

# **A Comprehensive Evaluation of Multimodal Feedback to Aid Virtual Reality Forklift Training**

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## **Abstract:**

Virtual Reality (VR) offers a promising substitution for time- and resource-consuming traditional forklift driving training. Current VR forklift training programs focus on basic skills and safety but may not fully prepare novices for real-world challenges requiring advanced maneuvering and spatial awareness. To facilitate key forklift skill training (maneuvering, load handling) in a VR-based forklift simulator, we first performed retrospective think-aloud (RTA) with 12 experienced forklift drivers and developed multimodal feedback that can aid simulated forklift driving training based on their input. Fifteen novice forklift drivers participated in an experimental study that evaluated the efficacy of four feedback modalities (No feedback, Visual, Haptic, Combined Visual, and Haptic) on two distinct forklift driving tasks (fork-pallet engagement, and load handling). Completion time was significantly lower in fork-pallet engagement task for haptic feedback. Females with haptic feedback showed less mental task demand and frustration. Eye tracking metrics showed differences in gaze behavior among males and females, as females showed higher dwell time and gaze entropy. Feedback preference did not show any significant difference among the participants. However, semi-structured interviews revealed potential feedback design suggestions for future implementation. This research demonstrates the potential of VR-based forklift simulators to enhance training efficiency among novices by integrating experienced drivers' feedback. Future researchers and practitioners in VR-based training can utilize the findings presented in this study to develop more effective training programs that incorporate tailored multimodal feedback, consider individual differences and preferences, and ultimately improve the safety and efficiency of forklift operations in real-world scenarios.