InnovateFPGA
2018
Grand Final

AS015

Flex Force Smart Glove for Measuring Sensorimotor Stimulation

LASARRUS Clinic and Research Center

Lloyd Emokpae,
Roland Emokpae Jr.,
Brady Emokpae

Headline Sponsor | Organizer | University Progam Sponsor | Sponsors | Distribution Partner | University Progam Sponsor

InnovateFPGA 2018 Grand Final

Presentation Outline

ASO15

1. Introduction
2. Motivation
3. Design Block Diagram
4. Design Method
5. Performance Metrics / Goals
6. Conclusion & Future Work

InnovateFPGA 2018 Grand Final

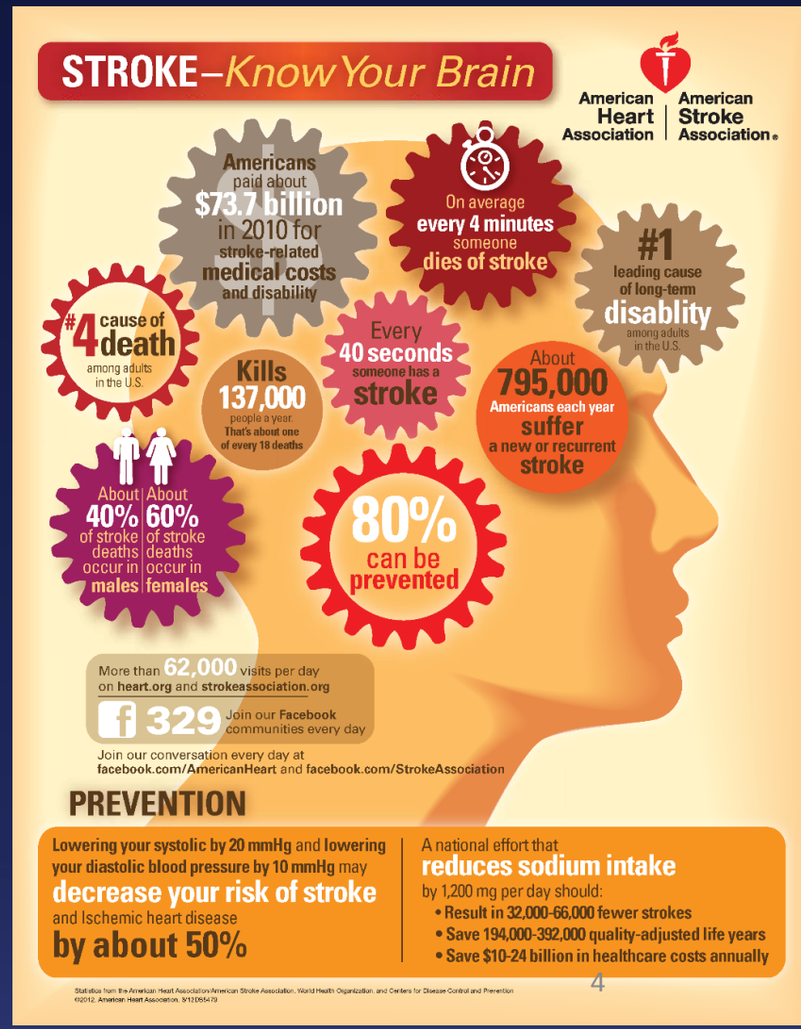
Introduction

ASO15

- Goal: Create a nonintrusive and noninvasive smart glove for acquisition and processing of hand sensorimotor information
- Solution: Flex Force Smart Glove Design
  - ✓ Glove that incorporates sensors to measure force and rotation of wrist and fingers.
  - ✓ Acquisition of sensorimotor data
  - ✓ Processing of sensorimotor data
  - ✓ Classification of hand exercises
  - ✓ Improved Physical Therapy Sessions

Motivation

- Each year over 700,000 stroke related disabilities in the U.S.
- Leading cause of permanent disability
- Motivation:
  - ✓ Upper extremity rehabilitation
  - ✓ Improved Physical Therapy with Quantitative feedback

