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Haptic Guidance Feedback Design for Virtual Tutting Dance Training

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***Abstract*— This study investigates haptic feedback approaches for effective Tutting dance training within virtual reality (VR) environments. Five haptic feedback strategies were deployed in two stages: (1) single-feedback condition of Beat, Signifying Error (SE), and Correct Movements (CM) and (2) combined-feedback conditions of Beat+SE and Beat+CM. User study results indicated that a strong preference for the Signifying Error (SE) feedback due to its effective assistance. Based on these findings, we are developing a more effective and personalized VR dance training system with haptic guidance.**

I. Introduction

Dance is an art consisting of sequences of body movements with aesthetic and symbolic meaning, and it has been taught and performed across ages and cultures. For dance training, the typical setup is a studio with mirrors, which reflects the learners enabling them to self-correct their posture and movements. Instructors often correct the learner's movements physically by guiding or constraining their body, which requires considerable cost and effort.

MR-based systems have been considered to reduce such efforts and expert-demanding characteristics [5]. Most applications offer visual cues such as MR mirror [6] to support dance training. However, the lack of proprioceptive cues often limits the usability of system. To supplement this, haptic guidance can be considered. Its usefulness has been demonstrated in complex skill transfer including playing a drum set [1] and carving skills [2]. Moreover, to help dance training, which often accompanies dynamic body movement, an immediate and intuitive feedback regarding body movements is desirable. Efforts on motion-to-haptic pattern conversion [3] and generating haptic effects that reflect the characteristics of dancing [4] has been made, yet such patterns are not designed for real-time feedback.

To this end, this ongoing work aims to find an effective strategy on designing effective haptic feedback system for dance training. Among different genres, we selected Tutting, which emphasizes precise joint angles and spatial arrangements. It has been widely adopted in performances associated with popular music. We initially gathered knowledge on Tutting, especially regarding rhythm, angles, and timing from an expert dancer, and captured the expert's motion. Then, we designed five strategies to help the novice learners using the input of the expert. Lastly, we conducted an initial user study that compares five different strategies to find effective strategies for real-time haptic-based dance learning.

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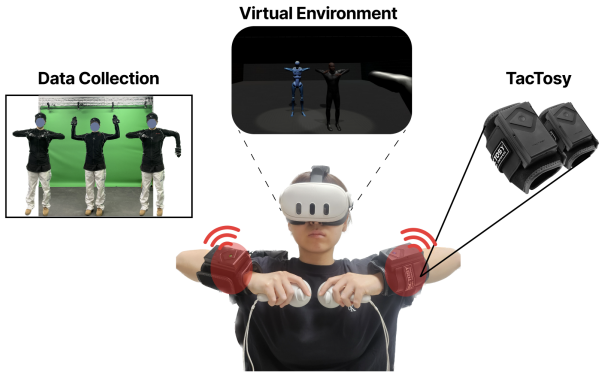

Fig. 1. System setup for Tutting dance training with haptic guidance.

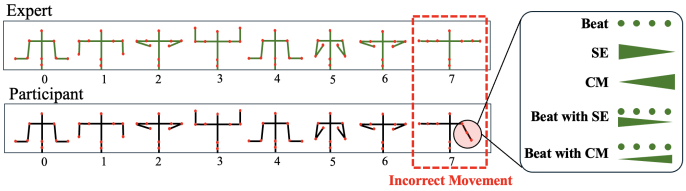

Fig. 2. An example dance sequence and feedback triggered on incorrect moves.

II. Initial Feedback Design

Our dance sequence is structured as a *"one-eight"* consisting of distinct movements correspond to eight beats. We designed five different feedback strategies as follows (Fig. 2).

- **Beat**: In addition to the visual guide, vibrotactile stimuli synchronized with the beat of the music were delivered via wrist-worn devices.
- **Signifying Error (SE)**: Vibration intensity increased as the participant's movement deviated from the target pose and decreased as it approached the correct position.
- **Correct Movements (CM)**: Vibration intensity increased as the participant's movement approached the target pose, reinforcing correct motion trajectories.
- **Beat With SE**: The Beat condition was applied to both hands, while additional Signifying Error (SE) feedback was provided to the dominant hand.
- **Beat With CM**: The Beat condition was applied to both hands, while additional Correct Movements (CM) feedback was provided to the dominant hand.

