ViVi-EAT: Augmentation of Food-flowing Sensation using Tactile Feedback

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ABSTRACT

Eating is a form of entertainment in which we enjoy each food through its texture, taste, flavor, appearance and the sound it makes when eaten. However, these sensations are momentary; i.e., we cannot feel the food once it is swallowed. We focus on the sensation of foods flowing down through the body (i.e., the food-flowing sensation) and present ViVi-EAT, a device that provides a simulated food-flowing sensation to the esophagus and stomach. The flowing sensations we provide are the sensation of foods flowing down through the throat and moving within the stomach according to body movements. By providing these sensations, we attempt to enhance the entertainment of eating even after food is swallowed.

Keywords

Entertainment of eating, Food-flowing sensation, Swallowing, Tactile interface, Virtual reality

1. INTRODUCTION

Eating is one of our most basic desires, but it is also a form of entertainment. We enjoy the differences of each food in terms of its texture, taste, flavor, appearance and sound it makes when eaten. However, these sensations are momentary; i.e., we cannot feel the food once it is swallowed.

To make the eating process entertaining even after food is swallowed, we focused on the sensation of food flowing through the body (i.e., the food-flowing sensation). This sensation is normally felt in the throat and is occasionally used to evaluate the quality of food. Thus, this flowing sensation is one of the important factors that make the eating experience entertaining. We expect that expanding the food-flowing sensation to body parts other than the throat will add an entertaining element to the after-swallowing process.

In this paper, we introduce ViVi-EAT, a device that provides a simulated food-flowing sensation to the esophagus and stomach. The flowing sensations we provide are the sensation of foods going down the throat and moving within the stomach according to body movements. By providing these sensations, we attempt to allow a more full-body enjoyment of eating.

2. RELATED WORK

Many studies have focused on expanding the entertaining element of eating by adding an interaction during the eating experience. Mori et al. [1] developed a system that changes the visual appearance of foods and dishes on a table to change the eating environment. Lo et al. [2] presented a tray that changes visual content according to the amount of the meal consumed. These studies focused on visual effects during a meal. In contrast, Kadomura et al. [3] developed a fork-type device that enabled users to play various sounds by eating food. Koizumi et al. [4] augmented food texture by altering the chewing sound.

Although there have been many studies on the eating experience, most have focused on the eating environment or mouth movement. We propose a device that provides a flowing sensation of food to body parts that normally do not sense food, and thus enhance the entertainment of eating even after food is swallowed.

3. DEMONSTRATION

The demonstration scenario of the ViVi-EAT system is shown below. There are two versions of this system, one for consuming water and the other for consuming chips.

(1) The user wears a jacket-type device, throat sensor and headphones, and consumes water or chips (hereafter referred to as food in either case) (Fig. 1).

Fig. 1. The user consumes water or chips.

(2) After the user swallows the food, the jacket starts vibrating and provides a sensation of food passing down from the esophagus to the stomach (Fig. 2).

Fig. 2. The jacket provides a food-flowing sensation.

(3) The food is displayed on a monitor in front of the user, and a flowing sound is output from the headphones (Fig. 3).

Fig. 3. The food is displayed on a PC monitor.

(4) Once the food reaches the stomach, it moves within the stomach according to the user's movements (e.g., a jump or sideways lean) (Fig. 4).

Fig. 4. The food moves according to the user's movements.

(5) For the chips version of the device, the user experiences a sensation of food clogging the esophagus (Fig. 5). The blockage can be dislodged with a blow to the back by a third person, after which the food will start flowing downward again.

Fig. 5. The user experiences a chocking sensation for the chips version.

(6) After the user sets the time forward by rotating a clock, the food is digested and passes out of the stomach (Fig. 6).

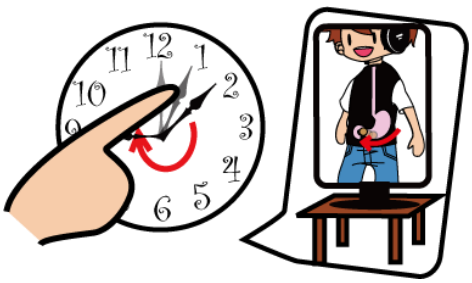

Fig. 6. The food would digest by rotating a clock.