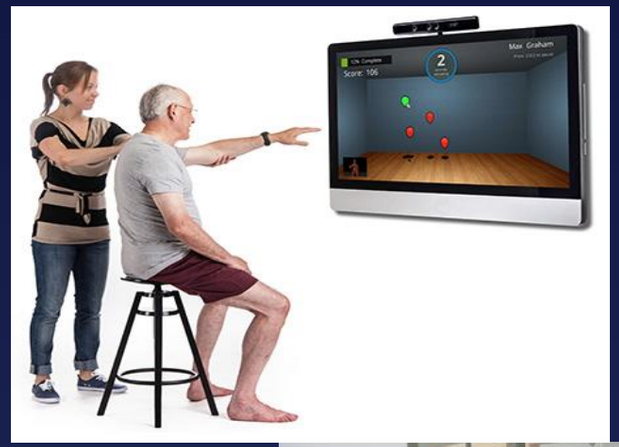


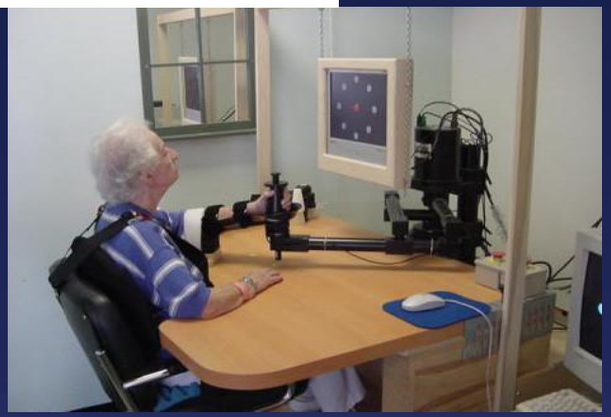
InnovateFPGA 2018 Grand Final

Motivation

ASO15

- Current Methods for Physical therapy includes:
  - ✓ Conventional: one-to-one
  - ✓ Tele-rehabilitation
  - ✓ Robotic-assisted rehabilitation
- All require patient to be in clinic for progress monitoring
- Smart glove design:
  - Can be used in clinic or home
  - Provides real-time patient's progress

