GAIT MONITORING SYSTEM
- SAFEWALK -

PROPOSAL

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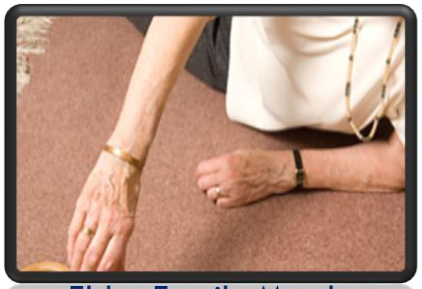
Wireless Sensor Network 18-748 Feb 24th, 2017

Agenda

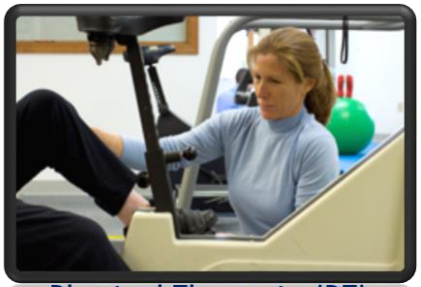
- Motivation
- Introduction to Gait Monitoring
- Hardware / Software Component
- Goal & Scope
- Role & Responsibility
- Purchase List
- Schedule

Motivation

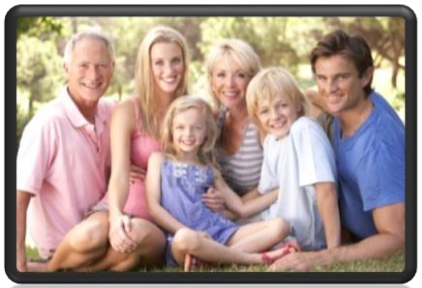
Gait Monitoring can be linked to a variety of intrinsic health related factors : past falls, medication use, neurological issues, weak muscles and lack of posture, sensory impairments, etc.



Elder Family Member



Physical Therapist (PT)



