KAYA: Internet of Wearable E-Textiles for Telemedicine

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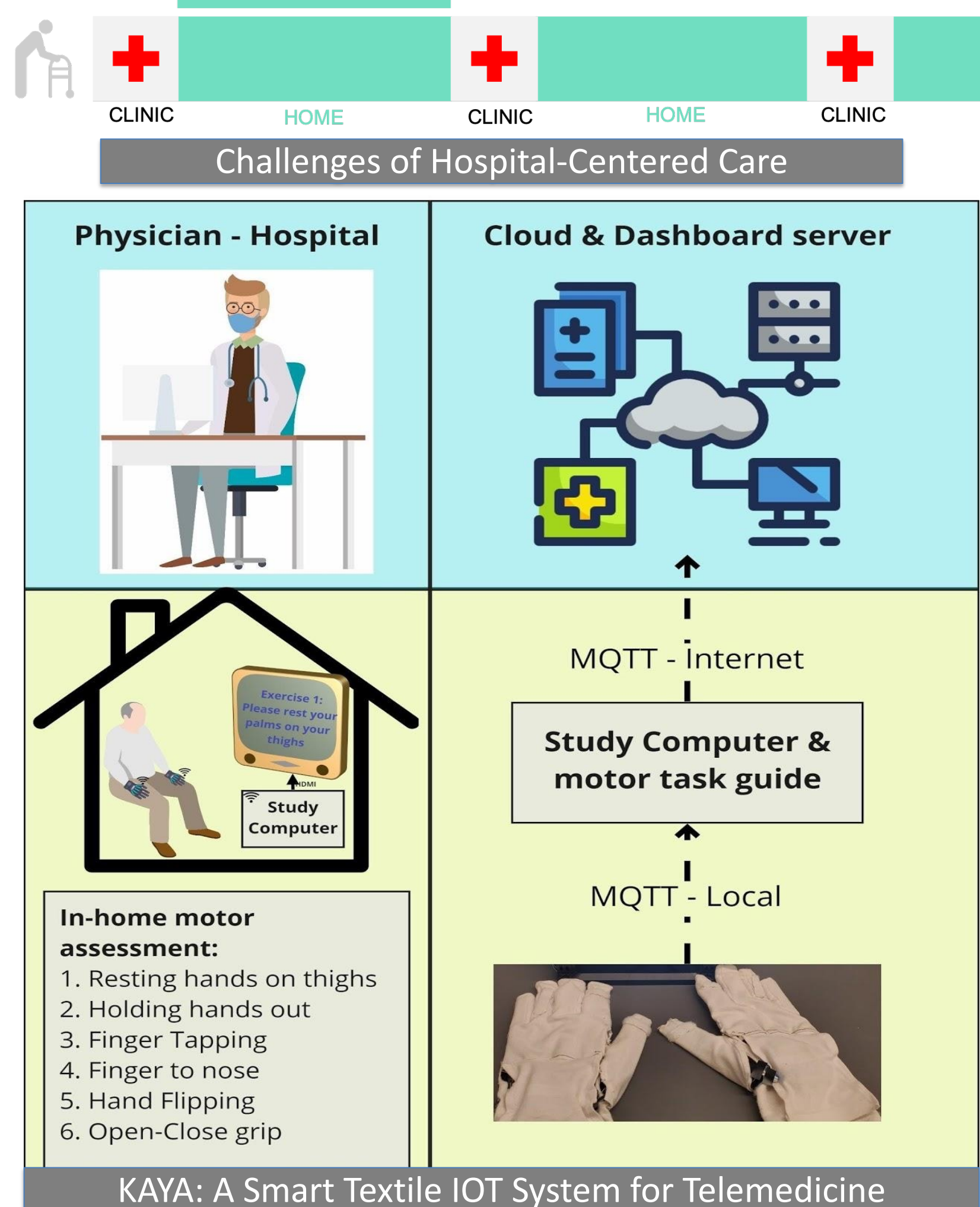https://www.ele.uri.edu/faculty/kunalm/

