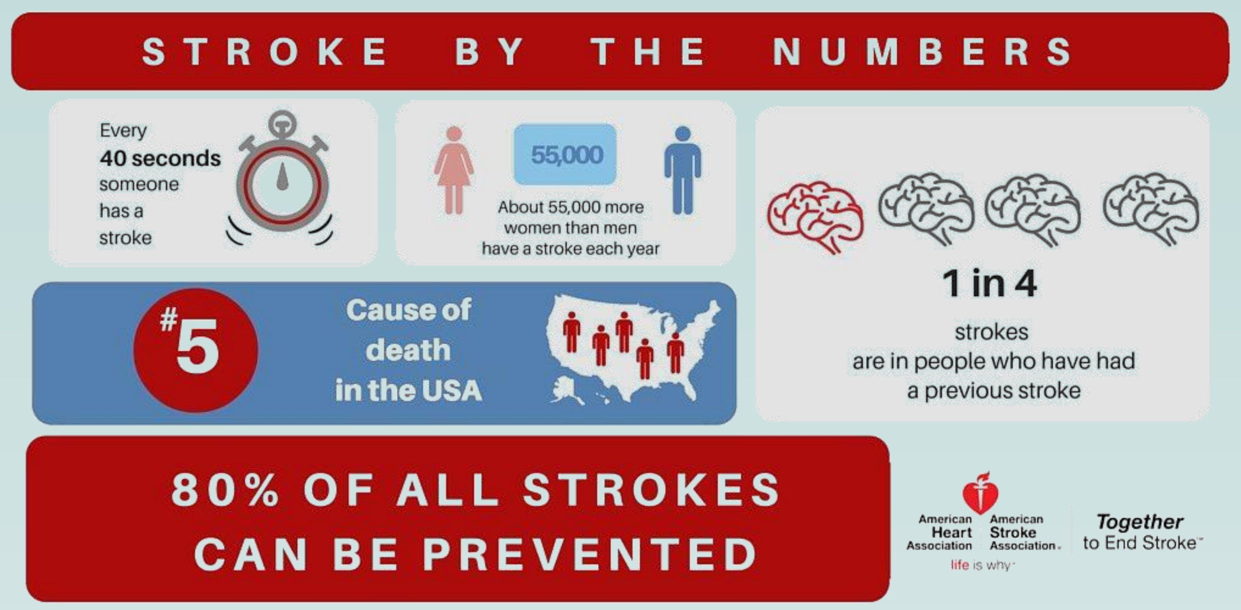
Upper Limb Rehabilitation in Virtual Reality for Stroke Survivors

Chloe Zirbel[1]
Advisor: Dr. Xiaorong Zhang[1]
[1]Intelligent Computing and Embedded Systems Laboratory (ICE Lab), School of Engineering, San Francisco State University

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

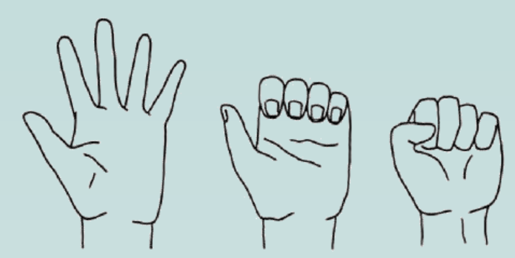


Objectives

- 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)