4. SYSTEM CONFIGURATION

ViVi-EAT consists of a jacket-type device, a throat sensor, and a video and sound output system (Fig. 7). Fig. 8 shows the system configuration. The user's swallowing motion is detected with the throat sensor, which is placed on the user's throat. After the swallowing motion is detected, the speakers embedded in the jacket are activated and provide the sensation of food flowing through the body. At the same time, the animation from the video output system shows the food movement and a flowing sound is provided by the headphones. The food moves within the stomach according to the user's movements, which are detected with an accelerometer embedded in the jacket.

Fig. 7. Overview of ViVi-EAT

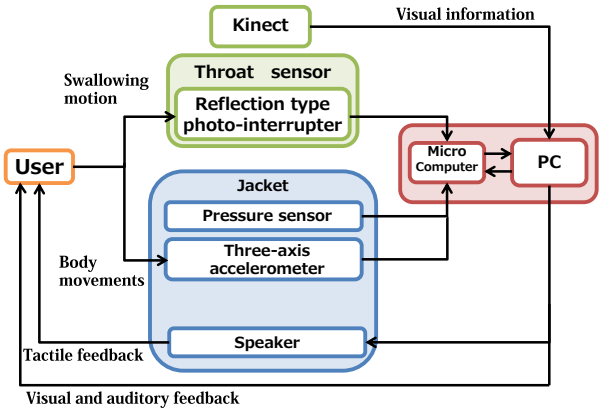

Fig. 8. System configuration

4.1 Throat Sensor

The swallowing motion is detected with the throat sensor (Fig. 9). The sensor consists of two reflection-type photo-interrupters (TRF-105, GENIXTEK CORP.) that measure the distance between the sensor and the user's throat. The throat moves up and down when a person swallows food; hence, the distance between the sensor and the user's throat changes.

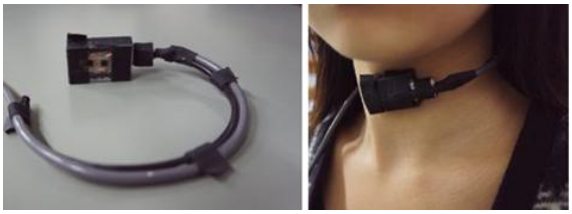

Fig. 9. Throat sensor

4.2 Jacket

The food-flowing sensation is provided by the jacket (Fig. 10). Speakers, an accelerometer and a pressure sensor are embedded in the jacket.

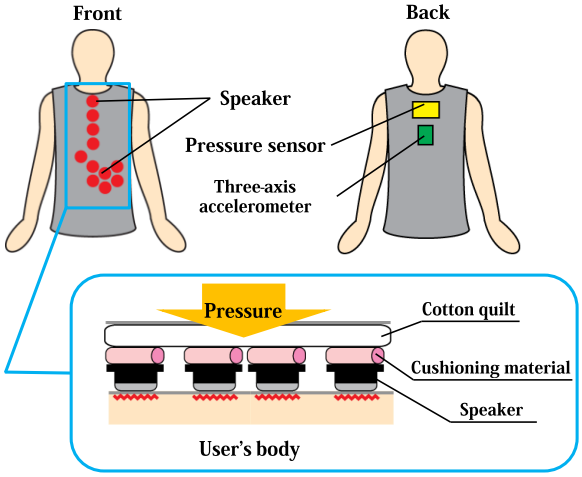

Fig. 10. Jacket

4.2.1 Speakers

There are 11 speakers (NSW1-205-8A, AURASOUND) embedded in the jacket. By activating each speaker sequentially, an apparent tactical motion [5][6] is elicited, providing the food-flowing sensation.

A sinusoidal wave is output from the speakers. The frequency, duration of stimulation and stimulus onset asynchrony of the output waveform are set for each consumable (i.e., water or chips) (Fig. 11). By altering these parameters, we create a different food texture. In a pilot study, we discovered that a high-frequency waveform (e.g., 150 Hz) provides a smooth fluid-flowing sensation. In contrast, a low-frequency waveform (e.g., 20 Hz) provides a weighty solid-flowing sensation.