Challenge

- Parkinson's disease (PD) is a progressive neurodegenerative, movement disorder causing motor and non-motor symptoms leading to difficulties in living quality life for patients.
- Currently, clinical evaluations are conducted by a neurologist through visual screening. The in-clinic evaluation is prone to inaccuracies due to interrater variability, subjectiveness, and sparce data samples. The progressive nature of PD makes it harder to implement a personalized treatment plan.
- Therefore, there is a strong need for systems which would allow for a continuous in-home evaluation of movement and other symptoms in patients with PD.
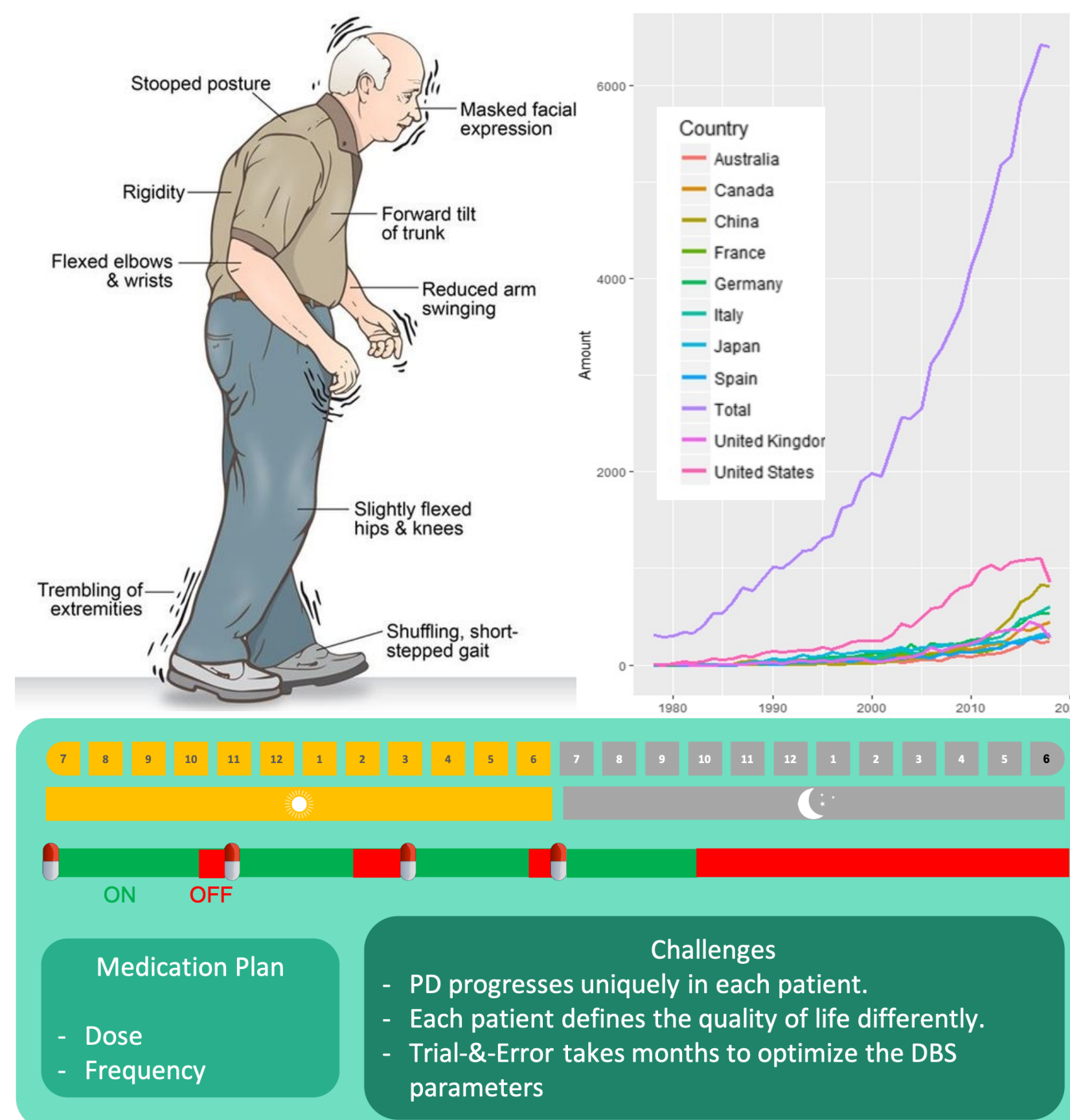
Solution

