Novel Smart Sensor Glove for Arthritis Rehabilitation

Brendan O'Flynn, Javier Torres Sanchez, Philip Angove,
Tyndall National Institute, WSN Group, Cork, Ireland.
James Connolly, Joan Condell and Kevin Curran,
University of Ulster, N. Ireland

Tyndall National Institute — Institiúid Náisiúnta

This work presents the NAP348 project to develop a smart glove to facilitate the arthritis rehabilitative process through the integration of sensors, processors and wireless technology

Rheumatoid arthritis is a chronic, inflammatory **joint disease**. **Stiffness, swelling and deformity** are the most common symptoms. Approximately **20% to 30% of people become work disabled** within the **first two to three years** of the disease
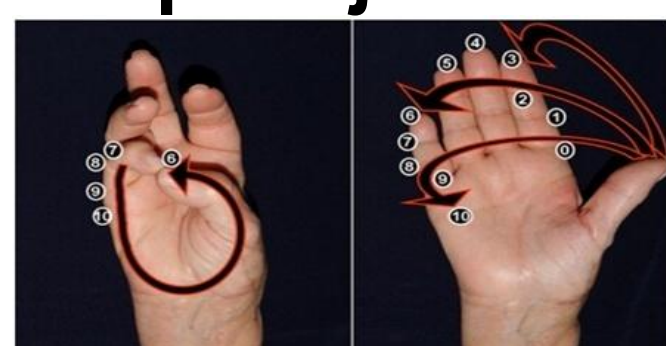
Clinical Assessment Techniques

A **Health Assessment Questionnaire** (HAQ) determines the patient ability to perform daily tasks

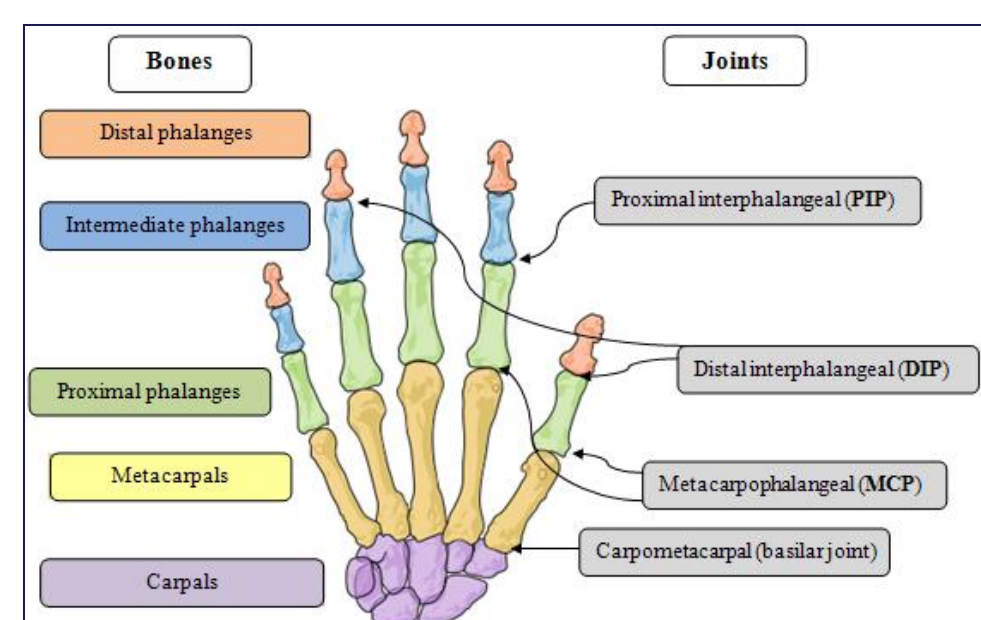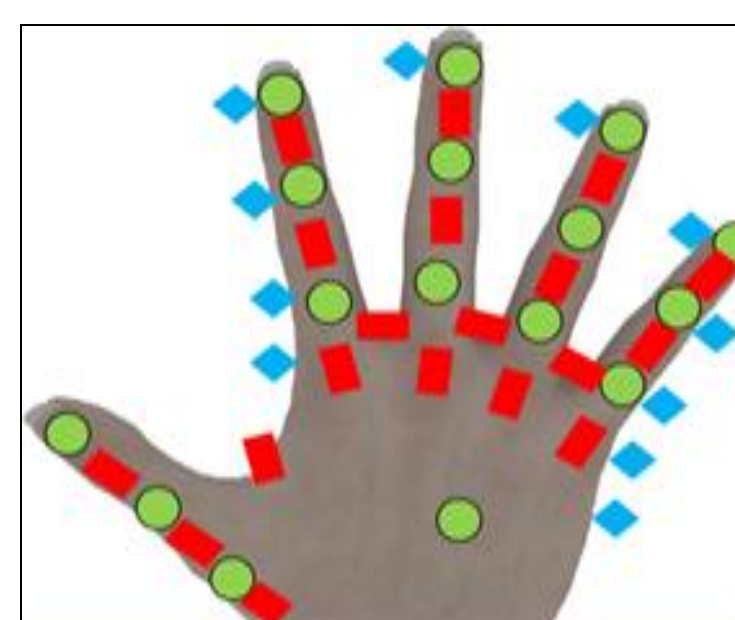**Goniometer**   **Kapandji score**   **Grip strength**

