Sensor-Assessed Clinic versus Home Gait Measures in At-Fall Risk Older Adults

Fall 2023 NIMLAS Pilot Award

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Aims

- The primary objective of this research is to utilize a pair of wearable sensors to analyze kinematic data collected throughout the performance of a battery of common, standardized mobility assessments, which will be completed in both a MRC setting and the participant's home.
- In addition to standard gait kinematics (such as step velocity), we propose collecting innovative, balance-performance and fall-risk impactful measures (such as turning radius) on a step by step basis, in addition to a variability analysis of each measure.
- Finally, machine learning will be applied to these real-world standard and novel gait kinematics to predict participant balance impairment.

The alternative… miniature wearable sensors

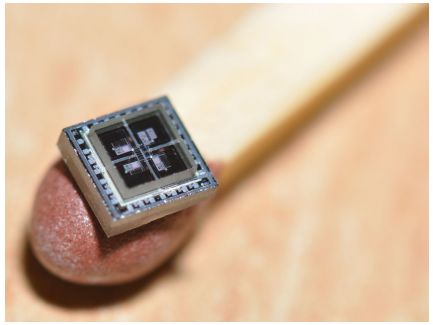
Gold standard

Very expensive

Complex setup

Requires an operator

Confined to lab spaces



Validated with gold standard

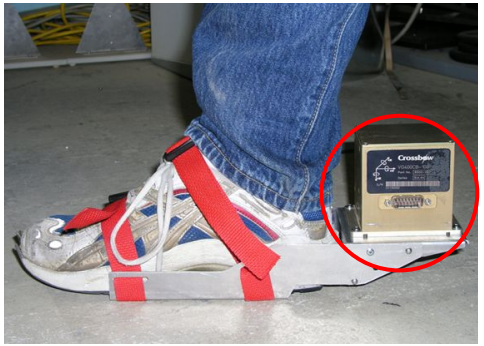
Inexpensive

Wear and go

Subject operated

Work anywhere

How did we get to this point?



