Interactive Approach to AI-Based Source Separation of Vibrotactile Signals for Haptic Transmission*

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I. Introduction

There has been growing interest in the use of vibrotactile signals, in addition to the usual videoconferencing system, to remotely transmit sports and other skills. As vibrotactile signals are felt differently by individuals, can focus on different parts, and may contain unwanted noise, it is necessary to convey them effectively by separating the signals appropriately. However, it is difficult to express individual feelings through vibrotactile signals and communicate them to others. Thus, the sender of a vibrotactile signal must communicate which component of the signal they want the receiver to focus on when interacting with the system. Here, we propose an AI-based signal extraction system with a dedicated interface that allows senders to make decisions about which parts to focus on and remove while the vibrotactile sensation is replayed in real-time.

II. Methodology

Our method consists of two parts: (a) decomposition of the input waveform by a signal extraction AI, and (b) a decision-making process in which the human interacts with the system to decide which components to emphasize or attenuate, based on the human's experiences with the decomposed waveforms. For (a), we use blind source separation based on this method [1] owing to its resistance to noise and white box features. This allows decomposition of the waveform into independent components that constitute vibrotactile sensation, thus decomposing noise from unexpected body movements and other sources. For (b), the input signal is decomposed into multiple components, and the signal strength is adjusted for each component, thus deforming the signal to match the sender's intent. Unlike heuristic methods, the strength and weakness can be adjusted while playing back the waveform in real-time, enabling flexibility when responding to various waveforms.

III. Results

As shown in Fig. 1, the impact and body motion components of hitting a ball into the sky with a ping-pong racket are decomposed; only the impact component is emphasized. Multiple waveforms after decomposition using BSSR are shown on the left. The waveform intensity was adjusted by moving the slide bar to experience the intensity in real-time. The right side shows how the waveforms changed. By replaying these waveforms, a person could repeatedly modify them while experiencing whether the intended part was emphasized or not.

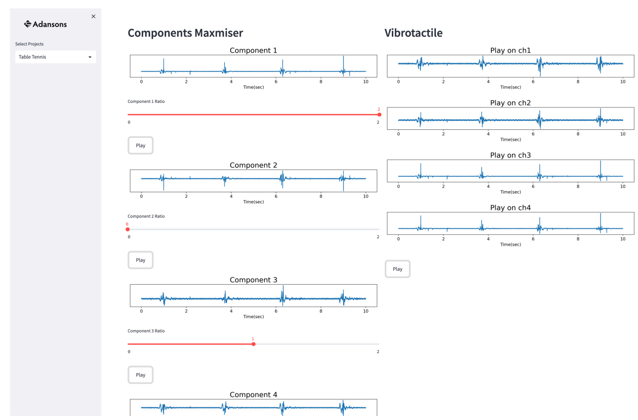

Fig. 1. Removing the body motion component in table tennis.

IV. Conclusion

We proposed an AI-based system to adjust the intensities of vibrotactile signals while experiencing them in real-time. The system consists of a part that decomposes the vibrotactile signal into its components using AI and an interface that adjusts the decomposed waveforms, and a web application version is currently available.

V. Future Work

This system is expected to be used for noise reduction with unexpected inputs mixed in during signal transmission.In addition, although currently only web applications are available, support for other platforms will be added in the future to enable a wider range of uses. Currently, there are still issues with processing speed and accuracy of presentation from AI to humans.

References

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