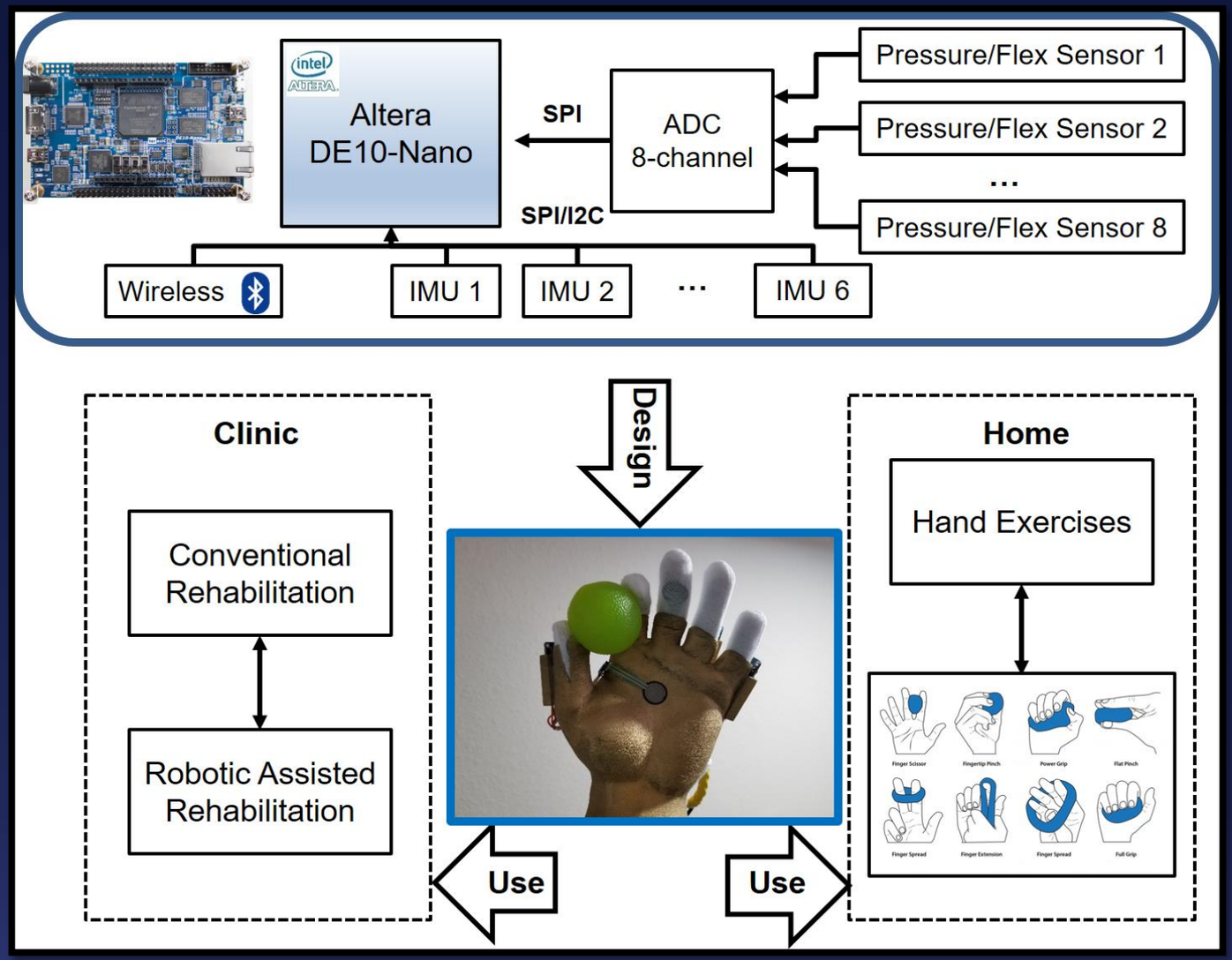




InnovateFPGA 2018 Grand Final

Design Block Diagram

ASO15



- Three resistive pressure sensors
- Five resistive flex sensors for finger angles
- Six IMUs, each with 9 DOF
  - ✓ One IMU/finger
  - ✓ One IMU for wrist
- Acquisition and signal processing on DE10-nano

InnovateFPGA 2018 Grand Final

Design Method

ASO15

Proof of Concept

Glove Design

1st Prototype

Acquisition & Processing

Altera DE10-Nano

Real-time Processing:
- ✓ **FIR Filters**
- ✓ **Kalman filters**
- ✓ **Neural Network classifiers**

