Graduate School of Science and Technology Master's Thesis Abstract

Laboratory name (Supervisor)	Interactive Media Design (Hirokazu Kato (Professor))		
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Thesis title	Smart Rehabilitation for Augmenting Therapists' Skills: A Mixed Reality System for Simulating AI-Generated Patient-Specific Impaired Walking Motions and an Assistive Robotic Walker		

Abstract

Rehabilitation professionals are increasingly required to address complex gait disorders using advanced tools that extend beyond conventional observation and exercise-based approaches. As clinical demands grow, so does the need for intelligent and immersive systems that empower therapists to both understand and intervene in patient-specific movement impairments. This thesis presents two distinct mixed reality systems: one for therapist training in gait analysis using AI-generated, patient-specific impaired walking animations, and another for real patient gait training using a robotic collaborative walker with impedance control and augmented reality guidance, designed to engage both patients and therapists through interactive, supervised rehabilitation.

System 1 focuses on therapist training and motion interpretation. A customized text-to-motion pipeline—built upon the MoMask generative framework—transforms structured clinical descriptions into AI-generated, patient-specific 3D impaired walking animations. These animations are visualized in immersive mixed reality using the Meta Quest 3 headset, allowing therapists to interactively observe a range of impaired walking patterns. This system enables skill development in motion recognition, diagnostic sensitivity, and clinical decision-making in a repeatable, patient-independent training environment. Evaluations with expert therapists confirm the system's effectiveness in enhancing diagnostic sensitivity and motion recognition.

System 2 addresses real-world rehabilitation through guided training. A collaborative robotic walker equipped with impedance control and real-time feedback is integrated with a spatially aware AR interface. This system enables therapists to design interactive walking tasks in MR, allowing patients to follow virtual avatars along custom paths while receiving adaptive haptic support from the robotic collaborative walker. Patients engage in interactive gait training with personalized robotic assistance, ensuring safe, engaging therapy supported by immersive visual feedback under continuous therapist supervision in a shared physical space.

Although the two systems serve different purposes and operate independently, they reflect complementary strategies in the use of mixed reality to improve rehabilitation practice. System 1 supports therapist education through immersive exposure to virtual gait impairments, while System 2 facilitates therapist-guided patient training in real-world settings. Together, they contribute to a broader vision of human-centered rehabilitation technologies that enhance both clinical decision-making and therapeutic engagement.