2003

2006

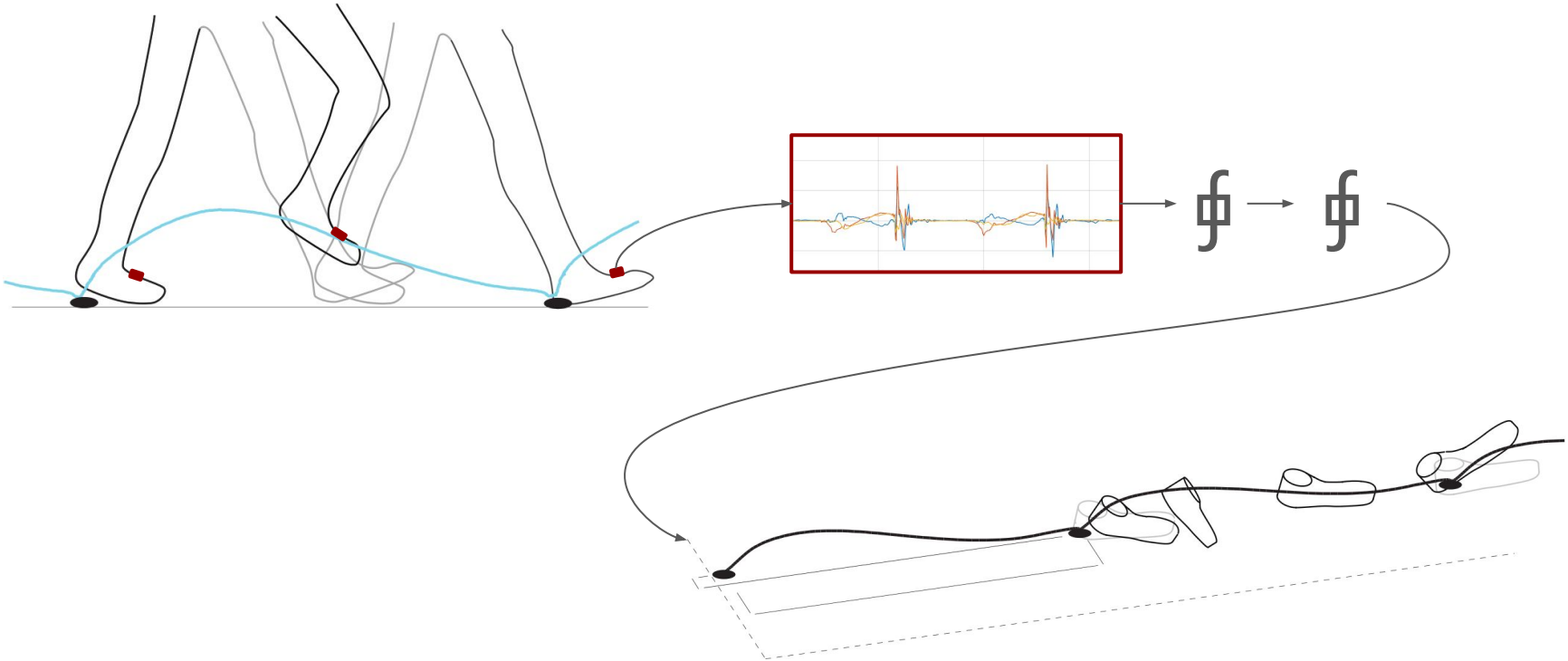
2009

2013+

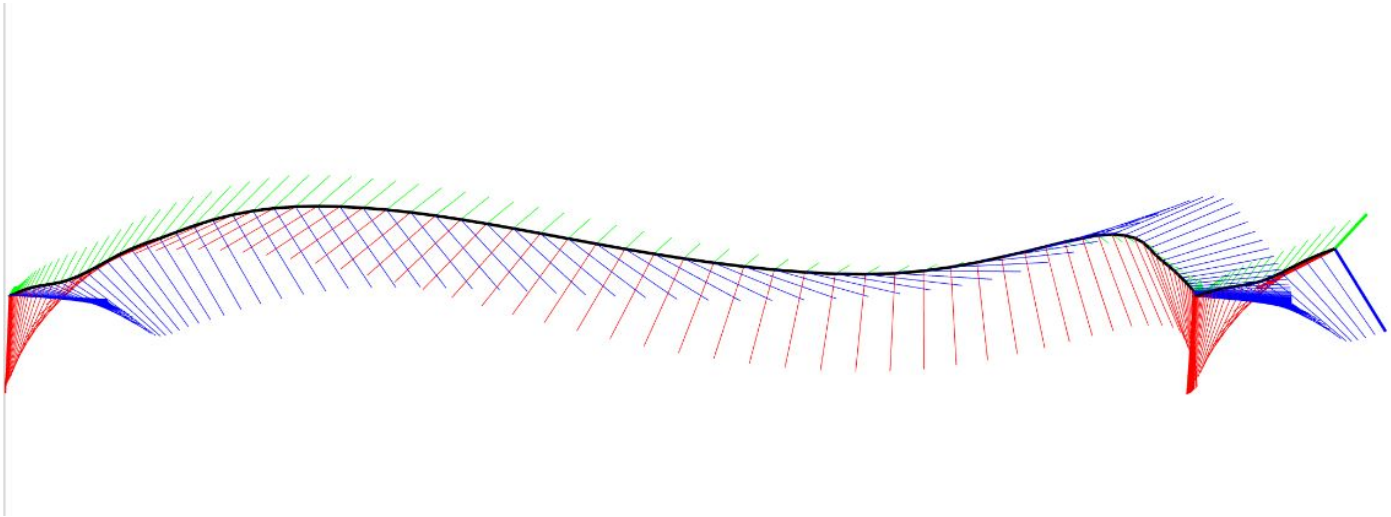
DISCLAIMER: I own Navigation Solutions LLC, a real-time foot tracking system manufacturer.