- Based on **manual assessment techniques**
- It is a **time consuming process**
- To date, **join stiffness is not sufficiently quantified** and it is difficult to measure empirically

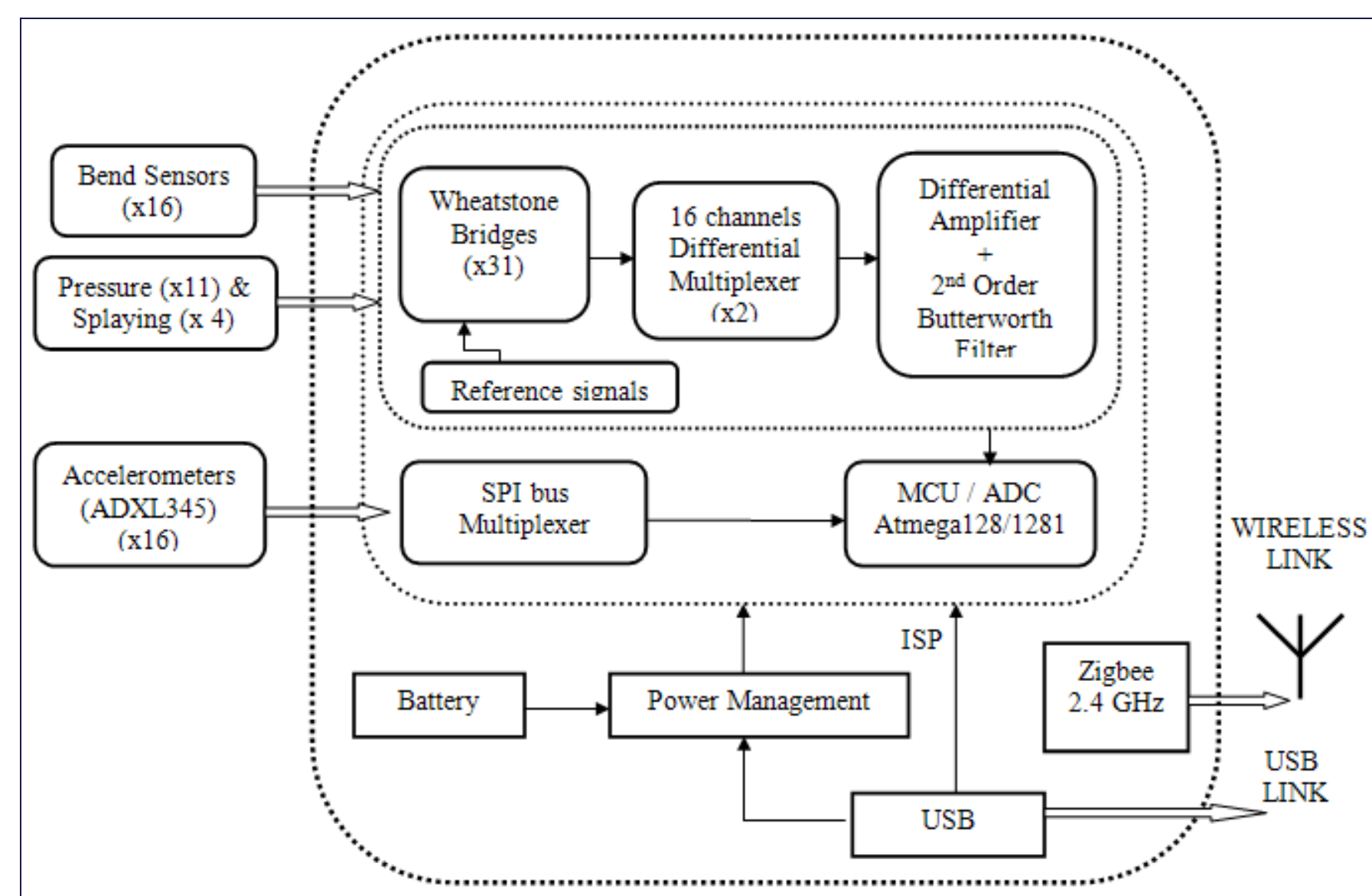### Biomechanical model, Sensor Choice & Positioning

