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Anthropomorphic Passive Mechanism for Performing Hand Exercises

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Abstract. Hand disabilities resulting from traumas, accidents and other causes impact how people carry on everyday tasks, thus, the importance of physical therapy. This process is characterized for performing repetitive sequences of motion with the guidance of a physical therapist, and in some cases, requires doing the therapy without attendance, which may lead to unsatisfactory results due to pain, unclear guides and poor feedback on their performance. This paper presents the development of a humanoid passive mechanism for hand exercising using its limbs for achieving flexion/extension, pronation/supination and radial/ulnar deviations. Preliminary tests show an interest in having similar devices for hand training associated as a leisure activity that could be used as a stress reliever that allows entertaining while training.

Keywords. Hand, Mechanism, Therapy

Introduction

Disabilities affect around 15% of the world's population, with hand disabilities causing loss of mobility and dexterity due to traumas, accidents, and other causes leading to experience significant difficulties in performing daily tasks [1][2][3]. Hand exercises involve flexion/extension, abduction/adduction and ulnar/radial deviation movements that may stimulate muscles for recovering mobility and increase dexterity, with intensive repetitive sequences of motion for improving motion skills [4]. A successful therapy may depend on factors such as pain, lack of motivation, unclear guides, unattended guidance and repetitive monotonous activities that can affect the intrinsic motivation for completing the therapy sessions [5]. These challenges have motivated the development of assistive devices and Virtual Reality (VR) based solutions that stimulates, monitors and guide users through interactive and immersive environments using natural interfaces [6][7][8], along with gamified and serious game systems [9]. Current technological trends are changing how people interact with several devices through virtual skeletons with depth maps [10], infrared sensors [11], inertial sensors [12], EEG [13], wifi [14], and miography signals [15], for motion capture, however these devices can also be used for treating minor affections, motivating users

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to engage in preventive exercises, that allows them to manage chronic pain, increase dexterity, gain muscle strength, and regain motion.

This project presents a humanoid passive mechanism for practicing wrist flexion/extension, supination/pronation, and ulnar/radial deviations along with finger flexion/extension. The mechanism is configured with motion sensors for collecting motion data as a tool monitoring exercise progression while solving targeted positions as motivational goals.

1. Methods

The system is designed considering the flexion/extension, pronation/supination and ulnar/radial deviations of the wrist, and fingers. The goal is to achieve targeted positions using a passive humanoid mechanism that allows performing exercises. The system architecture takes the motion data as inputs feedbacks the user for providing adequate feedback for monitoring and motion improvement, as presented in Figure 1.

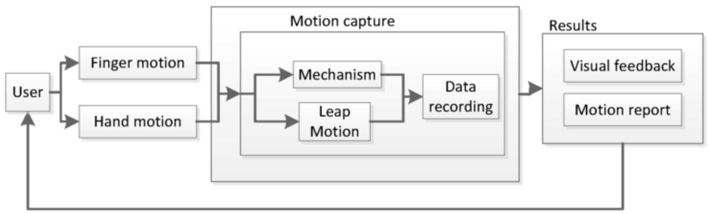

Figure 1. System architecture

The mechanism is composed of 16 DOF and equipped with motion sensors at its joints. Data acquisition was achieved with Arduino boards using inertial sensors placed inside the structure. A second motion capture noninvasive device was included for detecting flexion/extension and supination/pronation motion for using when the mechanism is not available Both motion capture devices recorded rotational information for monitoring user performance through the exercises.

2. Results

The developed system allows practicing wrist and finger flexion/extension, supination/pronation and ulnar/radial deviations by rotating the mechanism joints as presented in Figure 2. The mechanism allows tracking the wrist and finger's motion while performing exercises that may help prevent hand disorders caused by excessive use of computer keyboards or as a tool for using after an accident or during physical therapy. Motion tracking with the LeapMotion was limited to flexion/ extension angles of +-80º and supination/ pronation angles of +-60º.

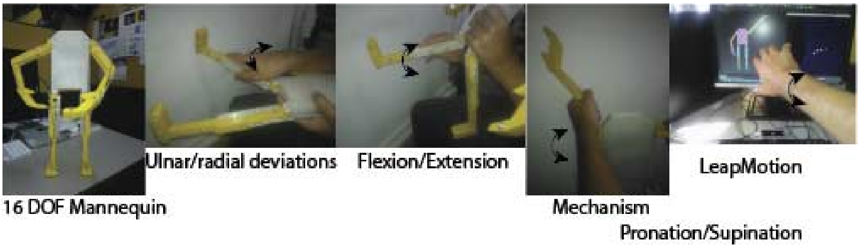

Figure 2. Passive mechanism and hand tracking

3. Conclusions

The passive mechanism and LeapMotion are suitable complimentary tools for hand exercising, during preliminary tests users preferred the mechanism as it provided a physical structure to hold and manipulate that served as reference; however, the LeapMotion caused more interest and curiosity. Tracking issues were more evident on the LeapMotion as it depends on what the infrared sensors track while the fingers do not overlap. Users found very useful to perform guided tasks while checking their progress and performance through motion curves. Future works will continue to explore both devices capabilities for improving hand exercise along with serious games mechanics for improving motivation and use of the system.

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