Our innovative algorithms turn signals into motion data

(2003 – Ojeda, Borenstein)

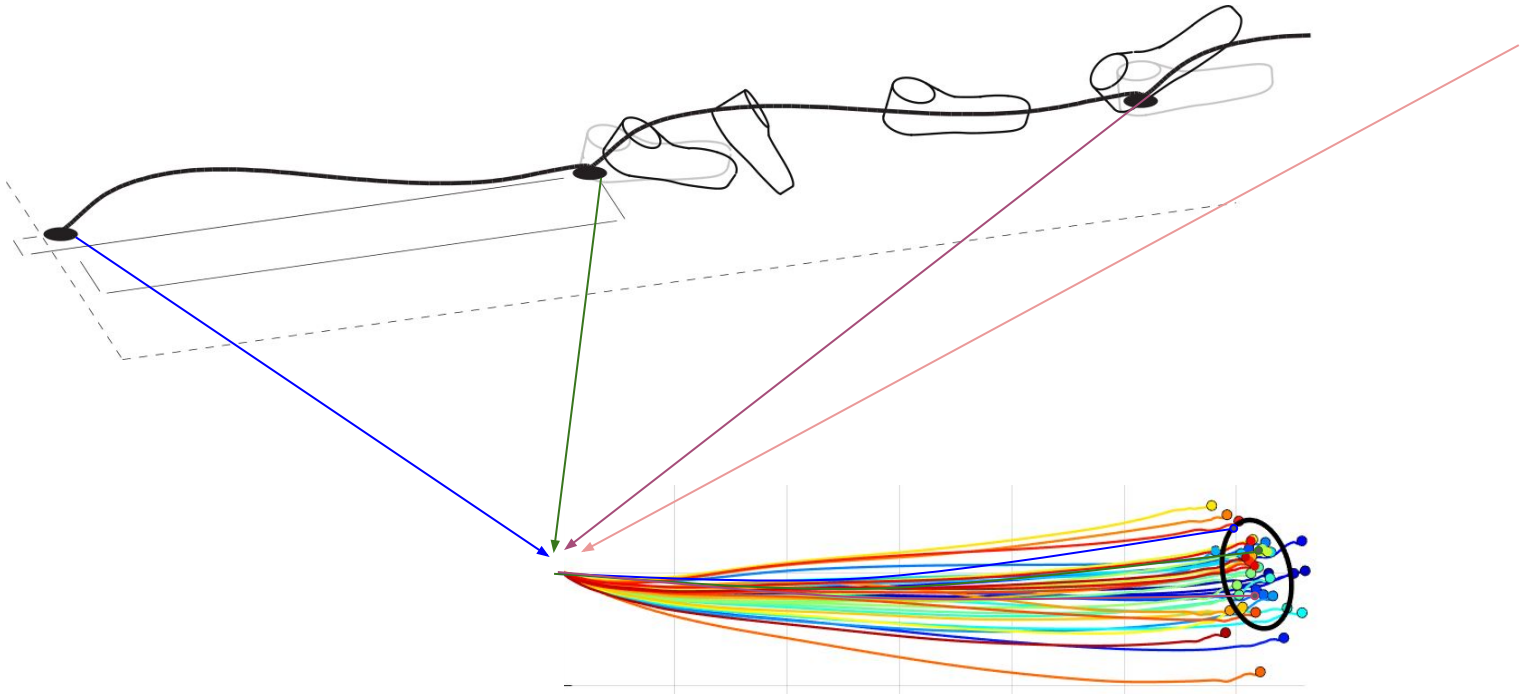


One step, a wealth of information



Wearable sensors provide comprehensive information

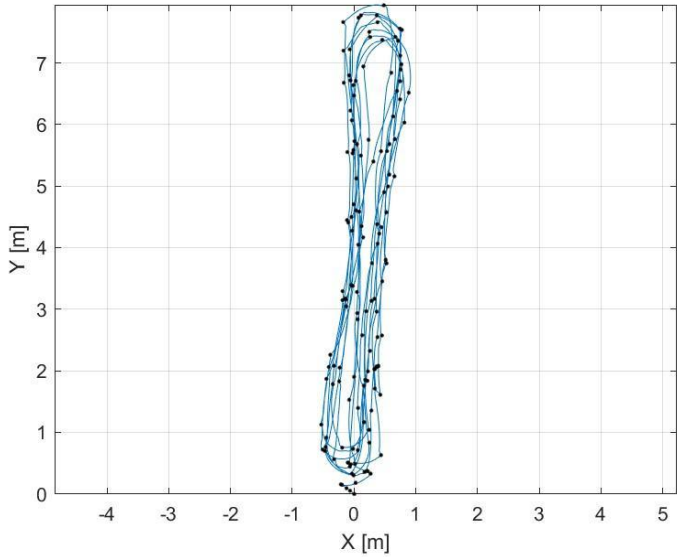
(2011: Ojeda, Kuo, Adamczyk)