We have designed a Smart Textile IOT Kit called "KAYA" consisting three interconnected elements:

- **KAYA e-textile wearables (smart gloves and insoles)** are embedded with pressure and flex sensors, IMUs, edge computing module, and a rechargeable battery. They run event-driven protocols for sensing the movement activities and for offering feedback to the patients on the screening protocol.
- **A Patient Interface Device** is a touchscreen-based fog computing device offering orchestration of clinical screening movement exams through MQTT-driven body sensor networks.
- **Data Analytics Pipeline** is divided into *(i) edge computing* for real-time monitoring and feedback of screening exams; and *(ii) fog computing* for clinical-grade analysis to score the motor exams.

Challenges of Hospital-Centered Care

In-home motor assessment:
1. Resting hands on thighs
2. Holding hands out
3. Finger Tapping
4. Finger to nose
5. Hand Flipping
6. Open-Close grip

KAYA: A Smart Textile IOT System for Telemedicine

Key Innovations

- **BODY SENSING**: Our works offer deeper insights into how to integrate sensors into daily life objects (gloves and insoles) using technical embroidery for improving accuracy and sensitivity of movement monitoring.
- **CLOSE-LOOP CONTROL**: Our edge-to-fog computing model allows to give feedback to patients in real-time if they carry the motor exams correctly or not. The patient-centered interface enables patients to run screening independently.
- **SIGNAL PROCESSING & ML**: The analytics pipeline allows the automation of the data preparation, sorting, feature extraction, and motor scoring classification.
- **HUMAN STUDIES**: Our pilot studies on patients with PD are allowing us to make iterative design improvements in hardware, firmware, software, and interfaces. We plan to deploy the KAYA kit in the patients' homes to measure the clinical feasibility and overall system performance.

