From Hand to Foot: Expanding Multi-Sensory Feedback for Accessible Dance Participation

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Abstract

Assistive technologies for body movement participation among people who are blind or have low vision (BLV) have primarily relied on upper-body-worn haptic and auditory feedback, with limited exploration of foot-based interactions. While some research has investigated foot-based interactions in navigation, their potential for supporting recreational body movement learning remains under-explored. This position paper builds on insights from an ongoing PhD project exploring multi-sensory feedback to support BLV people's participation in contemporary dance. Early research focused on hand movement feedback, as distributing attention across multiple body parts simultaneously posed cognitive and sensory challenges. Based on co-design feedback, future work may explore how foot-based augmentation could be meaningfully integrated into dance learning. We discuss key design challenges, including sensory integration, adaptability to expressive movement, and balance support, and highlight the need for iterative, co-design to explore how foot augmentation can complement existing accessibility methods.

CCS Concepts

• **Human-centered computing → Accessibility**.

Keywords

foot augmentation, blind, low vision, dance, education, design challenges

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1 Introduction and Background

In assistive technology research related to body movement accessibility for people who are blind or have low vision (BLV), a significant focus has been on obstacle detection and navigation systems. These systems often employ wearable devices that provide feedback through various modalities, such as haptic or auditory signals. However, the placement of these feedback mechanisms is predominantly on the upper body, including the wrist, waist, or head [11], while having limited research based on foot-based solutions [9, 10].

While most assistive technologies for BLV people have focused on navigation and spatial awareness, a smaller body of research has begun to explore their participation in **recreational body movement** activities. These technologies aim to support engagement in movement-based learning and sports by providing alternative sensory feedback to compensate for the lack of visual cues. Many of these solutions use audio cues or haptic signals attached to the upper body, where movement guidance is represented through feedback mechanisms placed on the wrist, waist, or head. For instance, studies have explored recorded auditory instructions to guide movement learning [4, 5], binaural moving sounds to help predict spatial positioning, and verbal cues to provide feedback in sports like swimming [6, 7]. Similarly, haptic solutions have been integrated into sports training, such as vibrational wristbands for Paralympic runners to assist with lane alignment [3, 8] and haptic bracelets for ski instructors to provide directional cues [1].

Foot-based interactions have been investigated to a limited extent in navigation-focused assistive technologies; however, their application in recreational body movement learning remains largely unexplored. This gap presents a significant opportunity for future research, where foot augmentation could contribute to enhancing movement guidance and accessibility for BLV people, expanding beyond navigation to support a broader range of movement-based activities.

2 PhD Project

Madhuka De Silva's PhD project, "Co-designing Accessible Artefacts for Contemporary Dance Participation by People who are Blind or have Low Vision", focuses on designing multi-sensory technologies to support BLV people in contemporary dance learning and participation (a paper is conditionally accepted for CHI 2025 and based on previous work published in ASSETS 2023 [2]). This research explores how accessibility in dance education can be enhanced to support teachers in their teaching practices through integrating haptic and audio feedback to BLV learners. By working closely with BLV dancers, and dance teachers, the project aims to design interactive artefacts that complement the embodied nature of dance while considering the nuanced ways BLV people engage with movement and space.

In the initial stages of this PhD research, the primary focus has been on hand movement as a starting point for exploring the design challenges of multi-sensory feedback in contemporary dance learning. This decision was informed by the lack of prior research deeply investigating haptic and audio feedback for specific body parts in BLV dance participation. Early findings indicated that when introducing multi-sensory feedback, distributing attention across multiple body parts simultaneously posed cognitive and sensory challenges for BLV dancers. As a result, the project prioritised hand movement as an initial area of exploration, allowing for a more manageable and focused approach to designing interactive artefacts that could support BLV dance learners.

However, ongoing co-design feedback from BLV dancers and dance teachers suggests that future directions should expand beyond hand movement to consider how other body parts, particularly the feet can be incorporated into movement guidance. Given that foot positioning, weight shifts, and rhythmic coordination are fundamental to dance, integrating foot-based interactions could provide an additional layer of embodied feedback to enhance spatial awareness, balance, and movement initiation. These insights open possibilities for investigating how foot augmentation can complement existing haptic and audio-based methods, creating a more holistic and inclusive approach to dance accessibility for BLV people.

3 Potential Design Challenges

Designing foot-based interactions to support BLV people in dance learning presents several challenges related to sensory integration, nature of dance movement, and body balance.

3.1 How can foot-based augmentation be introduced without overwhelming existing sensory strategies?

BLV dancers already rely on haptic, auditory, and proprioceptive feedback to navigate movement, and adding additional vibratory or pressure-based cues to the feet may compete with these established sensory modalities. Additionally, the sensitivity of the feet differs from other areas of the body. While the hands have high tactile resolution, allowing for precise haptic feedback, the soles of the feet are more attuned to pressure and vibration rather than fine-detail perception. This means that not all types of haptic feedback used in upper-body assistive devices will be equally effective when applied to the feet. Instead, designing foot-based augmentation requires leveraging the foot's natural strengths, such as responsiveness to pressure shifts and vibrations, without disrupting postural control or balance. Ensuring that foot feedback complements rather than disrupts the dancer's existing spatial awareness is crucial to designing an effective system

3.2 How can the dynamic nature and qualities of dance be represented?

Another challenge lies in developing intuitive and adaptable feedback mechanisms that can accommodate the **dynamic nature of dance**. Unlike navigation systems, which provide clear directional cues, dance requires expressive, fluid, and often improvisational movement, making it difficult to design predefined foot-based signals that align with diverse dance styles and teaching approaches. Additionally, the physical constraints of wearable foot technologies, such as comfort, weight, and response time must be carefully considered to ensure they do not hinder natural movement. These challenges highlight the need for iterative co-design with BLV dancers and teachers to explore how foot-based augmentation can be meaningfully integrated without compromising the embodied and artistic aspects of dance participation.

3.3 Can foot-based interactions support body balance while dancing?

Another important design challenge is addressing **balance difficulties** experienced by some BLV dancers. During observations and co-design sessions, some participants shared that maintaining balance, particularly when executing weight shifts or unfamiliar movement sequences, can be challenging without visual cues. While BLV dancers develop heightened proprioceptive awareness, certain movements, such as turns, one-legged balances, or rapid directional changes may require additional stabilisation cues. This raises the question of whether foot augmentation could play a role in enhancing balance support by providing haptic or pressure-based feedback that reinforces weight distribution, step timing, or stability during movement execution.

However, designing foot-based balance augmentation introduces new complexities. Any intervention must ensure that feedback remains non-intrusive and does not interfere with natural postural adjustments that dancers rely on. Additionally, individual differences in balance ability mean that a uniform solution may not be effective, necessitating adaptive or customisable feedback mechanisms. Exploring how subtle and responsive foot-based cues can assist with stability without overloading sensory processing is a critical area for future research.

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