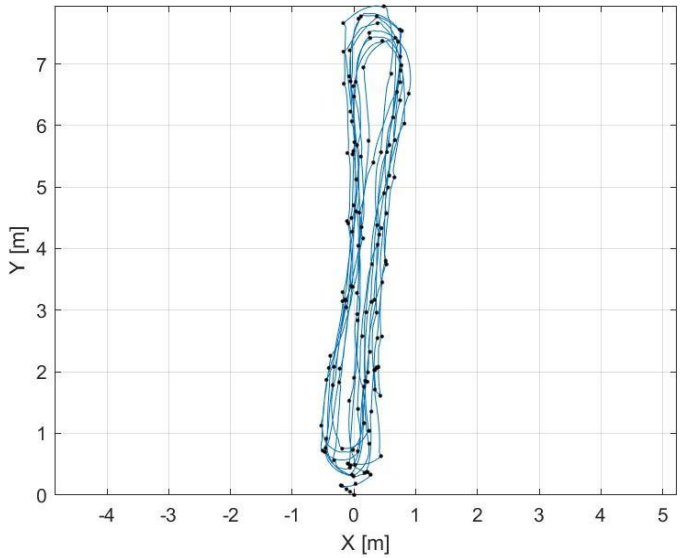
Pilot testing

- N=5 Age: 74 (72-90) - mean (range)
- N=3 Best unipedal stance < 10 sec (indicator of impaired balance)
- N=3 Timed up and go ≥ 13 sec (higher fall risk)
- Wore two IMUs, one on each foot
- Performed the 2-min walk in the clinic and at home (supervised)