Bones — Distal phalanges, Intermediate phalanges, Proximal phalanges, Metacarpals, Carpals
Joints — Proximal interphalangeal (PIP), Distal interphalangeal (DIP), Metacarpophalangeal (MCP), Carpometacarpal (basilar joint)

- **Biomechanical model:** The Objective is **to identify** the degrees of freedom
- **Sensor Choice & Positioning**: Sensors and their positioning need **to account for the identified** degrees of freedom
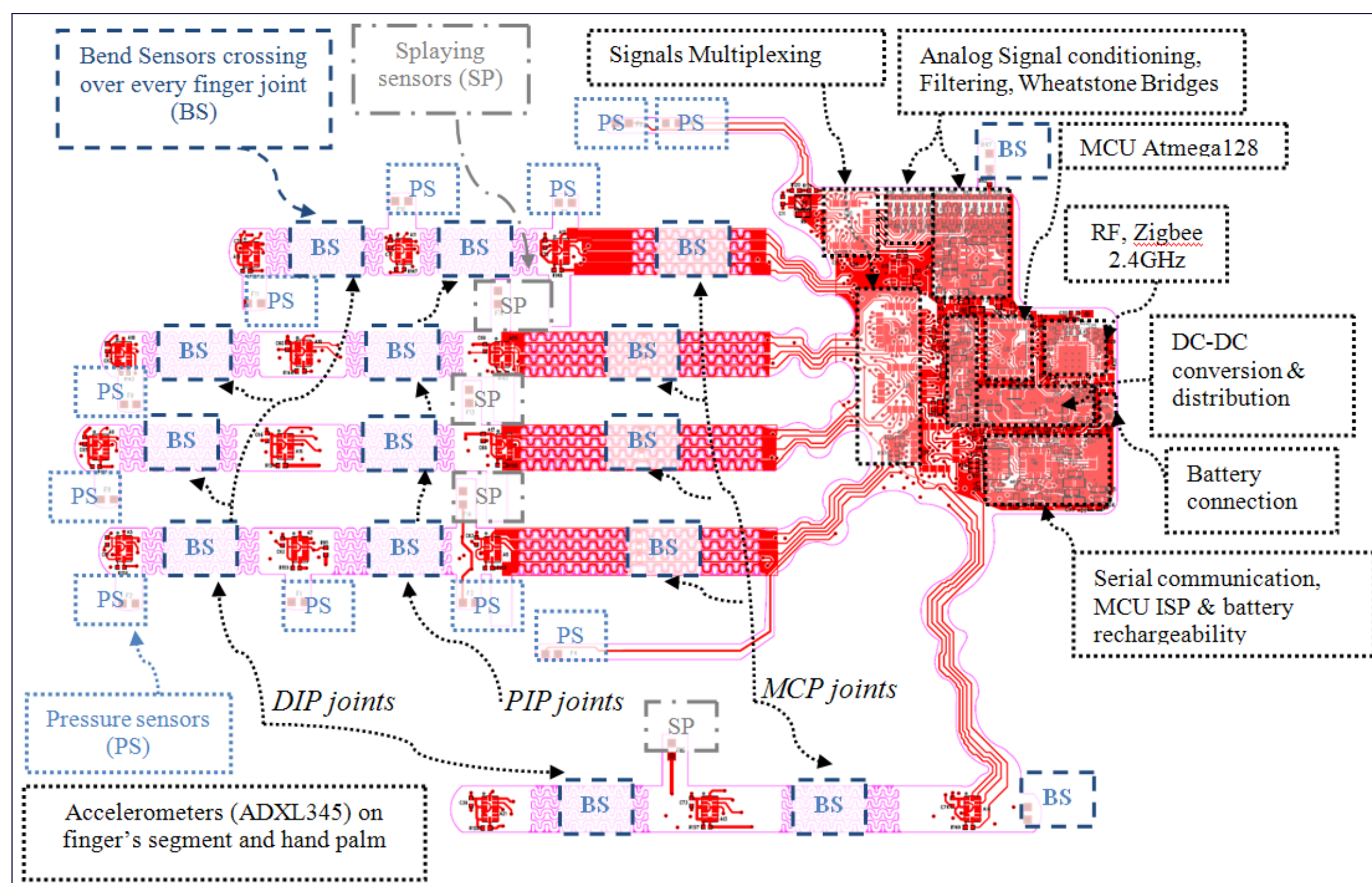
■ Bend Sensor
◆ Pressure Sensor
● 3-Axis Accelerometer

