

Gait Abnormality Diagnosis with wearable device



Zhaoxi Zhang
Mechanical Engineering

Outline:

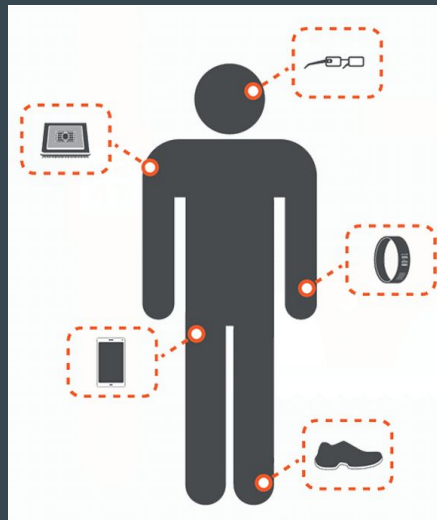
- Background
 - Data from wearable device
 - Importance of gait abnormalities
- Motivation
 - Telemedicine
 - Potential
- Project Components
 - Hardware
 - Algorithm
 - Future work: Interface

Background and Motivation

- Importance of gait

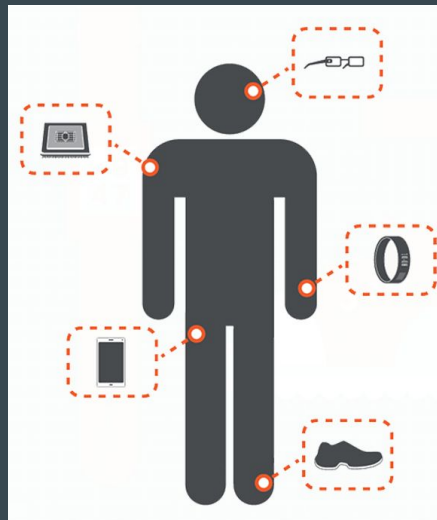
Background and Motivation

- Importance of gait
- Popularity of wearable devices



Background and Motivation

- Importance of gait
- Popularity of wearable device
- Willingness to share data

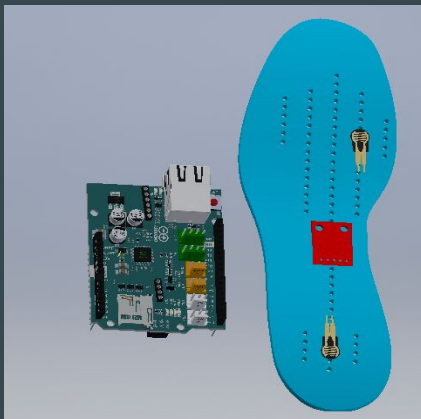
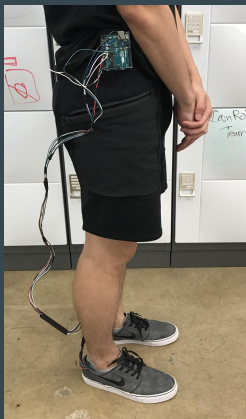


Background and Motivation

- Importance of gait
- Popularity of wearable device
- Willingness to share data
- Project potential influence
 - Shorten diagnosis time
 - Cost saving

Hardware

- 9 DOF IMU and Force Sensor on Shoe insole
 - Acceleration on x,y,z axes
 - Angular acceleration around x,y,z axes
 - Voltage to represent force

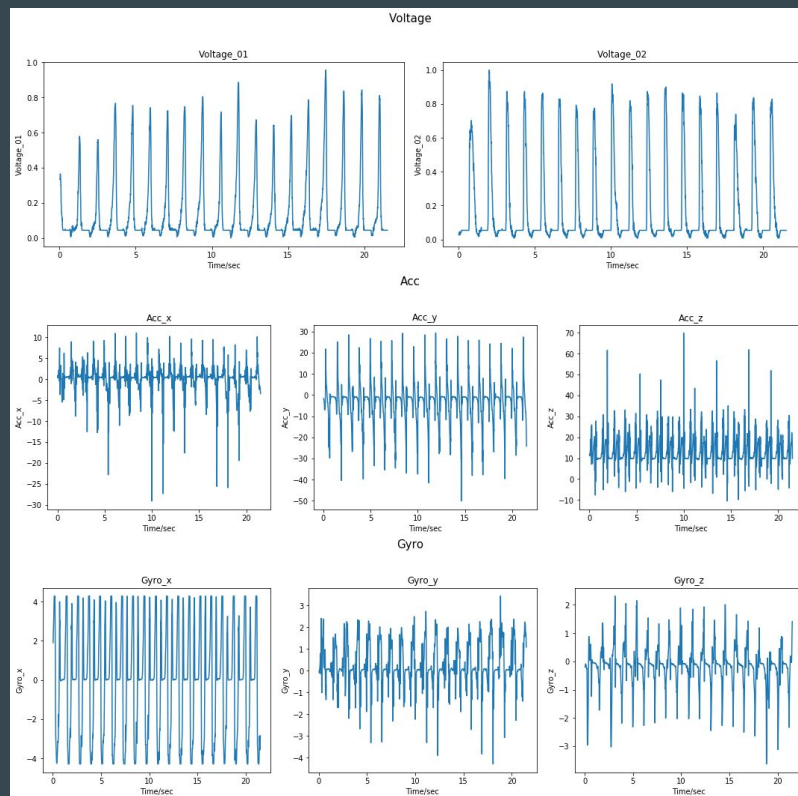


FlexiForce



LSM9DS1

Hardware



Data Collection

- Four Categories
 - Tendem Gait
 - Inward
 - Outward
 - Normal



Data Collection

- Four Categories
 - Tendem Gait
 - Inward
 - Outward
 - Normal



Data Collection

- Four Categories
 - Tendem Gait
 - Inward
 - Outward
 - Normal



Data Collection

- Four Categories
 - Tendem Gait
 - Inward
 - Outward
 - Normal



Algorithm

- Gait Phase State Machine
- Feature Engineering and classification algorithm
- Long Short - Term Memory Recurrent Neural Network for classification