Two-minute walk at clinic

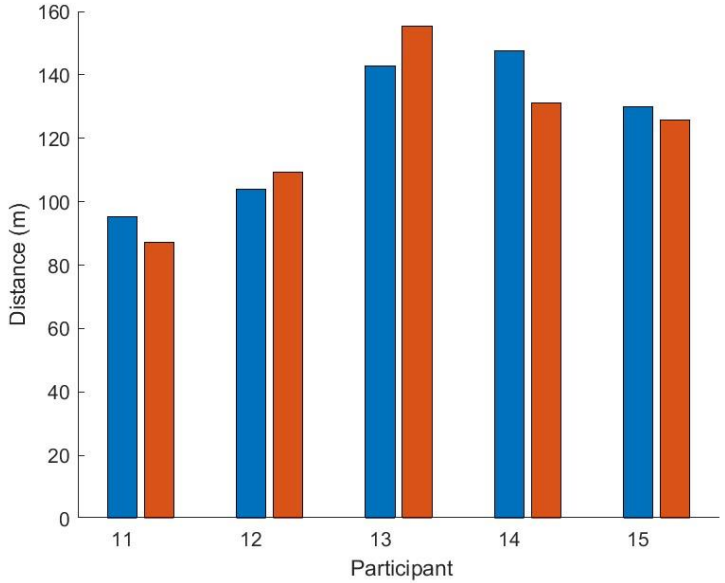


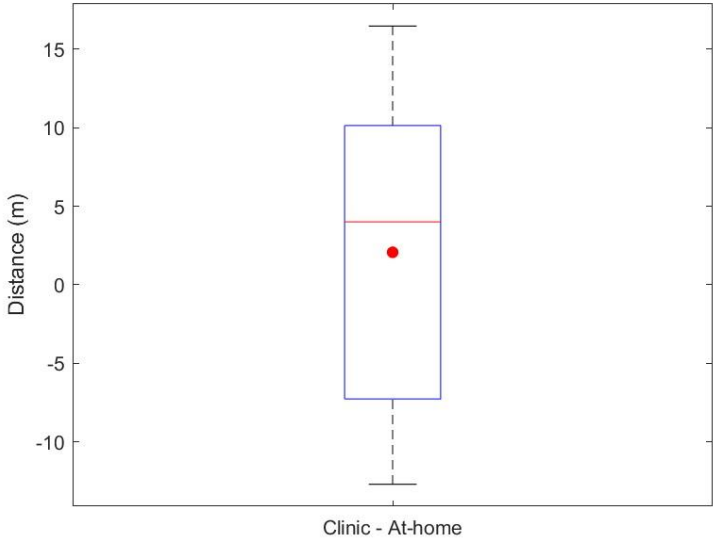
Two-minute walk at home



iPad is used to guide participants

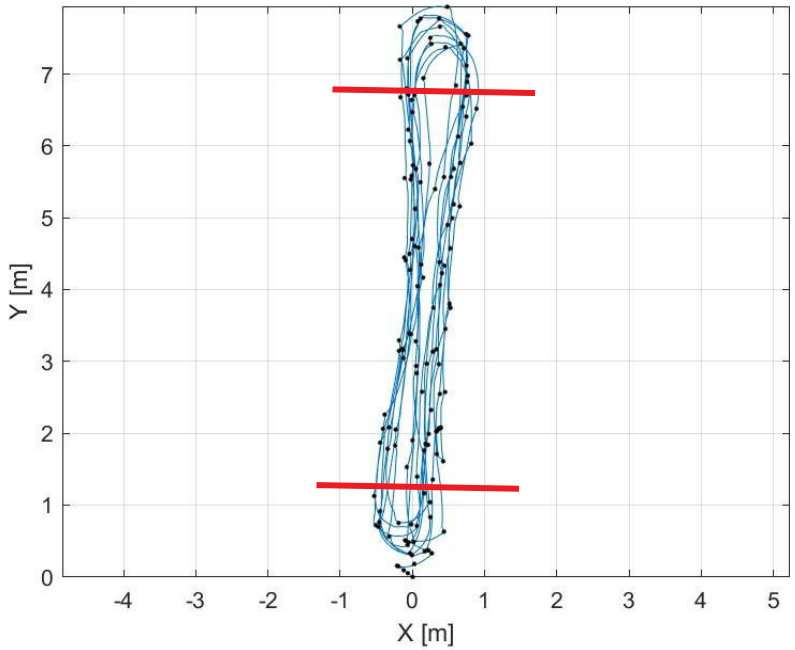
Two-minute walk distance: Clinic vs. Home