Data Acquisition
- ✓ **Record raw data**
- ✓ **Record converted data**

Client-to-Host

Stream to Host

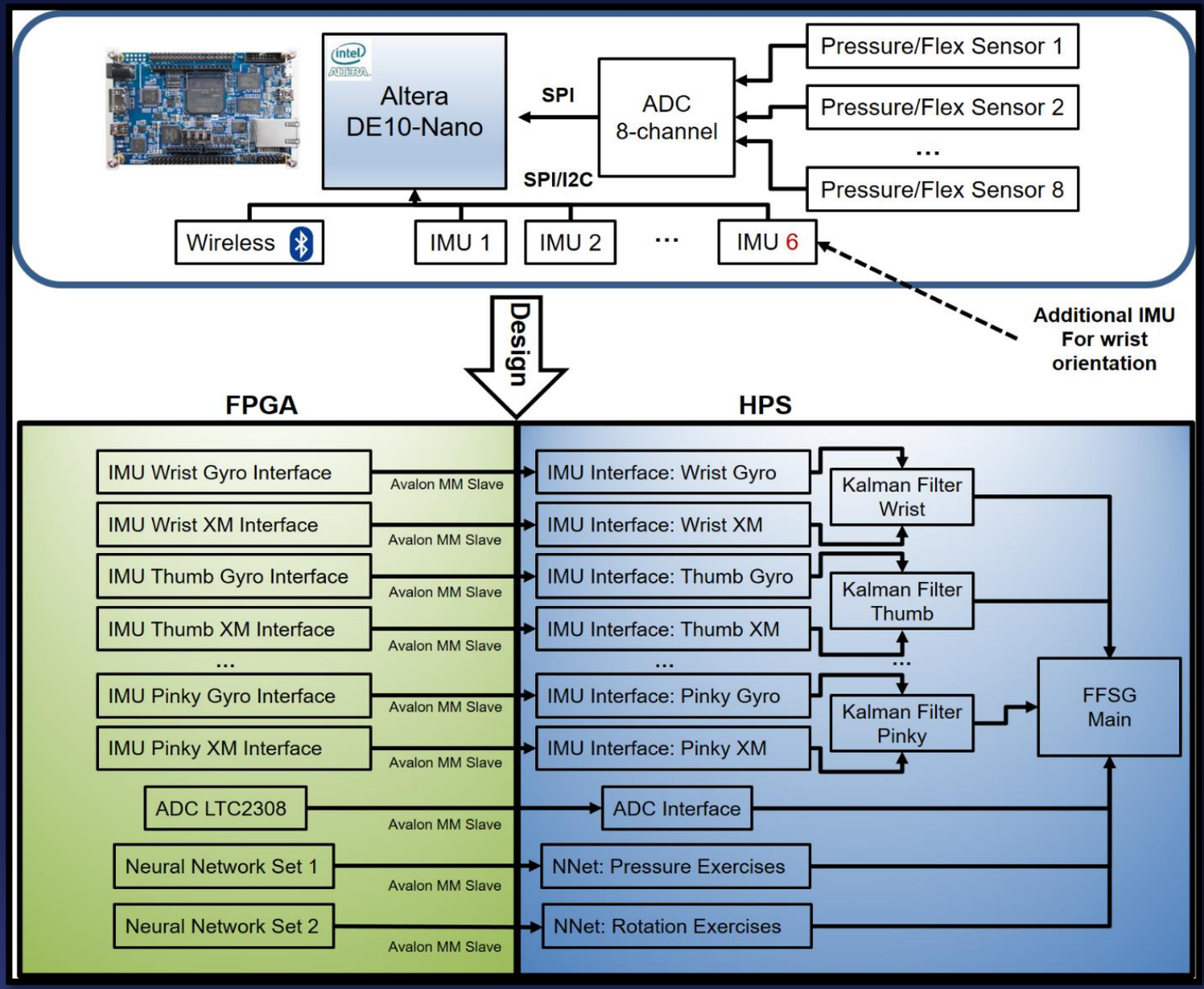
Physical Therapy Session GUI w/ Feedback

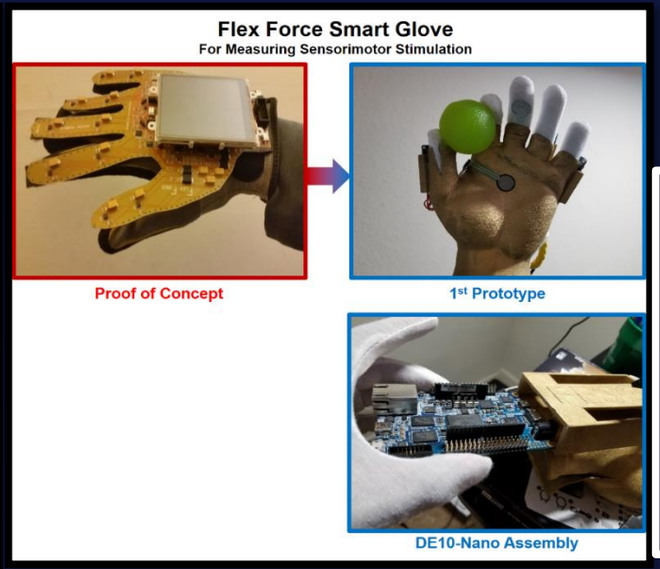
Real-time Visualization:
- ✓ **Observe raw and converted data sets**
- ✓ **Observe results of filters**

Exercise sessions
- ✓ **Force Exercises**
- ✓ **Rotation Exercises**
- ✓ **Hybrid Exercises**