Family

U.S. Government

Intro – Difference in Gait

Knee extension

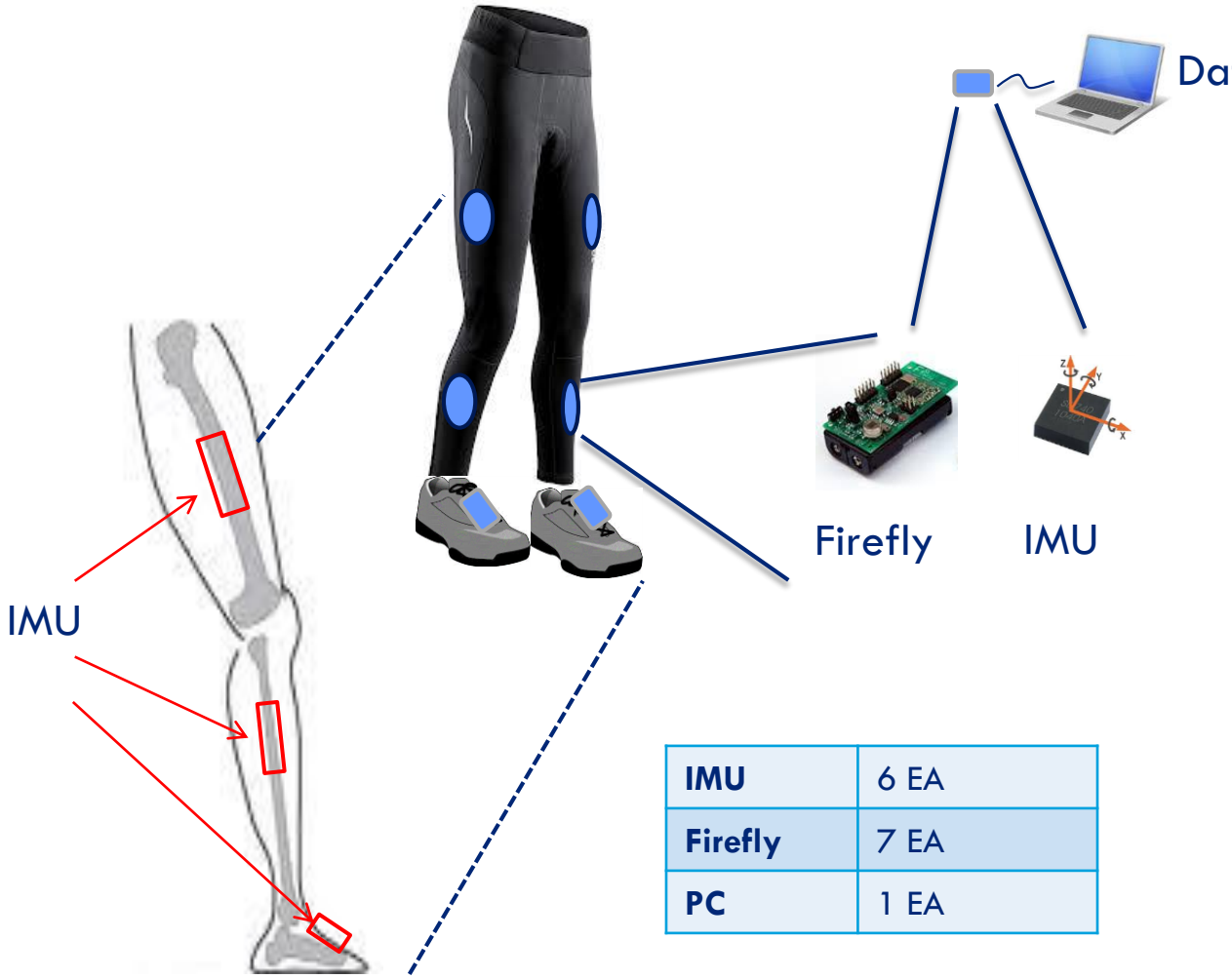
Stride length

Source: Ostrosky, VanSwearingen, Burdett, and Gee. A Comparison of Gait Characteristics in Young and Old Subjects. Journal of the American Physical Therapy Association. 1994. http://ptjournal.apta.org/content/74/7/637.

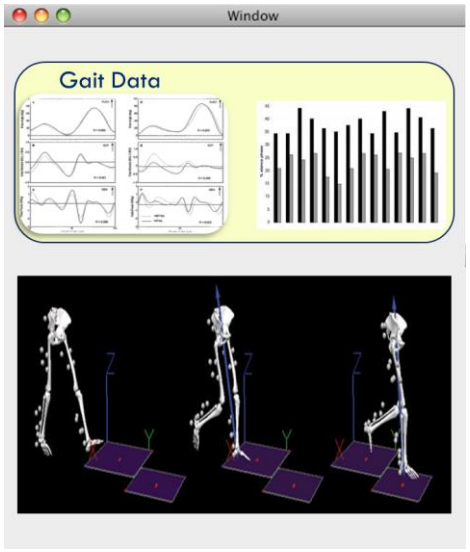
Intro - Gait Data

- Gait Speed
- Cadence
- Stride Length
- Double Stance Time
- Knee extension
- Swing Time
- Stride Length Variability
- Swing Time Variability
- Cadence Variability

System Configuration



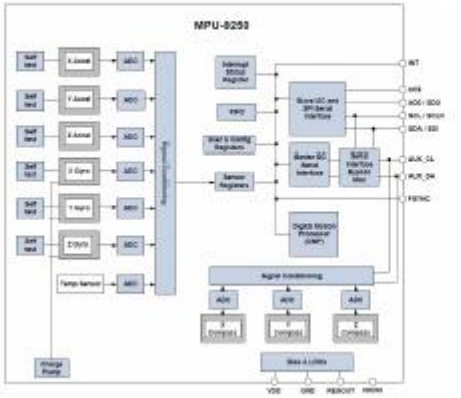
Firefly IMU



IMU	6 EA
Firefly	7 EA
PC	1 EA

System Configuration - IMU

SparkFun 9DoF Razor IMU M0



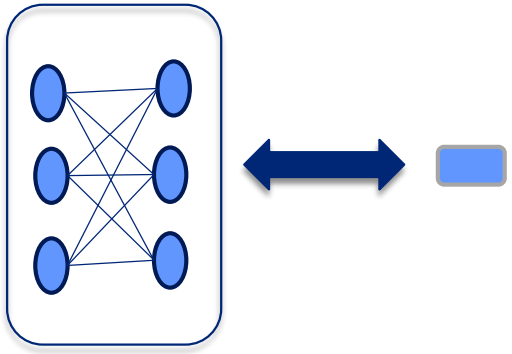
3-Space Embedded IMU

Goal & Scope

- Data Communication
- Multiple IMU Calibration
- IMU Data Process (Noise, Estimation etc.)
- Gait Data Analysis
- Visualization
- Real-time warning
- Sensor Enclosure box Design & Fabrication