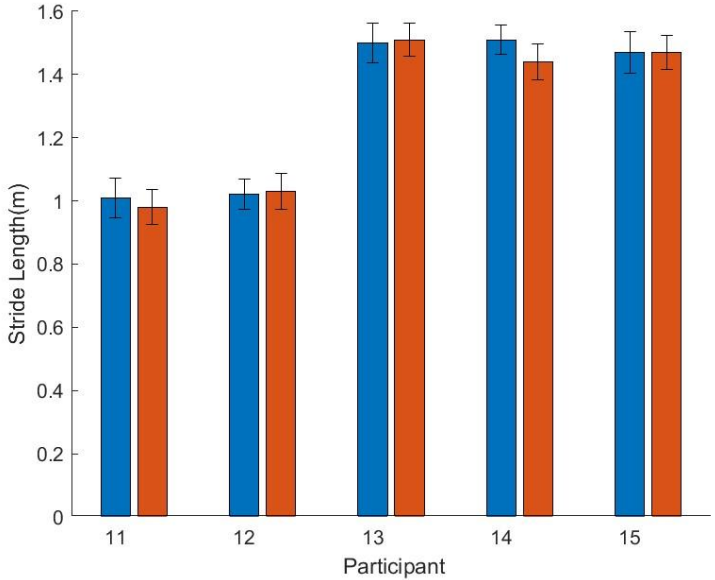


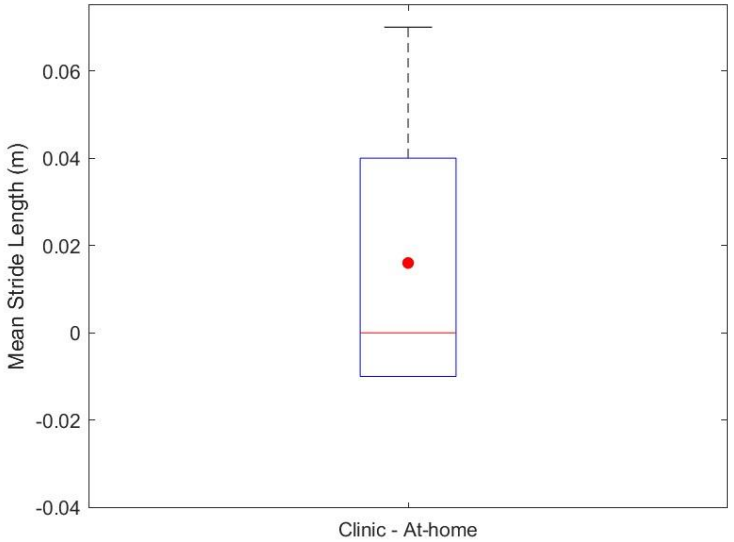
Clinic At home

Straight walk segmentation



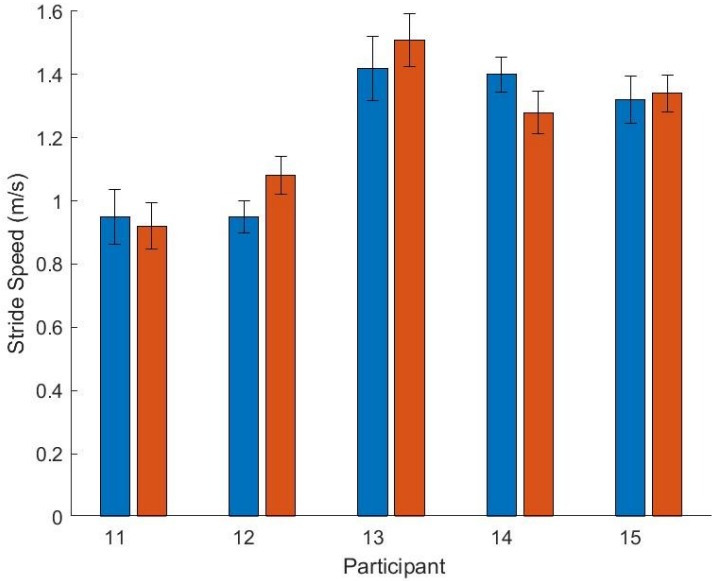
Stride length on straight segments

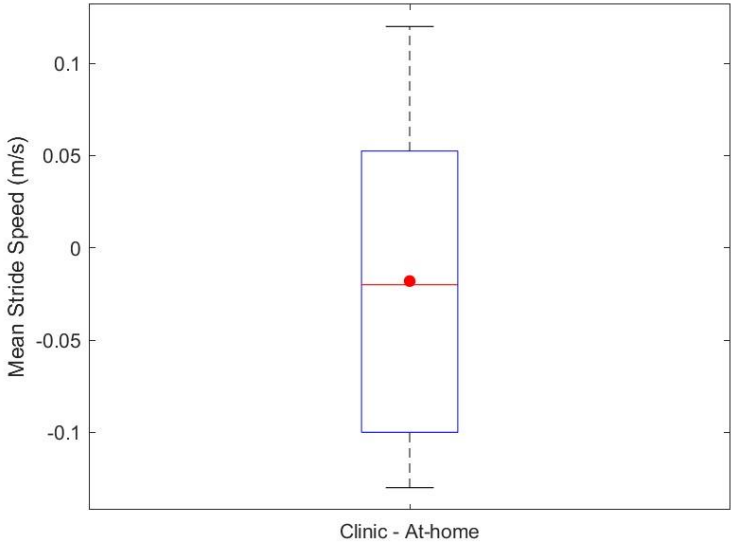




Clinic At home

Stride speed on straight segments





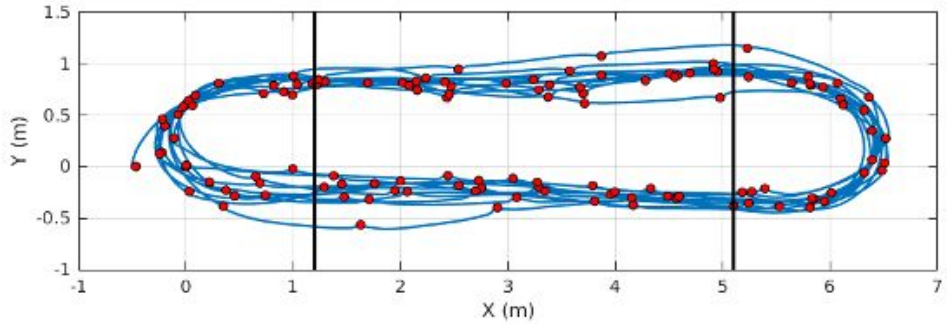
Clinic At home

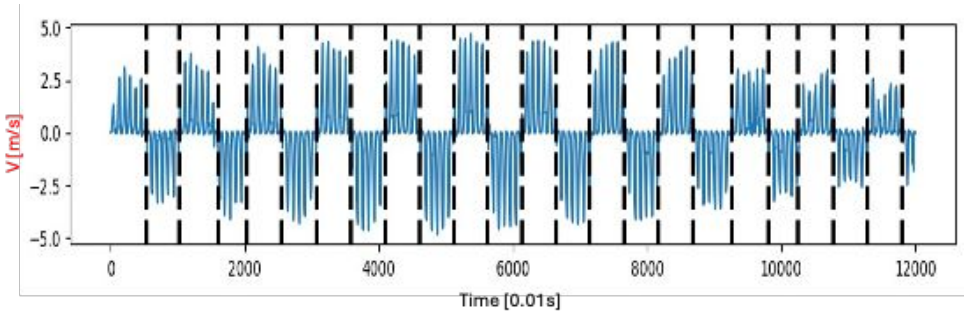
Is there a difference of 2MW between in-clinic vs. at-home?

- **Null hypothesis:** no significant difference
- **Alternative hypothesis:** significant difference
- **Selection of level of significance:** probability that the observed statistics occurred by chance

Variable	*Unit*	*Description*
A	m/s^2	Raw acceleration
W	radian/s	Raw angular velocity
$Quaternion$	/	Foot orientation (quaternion rotational angles)
Euler		Foot orientation (Euler rotational angles)
P		Foot position
V	m/s	Foot velocity

Hypothesis testing workflow





1. Segment time series using automated change-point detection

2. Extract summary statistics for segments

3. Calculate p-value for these statistics based on individual variable testing

4. Apply Holm–Bonferroni correction to counteract the problem of multiple comparisons

5. Compare p-values for overall statistical significance

Findings so far

- **Variable component level (single components):** all variables have at least one component that shows no significant difference

- **Variable level (all components):** significant differences exist in both the mean and covariance of all six variables

- **Patient level (multi-variable):** slower gait performance is likely to occur at-home compared to in-clinic

Acknowledgement

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