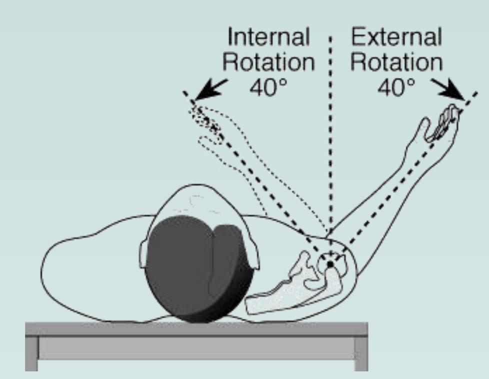
Methodology

- 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



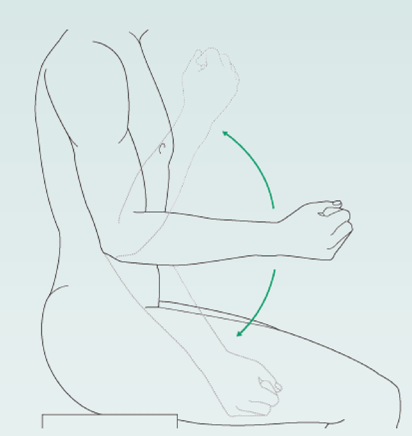
Level 1

- 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

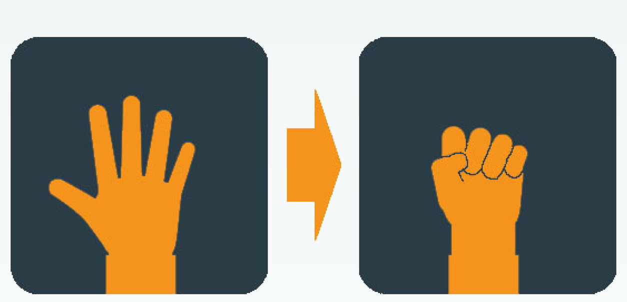


Level 3

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

Architecture of VRehab

User
- Performs target exercise



EMG & IMU data →

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

← Haptic feedback

Gesture and/or Orientation →

← Control signals

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

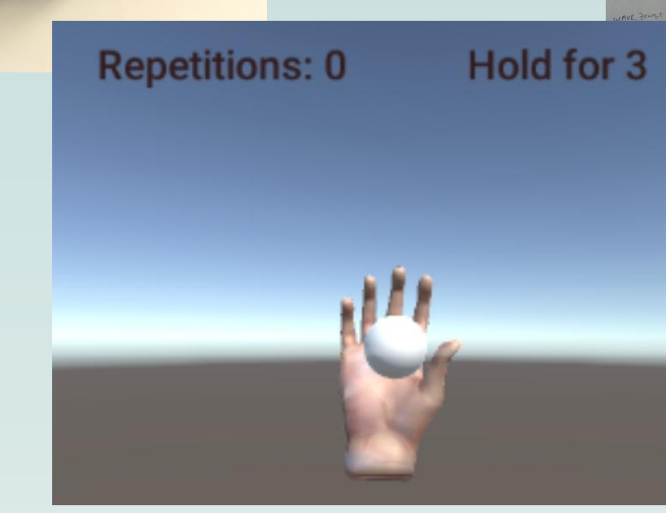
← Binocular view of virtual environment

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

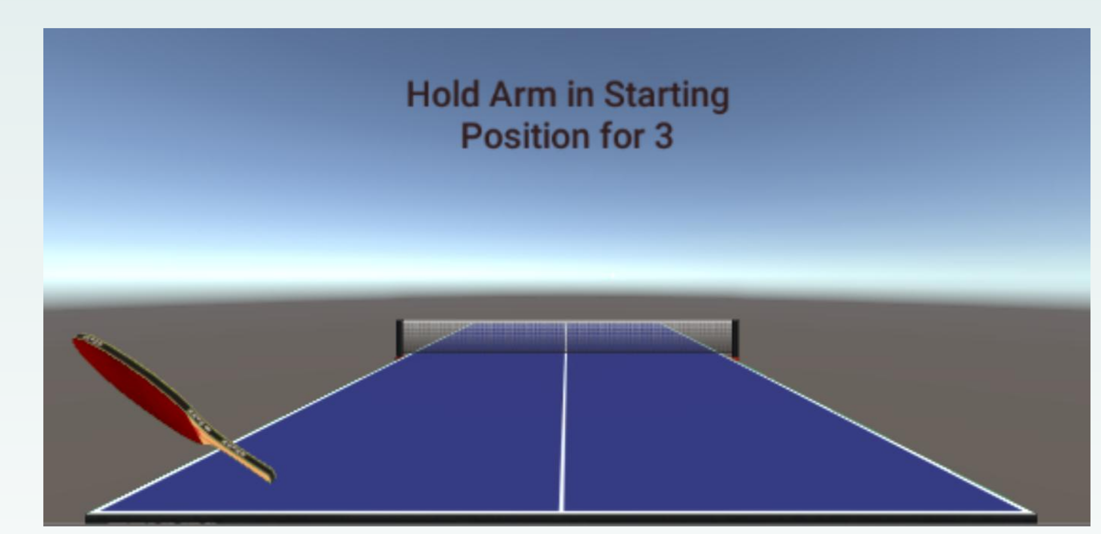
← 3D rendered environment

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



- Level 2 responds to orientation change of target forearm
- Ball and paddle move based on user's arm movement
- Both completed levels provide specific haptic feedback upon successful completion of each repetition



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

Acknowledgement

This work is partly supported by the San Francisco State University (SFSU) Center for Computing for Life Sciences (CCLS) Mini Grant, and the California State University Program for Education & Research in Biotechnology (CSUPERB).