Head-to-Head

Vibration Imaging on Facial Surfaces During Phonation

Sound from speech is radiated not only from the mouth and nostril openings but also from the surfaces of the head and neck.

Japanese scientists are therefore able to use vibrometers to study speech by measuring vibrations caused by phonation, taking advantage of their ability to analyze vibration for a particular frequency band of interest.

Getting Set

The vibration patterns of head and neck surfaces, and their contribution to the overall sound, has been inadequately studied until now. A male (22 years of age) with no speech disorder participated in these laser vibrometry measurements, intended to image vibration patterns that are generated by speaking.

The vibration velocity was obtained with a scanning laser Doppler vibrometer system (Polytec PSV-400-M4). The laser Doppler vibrometer is an optical transducer that senses the frequency shift of light reflected from a vibrating surface caused by the Doppler effect. It can determine the vibration velocity and displacement at a certain point. The scanning vibrometer can also scan and probe multiple points of a vibrating surface automatically.

Fig. 1 shows the experimental setup. The scanning head of the vibrometer was mounted on a tripod, perpendicular to the floor. The participant was positioned to lie directly beneath the scanning head.

The participant was asked to articulate utterances repeatedly while keeping his head immobile during the measurements. Speech sounds were recorded through a microphone.

The vibration patterns of the facial surface were measured from the frontal direction, which is perpendicular to the forehead, and from an oblique direction, which is nearly perpendicular to the left cheek and the left side of the nose.

In the experiment, scanning points on the facial surface were first determined using system control software. During the measurement, the vibrometer scanned each point and determined the vibration velocity. It took approximately one second to probe each point. The vibration velocity and speech sounds were measured up to 5 kHz.

Results

The two upper images in fig. 2 show the vibration patterns of the frontal facial surface during sustained phonations.

There were significant differences between the vibration velocity patterns for the vowel (left) and nasal (right) consonant. For the vowel, the facial surface around the mouth opening vibrated the most compared to the other regions. In contrast, for the nasal consonant, the facial surfaces of the nose and its vicinity vibrated strongly owing to resonances in the nasal sinuses. The forehead surface also vibrated to some extent, possibly indicating that the frontal sinuses resonated during the production of the nasal consonant.

The two lower images in fig. 2 show the vibration velocity patterns of the left facial surface for the phonemes. The vibration of the side of the nose was observed to be stronger for both phonemes than that indicated in the upper images of fig. 2. This means that the direction of the laser light is a significant factor in this measurement method. The result also revealed that, for the participant in the present study, the nose surface vibrated even when the vowel, not only just the nasal consonant, was articulated.

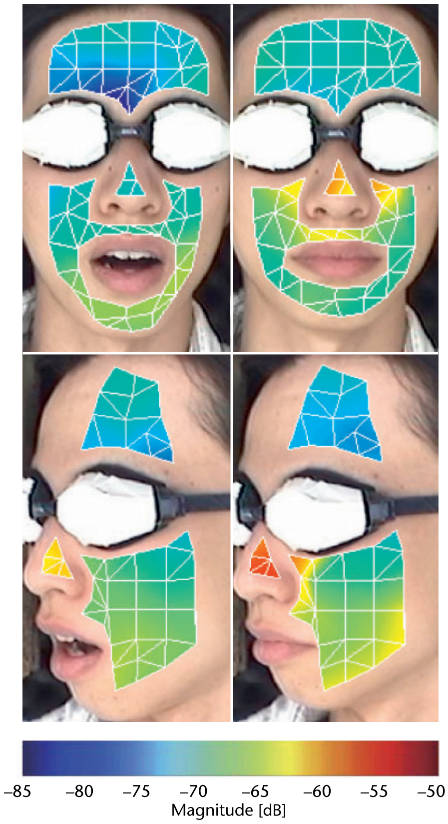

Fig. 2: Vibration velocity patterns of frontal and left facial surface during articulation of vowel (left) and nasal (right) consonant. The unit is m/s [dB] and 0 dB is equal to 1 m/s.

How Can It Be Used?

The proposed method enables us to evaluate the speech of patients with cleft palate or velopharyngeal insufficiency. The vibration pattern may be helpful as visual feedback of a speaking exercise for such patients. The vibration pattern may be easier to relate to their somesthesis than spectra of their speech sounds. This could also be useful for singing exercises.

In conclusion, the proposed method allows fast, non-contact and multi-point measurements of the vibration velocity of skin surfaces. The results will expand our knowledge of speech production. The next step that needs to be taken is to investigate the relationship between the vibration velocity pattern of skin surfaces and the formants and antiformants of speech sounds.

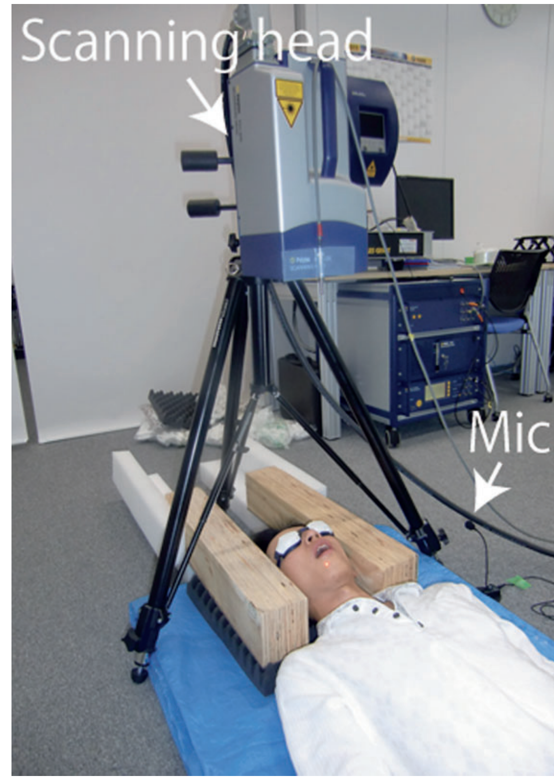

Fig. 1: Experimental setup.

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This article is based on the publication "Measurement of vibration velocity pattern of facial surface during phonation using scanning vibrometer" which can be found at **www.jstage.jst.go.jp/article/ast/33/2/33_2_126/_pdf.**

Acknowledgments
This study was supported by JSPS KAKENHI (21300071). The author wishes to thank Dr. Kazuhito Ito (National Institute of Advanced Industrial Science and Technology), Mr. Francois Bouteille, Mr. Ryo Ishiyama, Ms. Shoko Wakatsuki (Polytec Japan), and Professor Ken-ichi Sakakibara (Health Sciences University of Hokkaido) for their generous assistance and valuable advice.