System Design

Bend Sensors (x16) → Wheatstone Bridges (x31) → 16 channels Differential Multiplexer (x2) → Differential Amplifier + 2nd Order Butterworth Filter
Pressure (x11) & Splaying (x 4)
Reference signals
Accelerometers (ADXL345) (x16) → SPI bus Multiplexer → MCU / ADC Atmega128/1281
Battery → Power Management → Zigbee 2.4 GHz — WIRELESS LINK
ISP
USB — USB LINK

The **finger's side of the PCB** is expected to be **under flexion repeatedly** under glove usage

Bend Sensors crossing over every finger joint (BS)
Splaying sensors (SP)
Signals Multiplexing
Analog Signal conditioning, Filtering, Wheatstone Bridges
MCU Atmega128
RF, Zigbee 2.4GHz
DC-DC conversion & distribution
Battery connection
Serial communication, MCU ISP & battery rechargeability
DIP joints   PIP joints   MCP joints
Pressure sensors (PS)
Accelerometers (ADXL345) on finger's segment and hand palm

Minimizing the stress under finger flexion, the **meander-type** structure **allows the PCB to undergo large deformations without fracture**
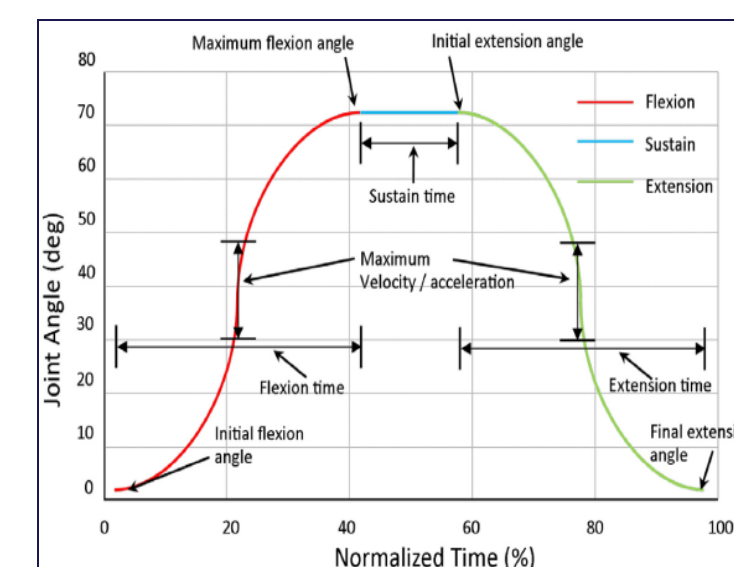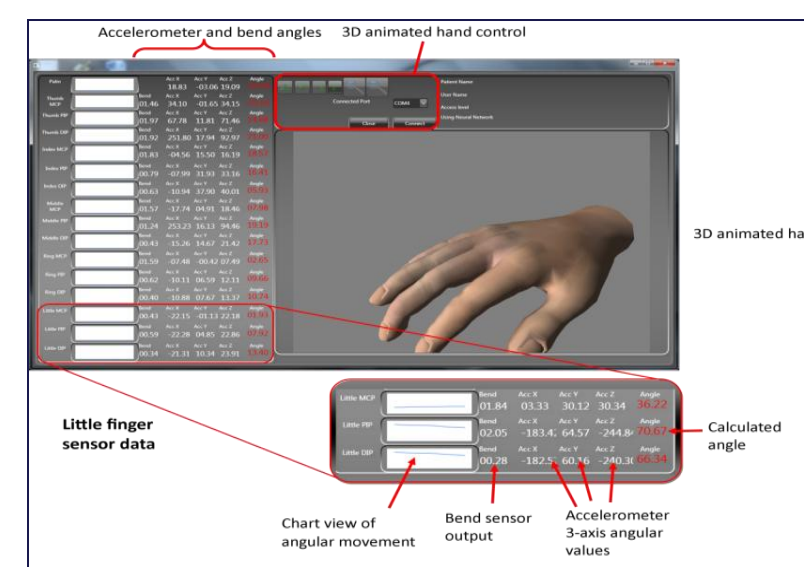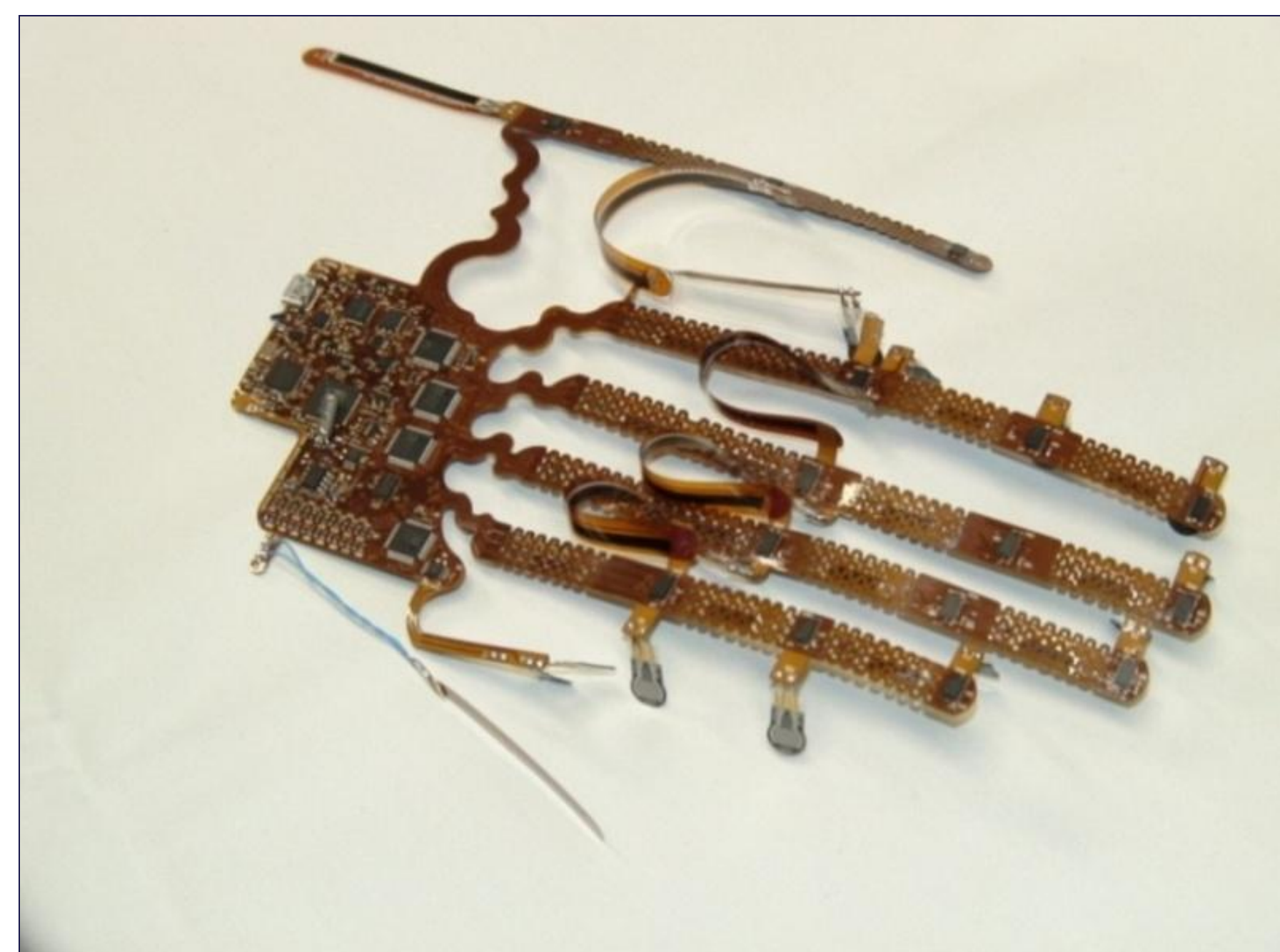
Conclusions

- This glove will help to **quantify** joint stiffness and allow for **joint stiffness** to be **dynamically** and **empirically monitored**
- **Auto Calibration**

Future Work

- **Integration in to glove**
- **Characterisation testing**
- **Test and validation** will commence with **clinical trials**