InnovateFPGA 2018 Grand Final

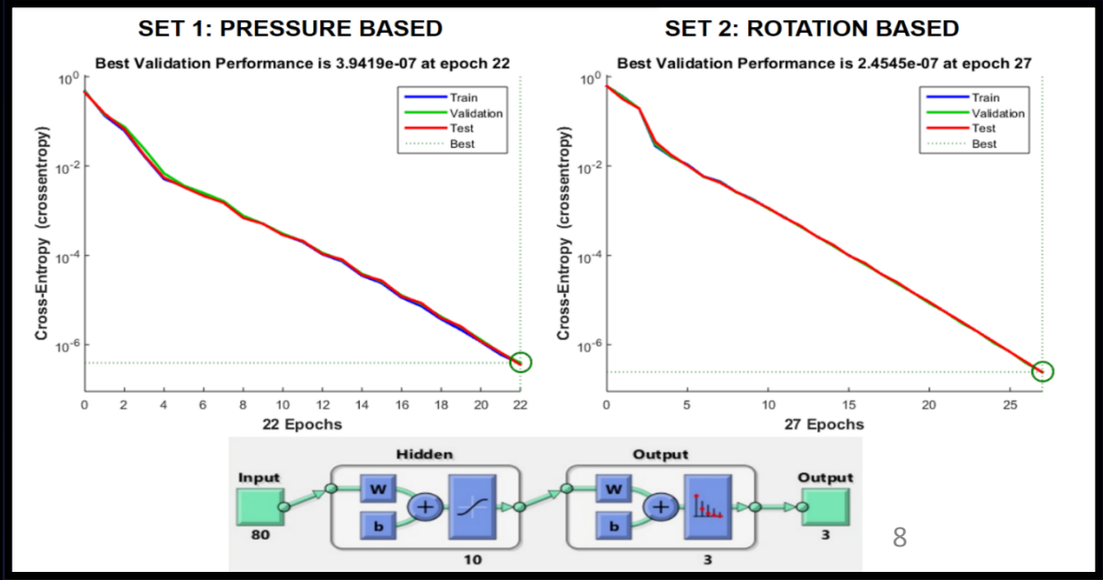
Design Method





ASO15

Logic Utilization: 7,438 / 41,910 (18%)
Total registers: 13432
Total pins: 260 / 314 (83%)
Total block memory bits: 1,198,848 / 5,662,720 (21%)
Total DSP Blocks: 1/112 (< 1%)
Total PLLs: 1/6 (17%)
Total DLLs: 1/4 (25%)



InnovateFPGA 2018 Grand Final

Performance Metrics / Goals

ASO15

Glove Design

Acquisition & Processing

Altera DE10-Nano

Stream to Host

Physical Therapy Session GUI w/ Feedback

Proof of Concept

1st Prototype

Real-time Processing:
- ✓ **FIR Filters**
- ✓ **Kalman filters**
- ✓ **Neural Network classifiers**

Data Acquisition
- ✓ **Record raw data**
- ✓ **Record converted data**

Client-to-Host

Real-time Visualization:
- ✓ **Observe raw and converted data sets**
- ✓ **Observe results of filters**

