Upper Limb Trajectory Reconstruction using Low-Cost IMUs

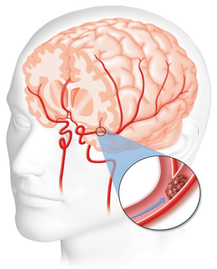
M. Sera[1,2], A. David[3], C.M.L. Hughes[2,4], X. Zhang[3], & X. Du[5]

1: Interdisciplinary Studies, 2: Health Equity Institute, 3: Computer Engineering, 4: Kinesiology, 5: China Academy of Railway Sciences

Problem

Stroke is leading cause of adult disability and second leading cause of death worldwide [2]

17 MIL people worldwide suffer a stroke each year, of which 4 MIL will survive



65% of people suffer from permanent sensorimotor impairments post-stroke having negative impacts [1]

- Activity of Daily Living
- Level of independence
- Quality of Life

Current wearable sensors integrated into mHealth rehabilitation systems are hampered by [3]

- High cost
- Clinically uninformative data
- Low overall system usability

Results and Discussion

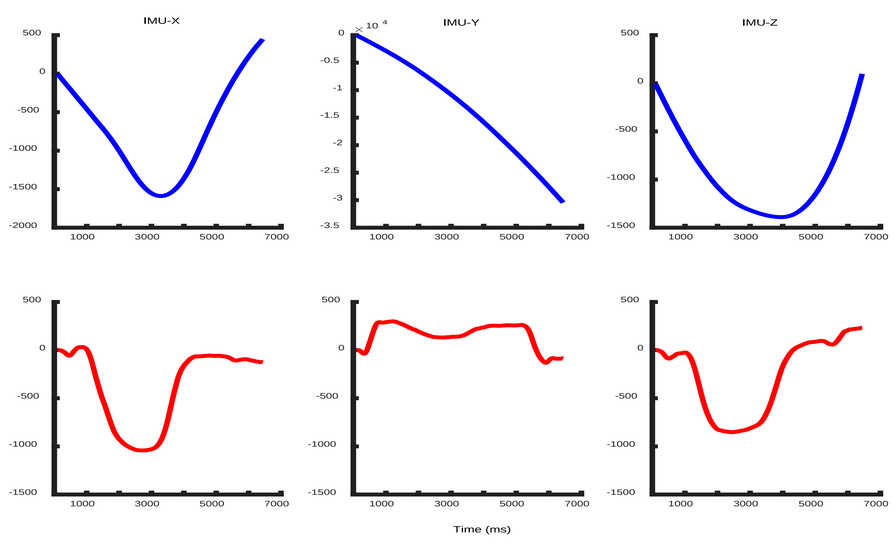


Figure 1. Representative IMU velocity trace during performance of a reaching movement. Top panel: Trajectory reconstruction using mathematical double integration. Bottom panel: Trajectory reconstruction using Support Vector Machine (SVM) learning algorithm.

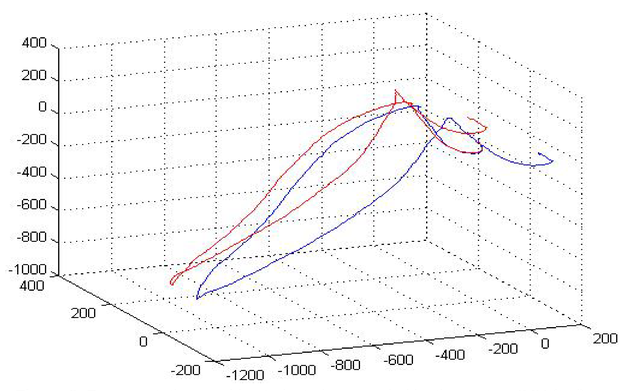


Figure 2. Representative reaching trajectories recorded by the custom IMU (red) and Vicon motion capture system (blue)

- MDI algorithm does not account for bias & drift inherent in IMU systems
- The quaternion & Madgwick compensation filtering algorithm along with SVM resulted in improved trajectory reconstruction (corr = 0.875)

Purpose

To develop & validate a low-cost wearable sensor, then integrate it into the outREACH mHealth system to provide quantitative information about movement strategy & quality

Methods

- Twelve participants between the ages of 21 & 35 years of age
- Three prehension tasks
  - 1D task (table slide), 2D task (washer task), 3D task (pour water task)
- Kinematic movement data were collected using a 7-camera Vicon 3D motion analysis system & wearable sensor
  - 100 Hz sampling rate
  - 3 reflective markers placed on wearable sensor

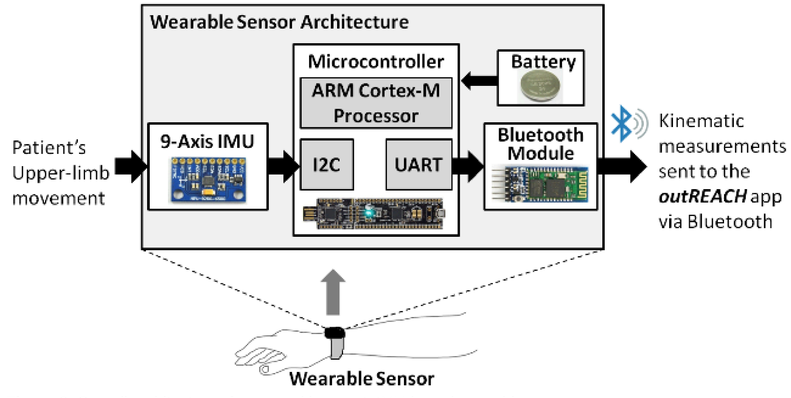


Figure 3. Overall architecture of proposed low-cost, IMU-based wearable sensor

Future Research & Implications

- **Future research should**
  - Determine whether other machine learning techniques (e.g., RNN, HMM) can better reconstruct the 3D trajectories
- **Implications**
  - Development of reliable & valid low-cost IMU
  - Integration of IMU into the outREACH tele-rehabilitation system
  - Utilize tele-rehabilitation systems for individuals who do not have financial &/or physical accesss to rehabilitation services

Contact Information

Michael Sera: msera@mail.sfsu.edu
Dr. Hughes: cmhughes@sfsu.edu

Health Equity Institute NeuroTech Lab
www.healthequity.sfsu.edu/neurotech-lab

References

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