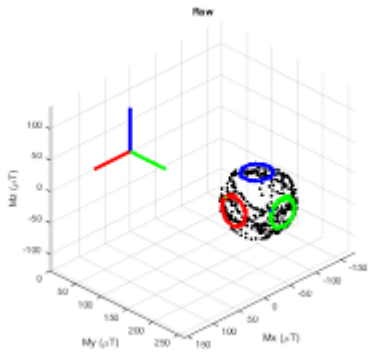
Goal & Scope

- Data Communication
  - Master-to-slave
  - Packet loss detection
  - Synchronization
  - Data logging

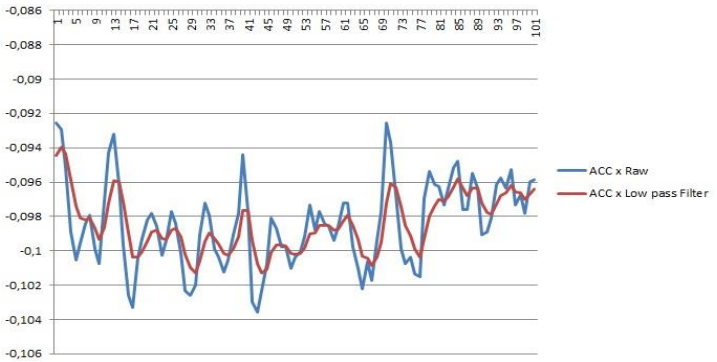


Goal & Scope

- Multiple IMU Calibration
  - Position & Orientation



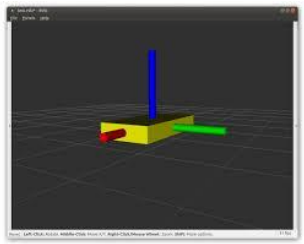
- IMU Data Process (Noise, Estimation etc.)
  - Kalman Filter

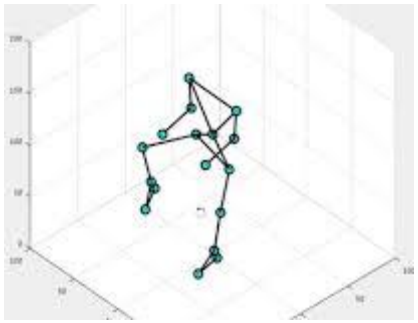


Goal & Scope

- Gait Data Analysis
  - Gait Speed
  - Stride Length
  - Swing Time
  - Knee extension (optional)

- Visualization
  - Data
  - Motion (optional)

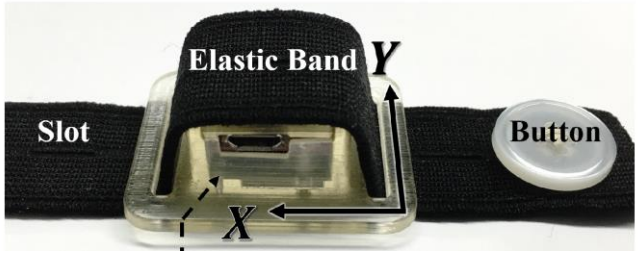




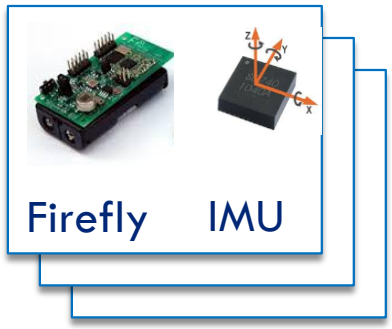
Goal & Scope

- Real-time warning (optional)
  - Gait-Change Detection

- Sensor Enclosure box Design & Fabrication



Implementation Plan



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Data server

ROS

- Data Communication (Topology, Error recovery..)
- Multiple IMU Calibration (Manual, Automatic)
- IMU Data Process (Noise, Estimation etc.)

