Mixed Reality and AI-based Data Glove in Post-Traumatic Hand Recovery

Benjamin C. M. Fung[1], Patrick C. K. Hung[2], Akira Tokuhiro[2], Alvaro Quevedo[2], Kamen Kanev[3], Hidenori Mimura[3], Masakazu Kimura[3]

[1]McGill University, [2]Ontario Tech University, [3]Shizuoka University

Abstract: Human hands are the first point of interaction with physical objects, being the base for many daily activities. That is why speedy post-traumatic recovery becomes essential when dealing with hand injuries. This article focuses on a research initiative addressing the rehabilitation process of hands by integrating Mixed Reality (MR) and Artificial Intelligence (AI) with a Data Glove (DG). Employing an MR headset and an AI system that tracks the hand's position and provides visual and audio guidance to perform the exercises, detecting mistakes and making corrective recommendations. The future works include conducting experiments with human subjects and integrating therapy techniques such as Functional Electrical Stimulation (FES) and Surface Electromyography (sEMG).

Introduction: Since human hands often serve as the first point of contact with physical objects, they are one of the most injured body parts. In the case of hand injuries, however, many daily activities cannot be performed and quality of life may significantly degrade [1], so speedy post-traumatic recovery is of utmost importance. Physiotherapy is an essential component of the recovery process that usually requires frequent visits to the hospital and meetings with physiologists for rehabilitation therapy and exercise instructions. The current research aims to facilitate the rehabilitation process by integrating Mixed Reality (MR) and Artificial Intelligence (AI) with a Data Glove (DG), to guide the patient in performing exercises with minimal or no supervision if permitted [2, 3, 4]. Furthermore, when medical personnel is involved, Functional Electrical Stimulation (FES) [5, 6] and Surface Electromyography (sEMG) [7, 8] techniques will help automate the exercise control process and reduce the physiotherapist's workload.

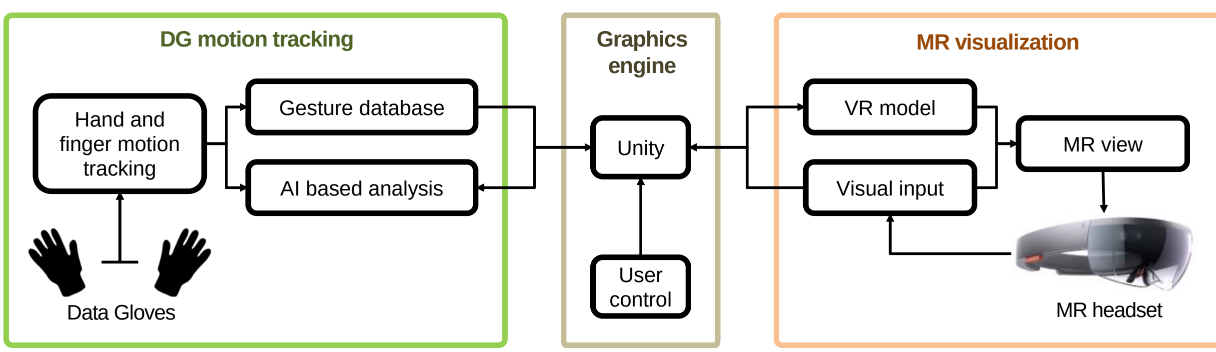

Fig.1. The main components of the core system.

Methods: The core system (Fig.1) is based on DG motion tracking [2, 3] enhanced with AI and MR [4] to guide a patient with a hand injury while performing different sequences of physiological exercises. By employing an MR headset such as HoloLens, the AI system will track the hand's position and provide visual and audio guidance to perform the exercises via the MR lenses. The fine finger motions will be tracked by the DG and if the patient fails to perform the tasks correctly, the AI system will detect the mistakes and make corrective recommendations. The medical extension of the core system (Fig.2) incorporates an FES output module [5, 6] for supervised rehabilitation treatment and direct physical guidance by electrical stimulation of the relevant muscle groups of the patient. Direct tracking of the neural activity associated with the specific physical exercise motions and postures will be carried out through an optional sEMG input module [7, 8].

With respect to the core system, the main research contributions are (1) to develop an AI system to track global hand movements, (2) to integrate the finger motion data received from the DG, (3) to visualize the guidance in the MR scene, (4) to detect mistakes by assessing the discrepancies between the expected and the observed actions, and (5) to make recommendations to correct the related movements. With respect to the medical extensions of the core system, the main research contributions are (1) to connect and integrate the FES output module into the core system, (2) to develop machine learning models for recommendation-based FES module control, (3) to connect and integrate the sEMG input module into the core system, and (4) to develop machine learning models for sEMG based motion and posture analysis.

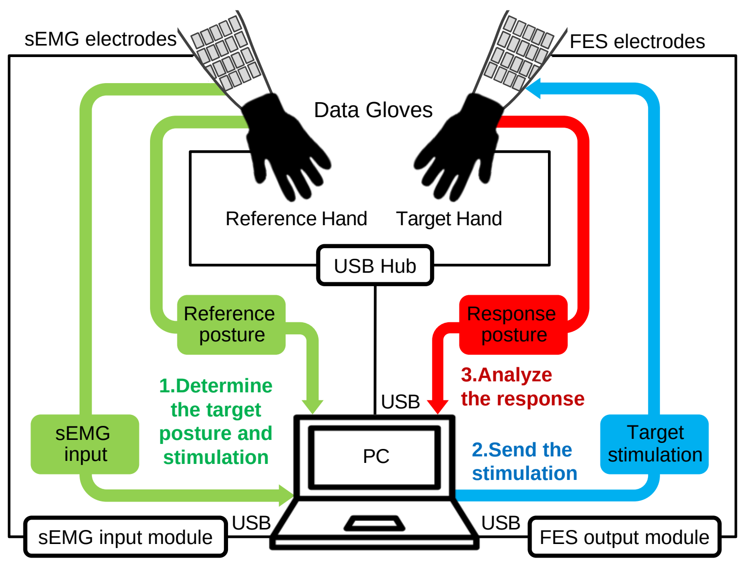

Fig.2. Components, data flow, and processing steps in the medical extension of the core system.

Results and Discussion: We aim to conduct experiments with human subjects and collect sensory data to train different machine learning algorithms to identify the most efficient models with the highest possible accuracy to properly match patient needs.

Conclusion: This research integrates DG with MR and AI technologies for physiological therapy. It could be extended with FES, sEMG, and more advanced machine learning models for upper limb physiotherapy, status evaluations, and health management by a medical professional.

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