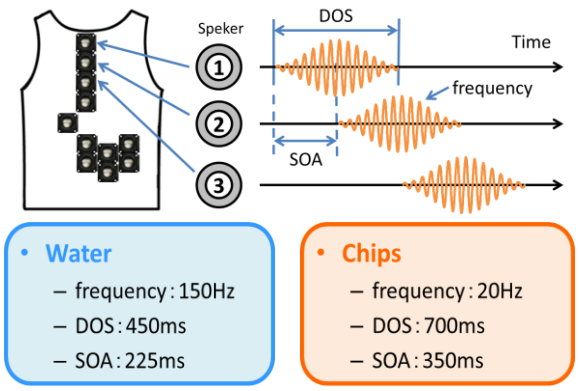

Fig. 11. Output waveform

The activated speaker is changed according to the user's movements (e.g., a jump or sideways lean) and provides the sensation of food moving within the stomach.

For the choking experience, one speaker continues to vibrate and provides the unpleasant sensation of food clogging the esophagus.

To provide the illusion that the speaker's vibratory stimulation is the food-flowing sensation coming from inside the body, all speakers must adhere to the body. We achieved this by stuffing the jacket with cushioning material and tightening the jacket with a belt while it is worn.

Additionally, stuffing the jacket with cushioning material made it more difficult to detect vibratory stimulation from outside the jacket. As a result, the user has the illusion that the surface of the jacket is part of the body and the vibratory stimulation from the speaker is coming from inside the body.

4.2.2 Accelerometer and Pressure Sensor

An accelerometer and pressure sensor are embedded in the back of the jacket. A three-axis accelerometer (KXM52-1050, Akizuki Denshi Tsusho Co. Ltd.) is used to detect the user's movements such as jumping or sideways leaning. A pressure sensor (FSR400, Interlink Electronics Inc.) is used to detect the back blow for relieving the choking experience.

4.3 Video and Sound Output

The video output system uses a Kinect device (Microsoft Corp., Redmond.) to receive video images and skeletal structure information. We used the skeletal tracking technique to place the three-dimensional models of the organs and food over the user's body (Fig. 12).

Fig. 12. Output video image. Water (left) and chips (right).

A food-flowing sound is output by the headphones according to the food's movement. We created different sounds for each food and each action (e.g., food going down the esophagus, choking, jumping, and leaning sideways).

5. CONCLUSION

We proposed ViVi-EAT, a device that provides a food-flowing sensation inside the body that cannot be perceived normally, to enhance the entertainment of eating even after food is swallowed. We participated in the 20th International Collegiate Virtual Reality Contest and received second place competing with more than 90 teams (Fig. 13). More than 2000 people tried our device and provided a great deal of feedback.

Several participants said that the experience was weird because it felt as if the food was actually moving inside their bodies. Although they felt weird, most participants laughed and enjoyed the experience. Additionally, they were able to tell the difference between consuming water and chips.

Fig. 13 Demonstration at the International Collegiate Virtual Reality Contest.

Although the purpose of this project was to enhance the entertainment of eating, we established a method with which to provide a sensation of movement inside the body that could be used for other applications such as video games. For example, there are several first-person shooter products that feed back the sensation of the impact from a bullet [7]. Using our method, the sensation could be applied more flexibly. Our method is also applicable to dietary education and rehabilitation for dysphagia, and we would like to test how our device affects the appetite in the near future.

REFERENCES

[1] Mori, M., Kurihara, K., Tsukada, K., and Siio, I. 2009. Dining presenter: augmented reality system for a dining table, In *Supplemental Proceedings of Ubicomp*.

[2] Lo, J.-L., Lin, T.-Y., Chu, H.-H., Chou, H.-C., Chen, J.-H., Hsu, J. Y.-J., and Huang, P. 2007. Playful Tray: Adopting Ubicomp and Persuasive Techniques into Play-based Occupational Therapy for Reducing Poor Eating Behavior in Young Children, In *Proceedings of Ubicomp*, pp. 38-55.

[3] Kadomura, A., Nakamori, R., Tsukada, K., and Siio, I. 2011. EaTheremin. In *Proceedings of the SIGGRAPH Asia*.

[4] Koizumi, N., Tanaka, H., Uema, Y., and Inami, M. 2011. Chewing Jockey: Augmented Food Texture by using sound based on the cross-modal effect, In *Proceeding of the ACE*.

[5] Kirman, J. H. 1974. Tactile apparent movement: The effects of interstimulus onset interval and stimulus duration. *Perception and Psychophysics* 15, 1–6.

[6] Sherrick, C. E. and Rogers, R. 1966. Apparent haptic movement, *Perception and Psychophysics* 1, 175–180.

[7] TN Games: 3rd Space, http://www.tngames.com/