Audio-Haptic Rendering of Water Being Poured from Sake Bottle

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Abstract. The impression of food can be affected by “rendition”—i.e., the surrounding environment such as the appearance of the food and the dish—not just by its taste. We focused on the sound and vibration of liquid being poured from a Japanese Sake bottle as a haptic rendition of liquid. Sake bottles are known for their unique “glug” sound and vibration which we believe affects the subjective impression of the liquid in the bottle. To examine this idea, we propose a method that reproduces the vibration of pouring liquid from a Japanese Sake bottle by measuring and modeling real vibrations. We measured the vibration of water by tilting a Sake bottle at different angles, and created a model consisting of two decaying sinusoidal waves of different frequencies. To verify the appropriateness of the model, we manufactured two types of devices and presented the modeled vibration characteristics.

Keywords: haptic rendering, pouring water, tactile display, tang

1 Introduction

Several studies have suggested that the impression of food can be affected by “rendition”, i.e., the surrounding environment such as the appearance of the food and the dish, not just by its taste [1]. While most renditions are limited to visual effects, we focused on the aural and haptic rendition of the eating environment. Some studies have reported on the audio-haptic effects during biting or drinking [2] [3], but we speculate that we first encounter food with our hands and that audio-haptic rendition is a tangible phenomenon.

In this study, we focused on the sound and vibration of liquid being poured from a Japanese Sake bottle as a haptic rendition of liquid. Sake bottles are known for their unique “glug” sound and vibration. We believe that these sounds and vibrations affect the subjective impression of the liquid in the bottle. To examine this idea, we propose a method that reproduces the vibration of pouring liquid from a Japanese Sake bottle by measuring and modeling real vibrations.

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2 Method

One of the ways to reproduce vibro-tactile sensation is to create a model by measuring a vibration and reproducing it. Okamura et al. created a vibration model that uses a decaying sinusoidal wave to reproduce the vibro-tactile sensation of tapping an object by measuring the real vibration and modifying reality-based vibration parameters through a series of perceptual experiments [4]. We extended this method to reproduce the vibration of pouring water.

3 Measuring and Modeling the vibration of water being poured

We surmised that the vibration of water being poured is a function of tilt angle of the Sake bottle. Fig. 1 shows the measured vibration of a pouring-water bottle with a tilt angle of 180° (i.e. the bottle was upside down). We took a single group of waves from the measured data, which resembled a decaying wave, and observed the spectrum of the wave using the Fast Fourier Transform (FFT) (Fig. 2 (Left)).

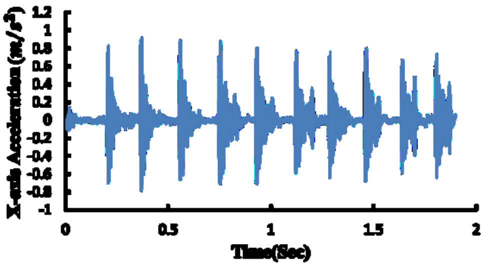

Fig. 1. Vibration of a bottle pouring water (Bottle angle 180°)

We found two peaks in the frequency spectrum. The higher peak was around 250Hz, which we speculated was caused by Helmholtz resonance [5]. The lower peak was around 20 - 40 Hz, which we presumed was caused by water surface fluctuation. Interestingly, while both frequency peaks can be perceived aurally, both can also be perceived by two types of mechanoreceptors in the skin (the Pacinian corpuscle senses the higher peak, and Meissner corpuscle the lower peak) [6], which implies that these peaks not only aurally but also haptically characterize the pouring water experience.

We reproduced the wave in the following model consisting of two decaying sinusoidal waves of different frequencies:

$$\mathrm{Q(t)} = \sum_{n=1}^{2} A_n \exp(-B_{nt}) \sin(2\pi f_n t) \qquad (1)$$

Here, A_1 and A_2 are the wave amplitudes, B_1 and B_2 are the attenuation coefficients, f_1 and f_2 are the frequencies of the sinusoidal waves, and t is time. Parameters were found using the least-squares method to fit the measurement result. The modeled waveform is also shown in Fig. 2 (Right).

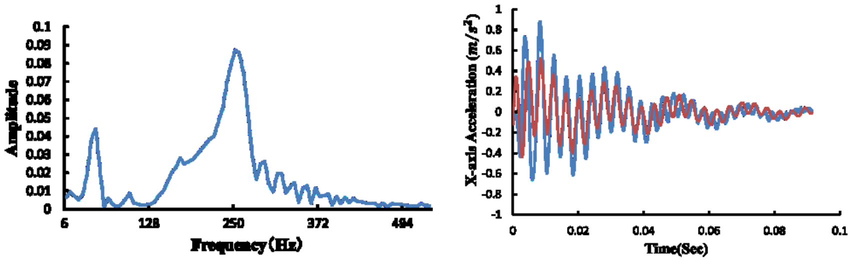

Fig. 2. (Left) Spectrum density of a single wave at 180°,
(Right) Red: Original single wave. Blue: Modeled wave.

4 Reproducing vibration on the haptic device

4.1 A Sake bottle type device

To verify the appropriateness of the created model, we manufactured a Sake bottle shaped device with a vibro-tactile actuator (Haptuator Mark Ⅱ, Tactile Labs Inc.) and present the modeled vibration in Fig. 3. We demonstrated our device at some domestic conferences and obtained quite positive reactions.

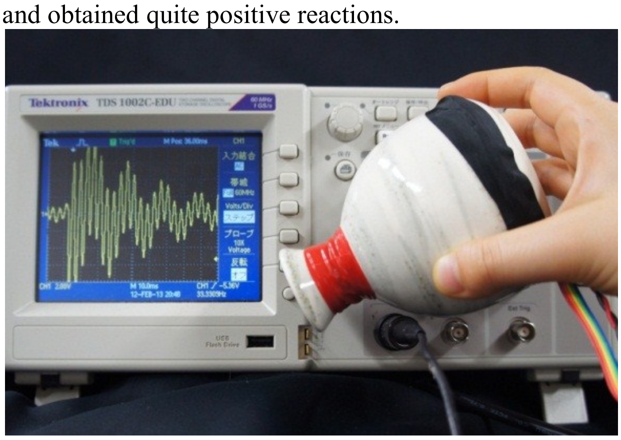

Fig. 3. Sake-bottle-shaped device with a vibro-tactile actuator

4.2 An attachment type device

Our model can also be used to alter the impression of real liquid being poured from various containers. To achieve this goal, we manufactured device which can be attached to the neck of any plastic bottle, as shown Fig. 4. The same algorithm as a sake bottle type device was employed to overwrite the impression, so that users felt as if they were really pouring from a sake bottle.

Fig. 4. The device attached to a plastic bottle

5 Conclusions

We proposed a method that reproduces the vibration of pouring liquid from a Japanese Sake bottle by measuring and modeling real vibrations. We measured the vibration of water by tilting a Sake bottle at different angles, and created a model consisting of two decaying sinusoidal waves of different frequencies. To verify the appropriateness of the model, we manufactured Sake bottle type devices and generated the modeled vibration. We also manufactured an attached device to alter the impression of real liquid being poured from various containers.

Our future work will include a more realistic rendering of pouring liquid, by monitoring and reflecting the remaining amount of water, which will cause a gradually diminishing effect. We will also add a multimodal cue such as a tabletop display to enhance the realism. Participants incline the bottle, feel the liquid aurally and haptically, and then, a few seconds later, visually observe the poured water on the table.

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