III. User Study

A. Participants

12 university students (5 male, 7 female; aged 21–27 years, $M = 23.25, SD = 2.01$) participated in the preliminary study. They were non-experts, without any experiences on tutting dance prior to the experiment.

B. Experimental Setup

We created a virtual reality (VR) environment for the study using Unity 3D Engine (6000.0.28f1). Vibrotactile feedback was delivered using a pair of wristbands (bHaptics, Tactosy) worn on both hands of the participant to provide precise and intuitive feedback. The full-body tracking of user was done using Meta's Movement SDK. For immersive visualization, participants wore a HMD (Meta, Meta Quest 3).

In the scene, a virtual dance coach demonstrated dance movements corresponding to each task (see Fig. 1). Participants were assisted by a virtual mirror and background music[1] throughout the session. The target Tutting movements were collected from expert dancers using an optical motion capture system (OptiTrack, Prime^{x}12) and motion capture gloves (Manus, Quantum Metagloves), and visualized in VR.

C. Experimental Design

We designed the experiment in two-phases. Phase 1 focused on comparing single feedback strategies with baseline of visual-only condition. That is, comparisons between **Baseline, Beat, SE** and **CM** were done, consisting of four sessions. Phase 2 evaluated combined feedback strategies, focused on comparing **Beat with SE** and **Beat with CM** conditions, consisting of two sessions. All conditions were given in a VR environment that presented the same *one-eight* sequence composed of eight movements visually.

D. Procedure

Participants were introduced to the experimental procedure and the devices we used, and they signed a consent form. In the experiment, they experienced the same *"one-eight"* dance sequence, and guided by the six different feedback conditions described above–four in the first phase and two in the second. In each session, the participants were asked to follow the given sequence in the VR. The system will wait for the correct movements, with a timeout of 20 s. After finishing a session, they answered an eight-item questionnaire: degrees of **Immersion, Consistency, Causality, Fatigue, Distraction, Preference, Motion Sickness, and Assistance** using a 7-point Likert scale, as done in prior literature [3], [4]. Each session lasted around 3 mins, and all sessions involved the same task with different feedback modalities. The whole procedure took approximately 40 minutes per participant.

E. Results

We ran Friedman tests first and Wilcoxon signed-rank tests for post-hoc analyses, given that the nature of the 7-point Likert scale data did not meet the normality assumption. The Baseline condition was excluded from analyses not to distort the comparison between feedback strategies. Among eight evaluation items, the degree of **Assistance** exhibited significance ($p < 0.001$). In particular, the SE condition received significantly higher ratings compared to Beat ($p = 0.005$), CM ($p = 0.046$), Beat with SE ($p = 0.010$), and Beat with CM ($p = 0.007$). Additionally, a significant difference was observed between Beat and Beat with SE ($p = 0.01$), highlighting the effectiveness of the SE condition in supporting task performance. Other items did not show statistical significance in the results, and nobody reported motion sickness.

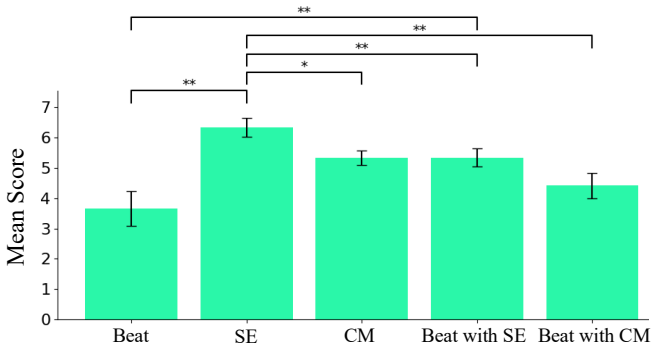

Fig. 3. Degree of assistance over feedback strategies.

Post-experiment interviews further reinforced these findings. Ten out of twelve participants selected the SE condition as their preferred, while only one participant each preferred CM and Baseline. These results suggest that SE would be the best strategy for achieving both objective performance enhancement and user satisfaction.

IV. Conclusion & Future Work

In this study, we explored the use of haptic feedback for effective Tutting dance training. In our initial results, SE condition demonstrated the highest user preference and was perceived as the most helpful (highest assistance score) during the task. Future work will focus on user-tailored optimization of the training system for beginners, which may include customized, complex dance routines and multisensory feedback including audio coaching. We also plan to evaluate the effectiveness of the system through a longitudinal study.

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