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Semantic Full-Body Haptic Effects for Virtual Reality First-Person-Shooter Games

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***Abstract*—We present a multisensory virtual reality (VR) system that delivers synchronized visual, audio, and full-body haptic feedback via sound-based event classification and conversion. The system utilizes a Long-Short-Term Memory (LSTM) model to classify game sounds and detect key events such as gunfire, explosions, and hits. These events are translated into full-body haptic patterns through a haptic suit, providing users with realistic and immersive haptic experiences.**

***Index Terms*—sound-haptic conversion, automatic generation, haptic suit, full body, game, user experience**

I. Introduction

Imagine a battlefield in a virtual reality (VR) first-person shooter (FPS) game. Explosions erupt, gunfire echoes, and your avatar takes a hit. You may feel the recoil of your weapon through your arm, the shaking caused by an explosion, and the strong impact of a bullet on your body. This immersive experience made possible by advances in haptic technology is no longer a distant dream of futuristic gaming.

Recently, however, such full-body haptic effects have to be manually created, which requires significant expertise and time. The key to solving this lies in sound-to-haptic conversion technology: generating haptic effects automatically by analyzing sound signals. However, applying such conversion algorithms to take full advantage of haptic suits (e.g., wearable devices with multiple tactile actuators) remains challenging. The algorithms must generate context-specific feedback across the body by interpreting the event semantics from audio signals in real time.

Here, we present a sound-to-haptic conversion system for VR gameplay with haptic suits. To this end, our system (1) understands the semantics of sound events in games and (2) delivers appropriate full-body haptic effects in real time.

II. System Overview

As shown in Figure 1, our system uses three haptic devices: a haptic vest, a regular VR controller with an additional voice-coil actuator, and an upper armband with a voice-coil actuator.

Our program for semantic sound-to-haptic conversion parallelly executes three modules: sound classification, haptic pattern generation, and haptic rendering. The sound classification module takes a sound segment within a short time window as the input and returns five classes: *gunfire*, *explosion*, *hit*, *reload*, and *none*. We constructed appropriate datasets for training a sequential model and chose a Long-Short-Term Memory for classification.

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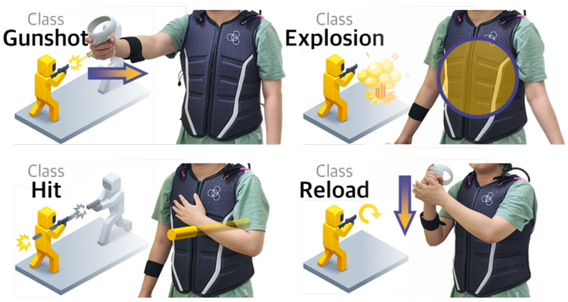

Fig. 1. Device, selected sound classes, and corresponding haptic patterns designed to convey semantic haptic effects in real time for FPS gameplay.

For each classified sound type, the haptic pattern generation module computes intensity profiles based on pre-designed spatiotemporal patterns. The *gunfire* and *reload* patterns simulate recoil forces propagating from the hand to the arm, and the *hit* pattern conveys the sensation of bodily penetration. These dynamic patterns are designed using a tactile illusion technique called phantom sensation [1]. For the *explosion* and *none* classes, the vest actuators are activated consistently with a strong or weak intensity, respectively.

Finally, the haptic rendering module produces analog output signals utilizing the original sound signal and the haptic intensity profiles. Our implementation guarantees real-time execution for synchronous sound-touch perception.

III. Demonstration at World Haptics 2025

Participants can experience real-time haptic feedback while wearing our device and watching a PC monitor. An FPS gameplay video plays on the PC, and a sound-to-haptic conversion program runs concurrently, enabling the device to produce synchronized haptic effects.

References

[1] J. Kim, S. Oh, C. Park, and S. Choi, "Body-penetrating tactile phantom sensations," in *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 2020.