Broader Impact

- **SOCIETY**: We regularly engage with patients with PD, neurologists, and other clinicians who get their feedback and suggestions.
- **WORKFORCE TRAINING**: 1 Postdoc, 4 PhD Students, 5 MS Students and 20+ Undergraduate Students have been trained.
- **OUTREACH**: We organize an annual hack-a-thon called *HealthHack RI*, serving as a platform to train and impact college students from various backgrounds and majors who conceptualize med-tech solutions for specific problems.
- **K-12 OUTREACH**: We run several *K-12 activities (Paper circuits, E-Fabrics, and Micro:Bit)* every year to inspire young minds for STEM with design and arts.
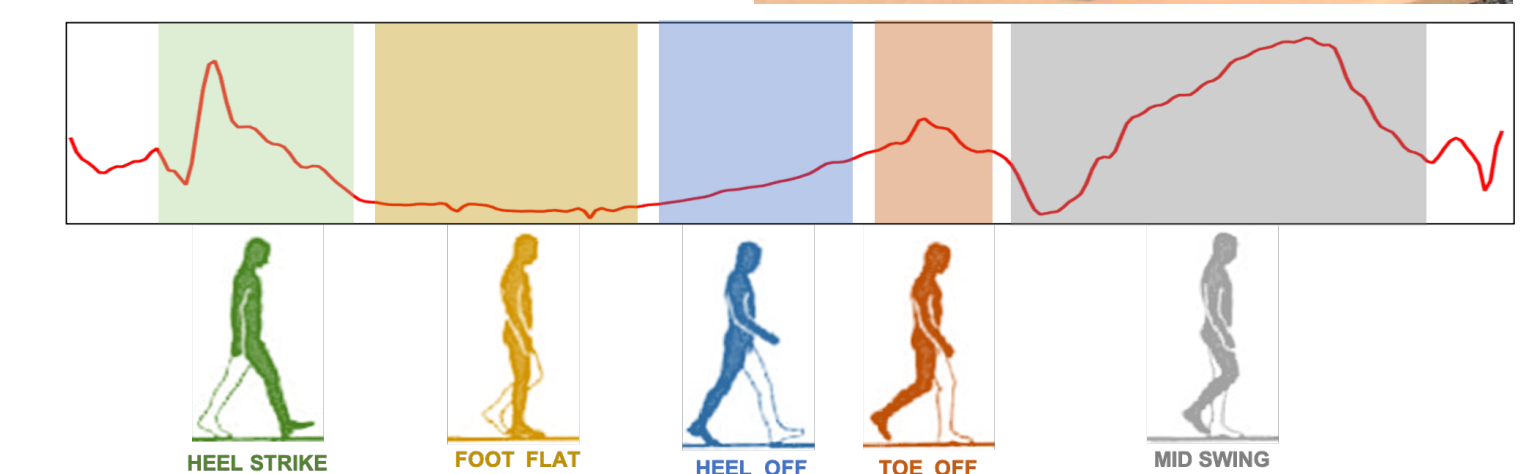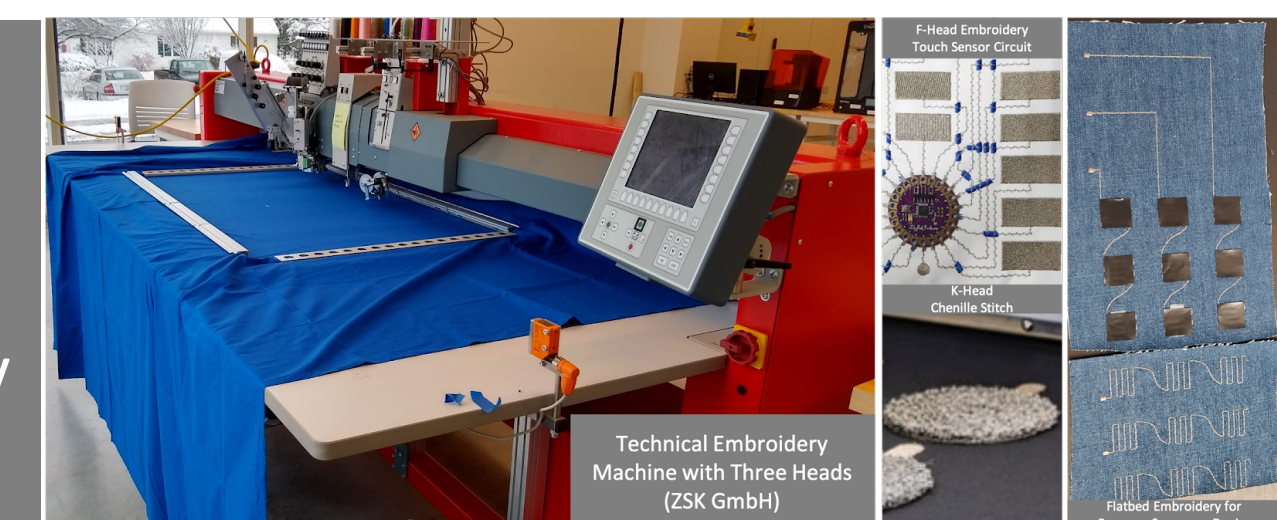
Smart Gloves
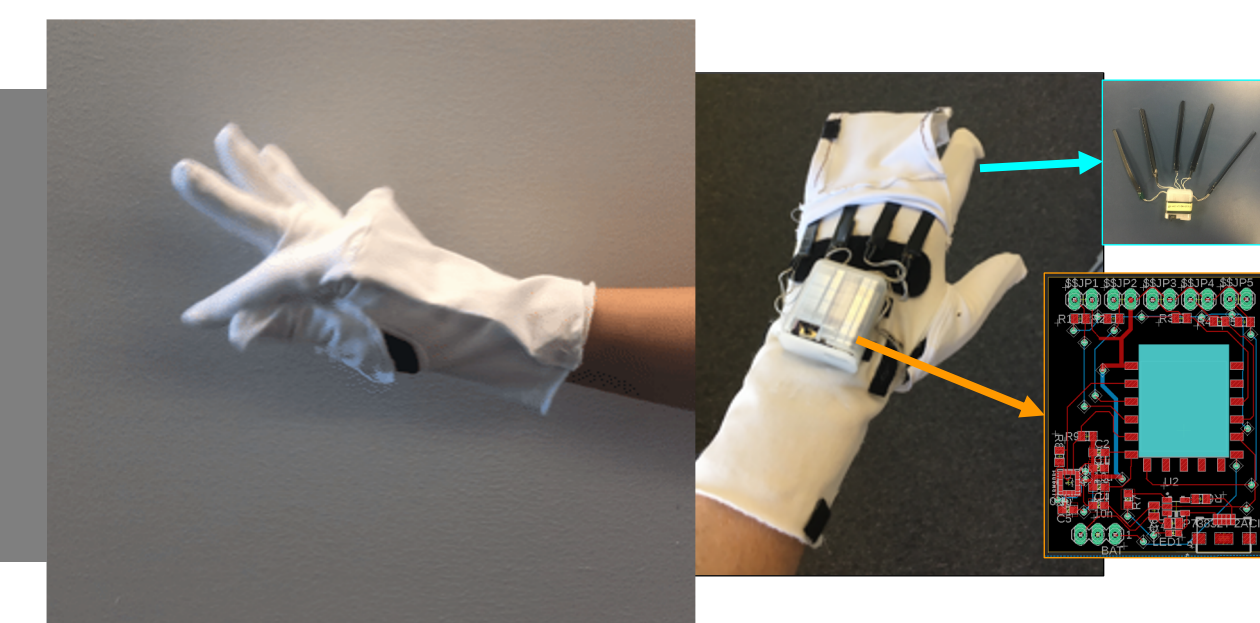
Finger Tapping
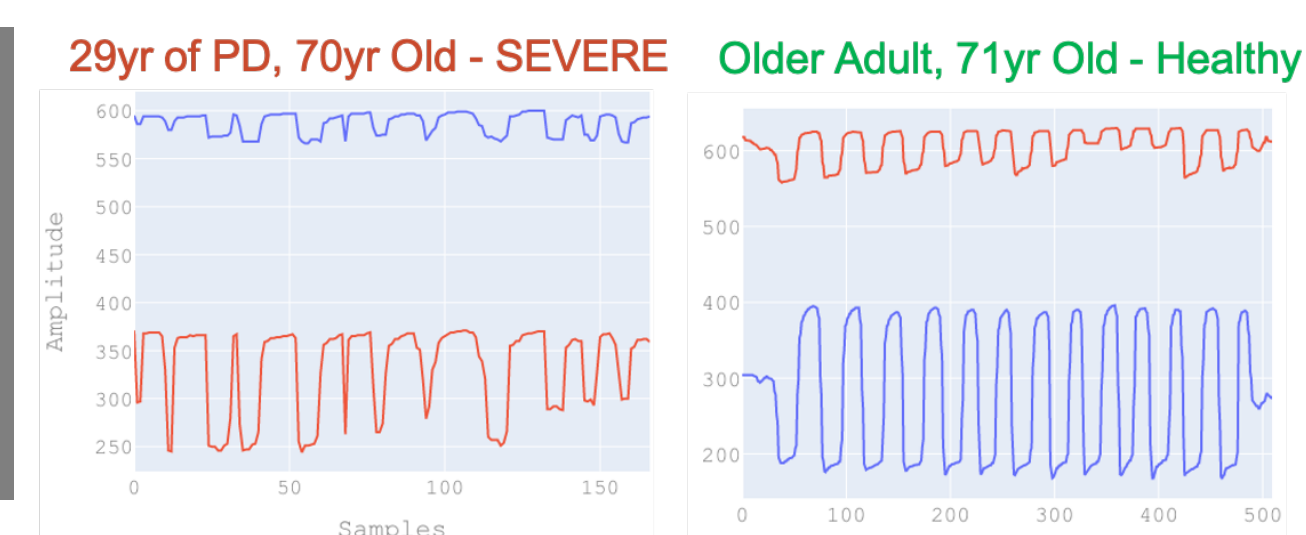
Smart Insoles

Smart Textile Embroidery

HealthHacks & K-12 Outreach Activities