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- Multiple IMU Calibration (Manual, Automatic)
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- Gait Data Analysis
- Visualization
- Data Logging

Role & Responsibility

- EMILY
  - Data Communication (between nodes)
  - Multiple IMU Calibration
  - Gait Data Analysis
- ALEX
  - Multiple IMU Calibration
  - IMU Data Process
- ILJOO
  - Gait Data Analysis
  - Data Communication (between node and PC)
  - Visualization
  - Data Logging

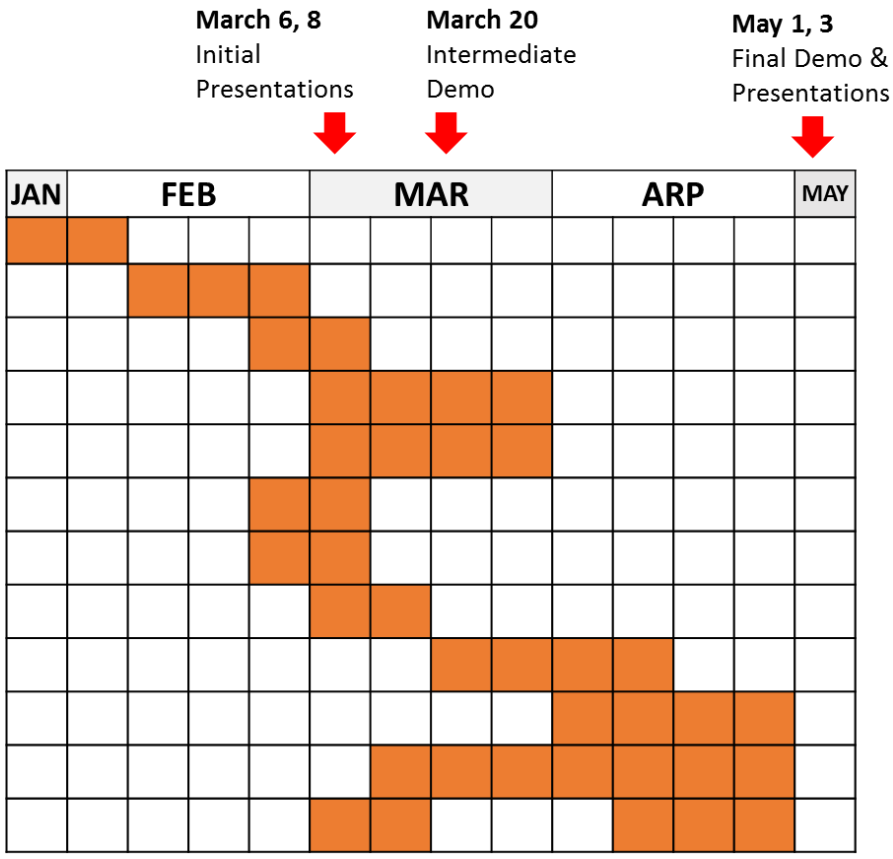
Purchase List

- Items to be purchased
  - Box Fabrication ($0)
  - Straps (<$20)
  - IMUs*) ($50 x 4 + $140 x 2 = $480)
  - Battery (<$50)
  - Total : ~$550

*) IMUs would be reusable for Alex's research project

Schedule

Dev. Environment setup	Project Proposal
	Study existing technology and literature
	Platform setup
Communication	Comm. Between node and data PC (Iljoo)
	Comm. Between IMU and Node (Emily)
	Define protocol (Iljoo)
Calibration	Search IMU Product (Alex, Emily)
	Individual IMU calibration (Emily, Alex)
	Multiple IMU calibration (Emily, Alex)
Analysis	Algorithm to extract Gait information
	Visualize gait information (Iljoo)
Fabrication	Attach node to body



Reference

- Anatomical Calibration through Post-Processing of Standard Motion Tests Data
  - http://www.mdpi.com/1424-8220/16/12/2011/htm
- Gait Analysis Using Wearable Sensors
  - http://www.mdpi.com/1424-8220/12/2/2255/htm
- Symbolic Modelling of Dynamic Human Motions
  - http://www.intechopen.com/books/biosensors/symbolic-modelling-of-dynamic-human-motions#
- Assessment of walker-assisted gait based on Principal Component Analysis and wireless inertial sensors
  - http://www.scielo.br/pdf/rbeb/v30n3/03.pdf
- Gait and Foot Clearance Parameters Obtained Using Shoe-Worn Inertial Sensors in a Large-Population Sample of Older Adults
  - file:///C:/Users/iljoo/Downloads/sensors-14-00443.pdf
- Automatic pairing of inertial sensors to lower limb segments – a plug-and-play approach
  - https://www.degruyter.com/downloadpdf/j/cdbme.2016.2.issue-1/cdbme-2016-0155/cdbme-2016-0155.pdf