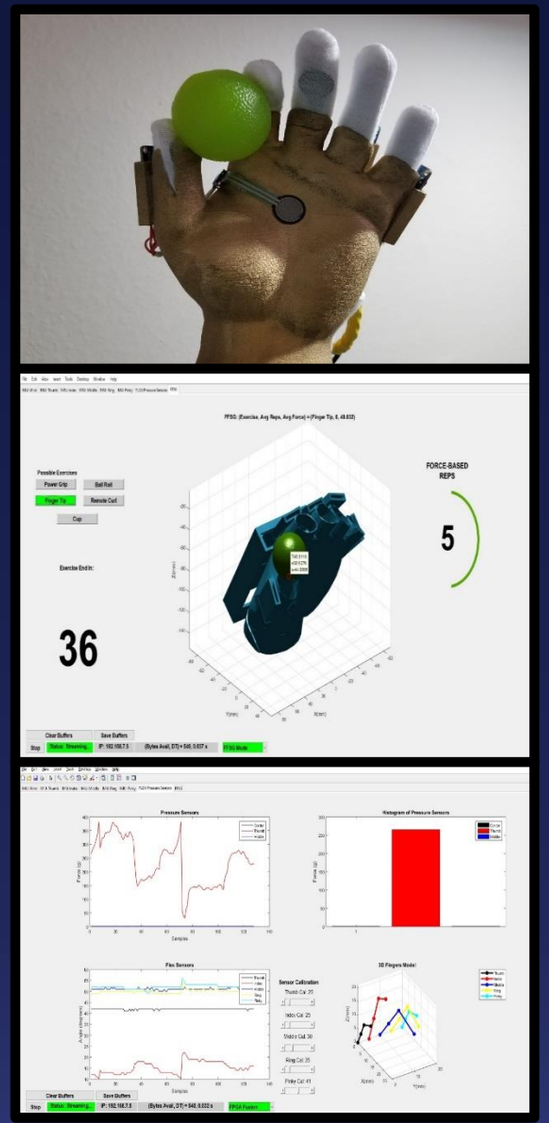
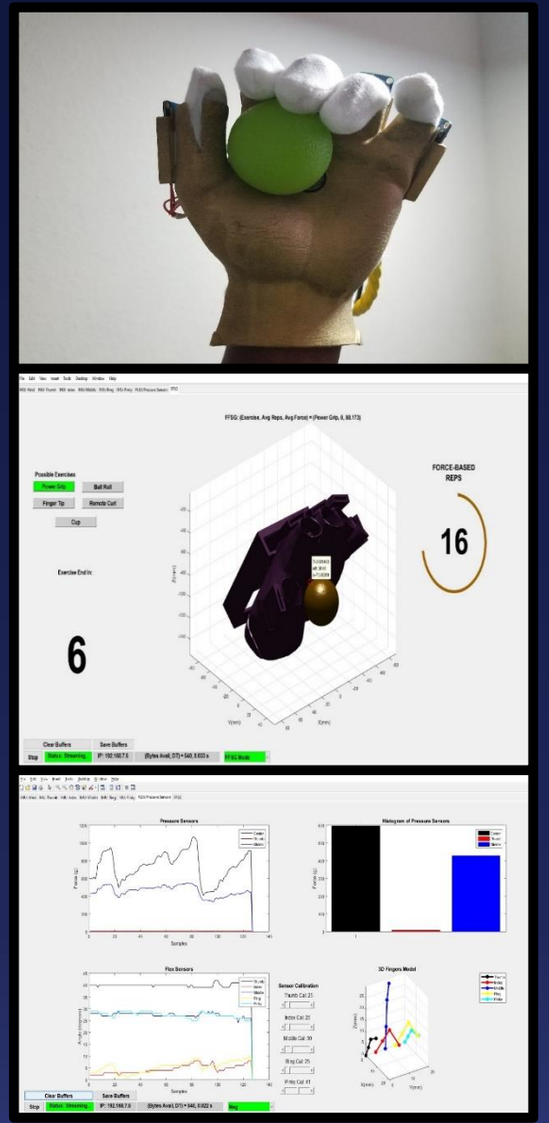
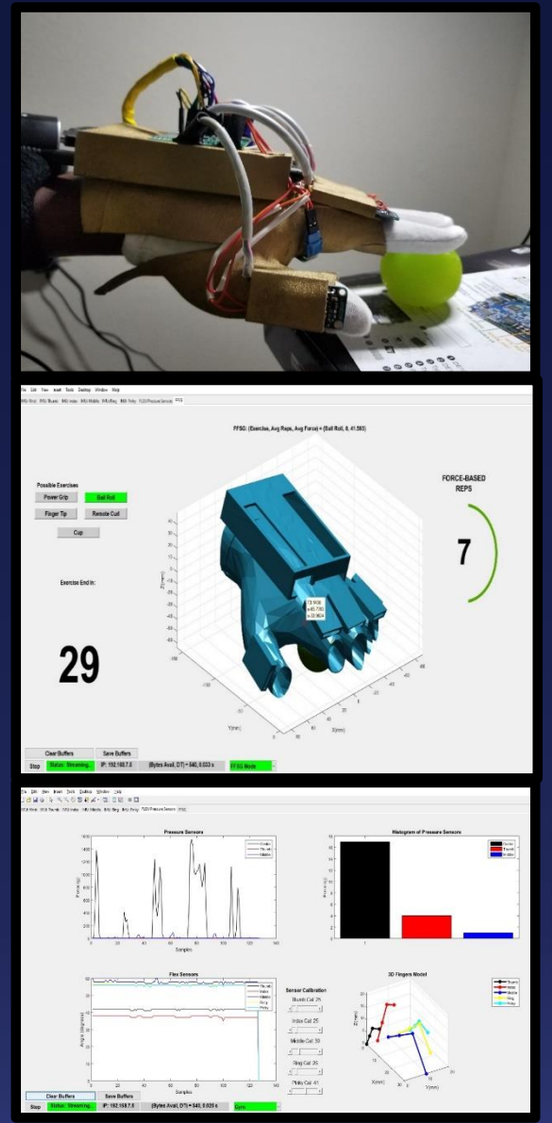
Exercise sessions
- ✓ **Force Exercises**
- ✓ **Rotation Exercises**
- ✓ **Hybrid Exercises**

