Upper Limb Rehabilitation in Virtual Reality for Stroke Survivors
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Motivation
• Stroke is the leading cause of serious, long-term disability in the United States
• Virtual Reality (VR) increasingly utilized to provide a more stimulating experience to stroke patients during rehabilitation
• Limiting factors in existing VR systems: expensive, PC-tethered, narrow target audience, difficult to operate

Methodology
• Develop for Android smartphones using Unity 3D and Google Cardboard SDK
• Establish gesture control interface by utilizing neuromuscular information and kinematic data from EMG and IMU sensors
• Incorporate several forms of feedback and adaptive exercise pacing to provide a user-friendly experience that reinforces rehabilitation requirements

Results
• Intuitive 2D menu screens provided for Myo connection and level selection
• Navigate within VR environment using head movement
• Level 1 responds to the user creating a fist with an animated hand reaching out and grasping a table tennis ball

Objectives
• Develop a low cost, portable, and flexible VR application, VRehab, based on the game of table tennis that assists stroke survivors in their recovery
• Select financially affordable and fully mobile hardware platforms
• Structure application content to target a wide range of patients with differing physical abilities
• Integrate intuitive gesture control by interpreting electromyographic (EMG) signals and kinematic data from an inertial measurement unit (IMU)

Architecture of VRehab

Gesture Control Interface
- Gesture recognition device
- Tracks arm orientation
- Bluetooth Low Energy

EMG & IMU data

User
- Performs target exercise

Haptic feedback

3D rendered environment

VR Headset
- 4.7-6.0 inch display
- Google Cardboard compatible

Binocular view of virtual environment

Smartphone App
- Android 5.1 or above
- VR rehabilitation game
- Intuitive gesture control

Gesture and/or Orientation

Control signals

Level 1
- Target exercise: creating and holding a fist
- User is seated to focus attention on intended exercise

Level 2
- Target exercise: ~90° shoulder rotation
- User may be seated or standing for increased difficulty

Level 3
- Target exercise: elbow flexion and extension
- User may be seated or standing for increased difficulty
- User may incorporate a hand weight

Future Work
- Continue to develop new levels that encompass additional rehabilitation exercises and routines
- Test application with stroke patient subjects
- Incorporate existing ICE Lab signal processing software to expand the number and type of gestures recognized by the application

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