AUDIO-GUIDED VIRTUAL REALITY SYSTEM FOR FINGER MOTOR SKILL REHABILITATION

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Introduction:

Extended Reality (XR) includes technologies such as VR, AR, and MR, creating an environment where people can train and rehabilitate their skills. Loss of finger motor skills is frequently associated with such conditions as stroke, brain injuries, Parkinson's disease, peripheral nerves injuries and other illnesses, causing difficulties with basic activities of daily living, which involve manipulating objects with fingers. Conventional physiotherapy practices often turn out to be tedious, costly and ineffective. There is a possibility to perform structured finger exercises at home, provided there is no need in any special equipment, as it is possible with the use of VR headsets with built-in hand tracking capabilities. The suggested Audio Guided Virtual Reality System for Finger Motor Skills Rehabilitation was developed for the Meta Quest platform by means of Unity 6 and the Meta XR SDK. The system consists of five finger exercises such as Finger Tapping, Finger Spreading, Grip Hold, Precision Pinching and Thumb Opposition, which make up interesting finger motor skill training activities.

Figure 1: Immersive virtual rehabilitation scene presenting exercise feedback and task instructions

Objectives:

1. To develop a standalone VR-based controller-less rehabilitation application for Meta Quest using optical hand tracking technology without any external devices or sensors.
2. To develop five different finger motor exercises for rehabilitation: Finger Tapping, Finger Spreading, Grip Hold, Precision Pinching, and Thumb Opposition.
3. To develop an audio guidance system for providing real-time guidance, feedback.
4. To develop a system for recording and synchronizing user exercise performance data with a server with support for storing data in an offline environment.

Methodology:

The application is built through user-centered design using Unity 6 and the Universal Render Pipeline (URP) to achieve optimal results on standalone VR headsets. The system makes use of the Meta XR SDK with the ability to track hand movement through the optical method without using any external equipment such as controllers. It contains five hand exercises namely Finger Tapping, Finger Spreading, Grip Hold, Precision Pinching, and Thumb Opposition all programmed with C# scripts following the modular nature of a BaseExercise model. The application utilizes the XR Interaction Toolkit for hand interactions and smooth navigation in the virtual environment. The logic component takes care of controlling the exercises, counting repetitions, and difficulty level adjustment according to the performance of users. The application employs TextMeshPro to provide feedback and instructions in world-space while the audio component gives voice instructions during training sessions.

Result and Conclusion:

The system runs reliably in real time on the Meta Quest, providing stable hand tracking and interaction. It is a standalone XR solution that enables controller-free hand exercises with continuous audio guidance and feedback.

Users can:

- Conduct five hand exercises by employing the movements of their hands naturally without any controllers,
- Receive continuous audio guidance and feedback during each exercise,
- Record progress on each exercise by measuring its performance,
- Execute the exercises independently by using a head-mounted VR device.

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Future Scope:

The future scope of this project includes:

1. Adding sophisticated modules to help improve the hand's strength and fine motor skills with activities such as writing or picking up things through virtual resistance objects in case of strength training modules.
2. Creating a multiplayer mode in which exercises could be performed jointly by participants either with or without a therapist guiding them through the process.
3. Integration of wearable fitness equipment like a smartwatch to monitor parameters such as heart rate, exercise duration, and overall body activity.
4. Integrate wearable glove compatibility for advanced motion tracking when higher precision is required.