InnovateFPGA 2018 Grand Final

Performance Metrics / Goals

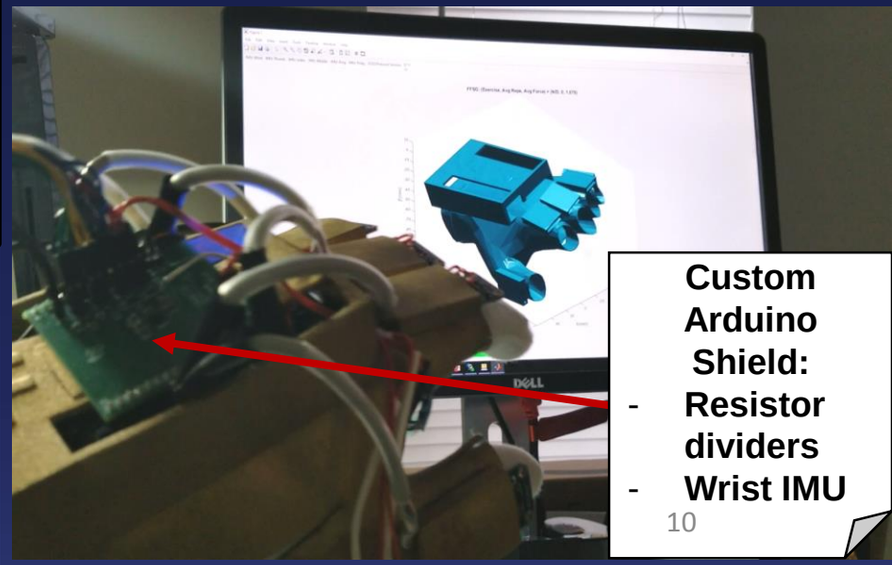
Pressure-based Exercise

ASO15

Finger Tip Grip	Power Grip	Ball Roll
		

Real-time Visualization: Exercise sessions

Physical Therapy Session GUI w/ Feedback



Custom Arduino Shield:
- **Resistor dividers**
- **Wrist IMU**

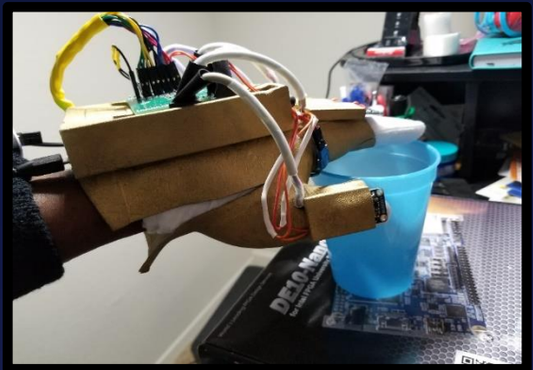
InnovateFPGA 2018 Grand Final

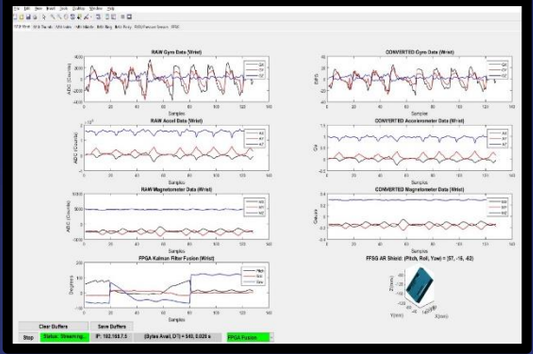
Performance Metrics / Goals

Rotation-based Exercise

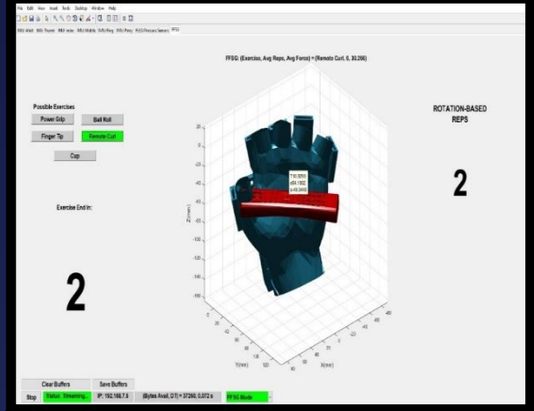
ASO15

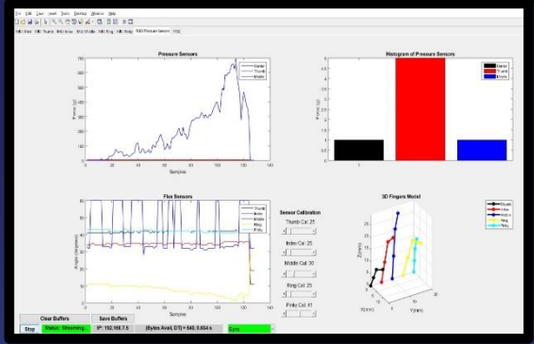
Cup





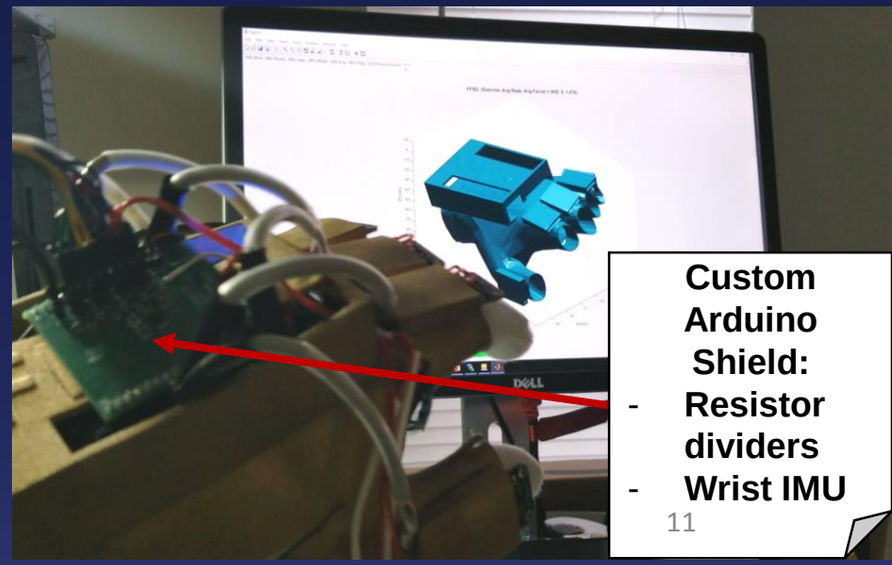
Remote Curl





Real-time Visualization: Exercise sessions

Physical Therapy Session GUI w/ Feedback



Custom Arduino Shield:
- **Resistor dividers**
- **Wrist IMU**

Conclusion

ASO15

- Project will help patients suffering from stroke or joint-related injuries
- Can be used to track rehabilitation process
- Fugl-Meyer Assessment scores can be used to assess performance of patient
- Other applications: 3D spatial interfacing, robotics, gaming and sports

InnovateFPGA 2018 Grand Final

Future Work & Goals

ASO15

- Improve and Finalize Glove prototype to prepare for clinical trials
- Extend the FFSG concept to help in the rehabilitation of other sensorimotor functions.
- Use feedback from medical personnel to guide development of game-based exercise sessions.

<u>New Demonstration:</u> Please checkout our demo booth.

InnovateFPGA
2018
Grand Final

Thank You !!

Headline Sponsor

Organizer

University Progam Sponsor

Sponsors

Distribution Partner

University Progam Sponsor