups or a thermography camera.

In this paper, we propose a simple visualization method using a temperature sensitive sheet for high-intensity airborne ultrasound. The proposed method is demonstrated to observe the focal point generated by a high-intensity ultrasonic phased array [6].

2 Experiments and Results

We used a temperature sensitive sheet to visualize the spatial distribution of high-intensity ultrasound, instead of a pair of a mesh screen and a thermography camera used in [5]. This sheet contains chromatic liquid crystal ink and changes its color with temperature change. We generated a focal point with a high-intensity ultrasonic phased array [6]. The peak value of sound pressure level at the center of the focal point and the distance of 95 mm was 170 dB when the focal length was set to 100 mm. The focal point was observed as color change on the temperature sensitive sheet (see Fig. 1).

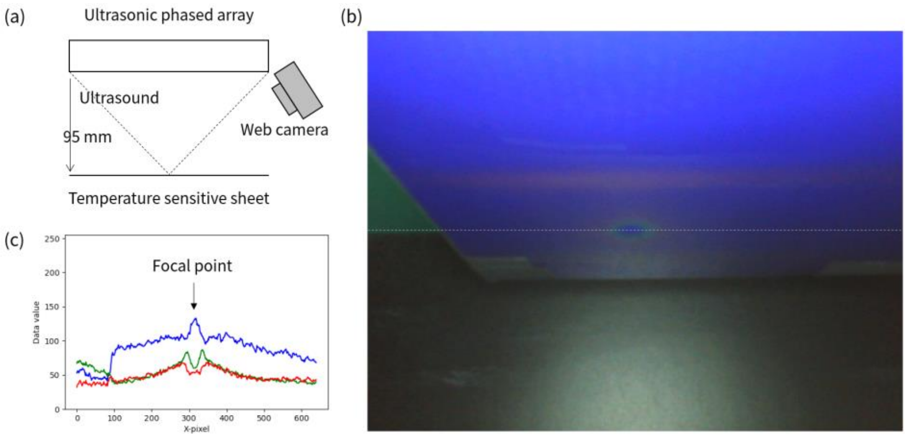

Fig. 1. Experiment of visualization of the focal point with a temperature sensitive sheet. The color changes in a few seconds after the ultrasound is applied. (a) Experimental setup. The temperature sensitive sheet was observed with a web camera (640×480 pixel). (b) Image taken by the web camera (upside down). (c) RGB values along the cross-section shown as the white dotted line in (b).

Next, we changed the intensity of ultrasound. As a result, the minimum detection threshold as color change was about 160 dB at the center of the focal point.

The future work of this study contains the followings. We will confirm the reproductivity of this effect under various environmental conditions and how to stabilize it. Next, we will try to estimate the sound pressure at the focal point from the color change. Note that, even at this stage, we can use this method to quickly check the position of the ultrasonic focal point, just like an IR sensor card used in laser optics.

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