Algorithm

- State Machine Approach:

- Four Gait Phases

- Stance
- Heel Off
- Swing
- Heel Strike

- Normal Gait Transition:

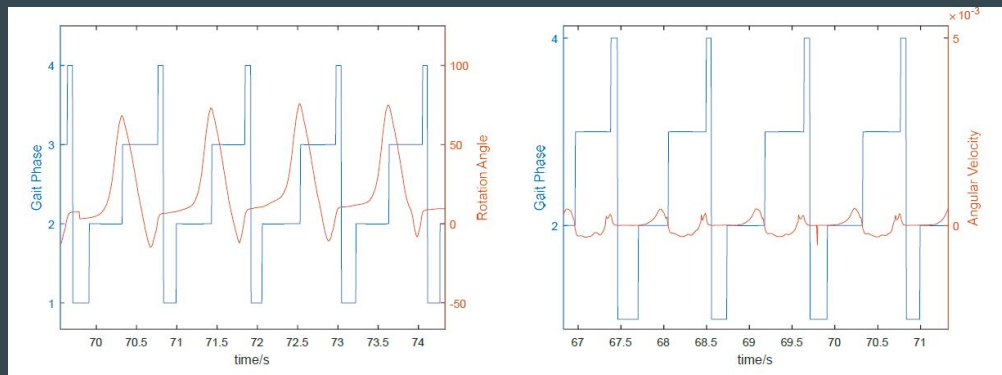
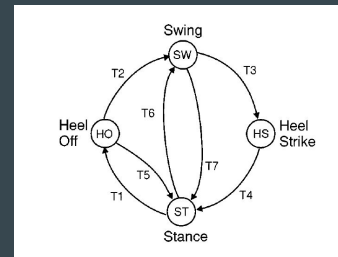
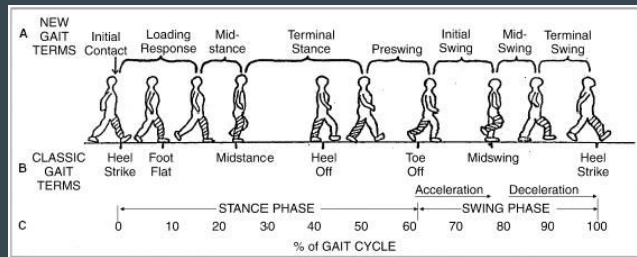
- T1: ST to HO
- T2: HO to SW
- T3: SW to HS
- T4: HS to ST

- Non-walking Transition:

- T5: HO to ST

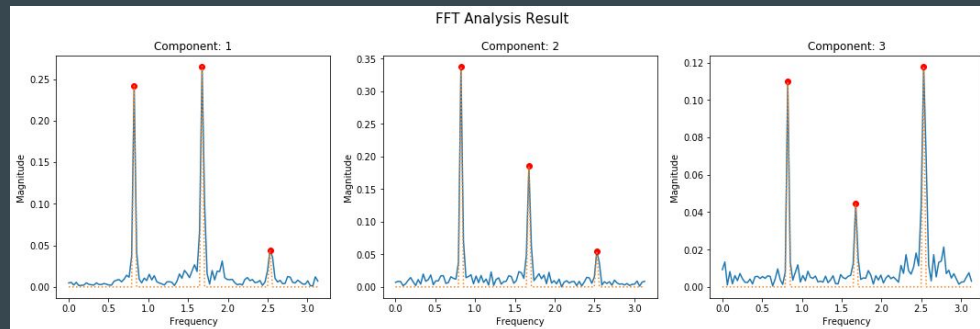
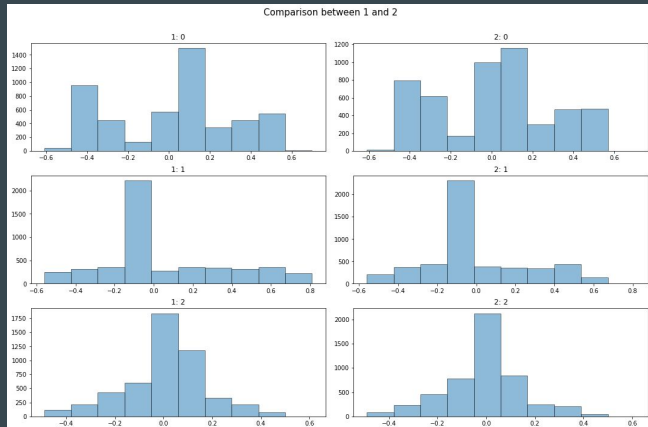
- Abnormal Gait Transition:

- T6: ST to SW
- T7: SW to ST



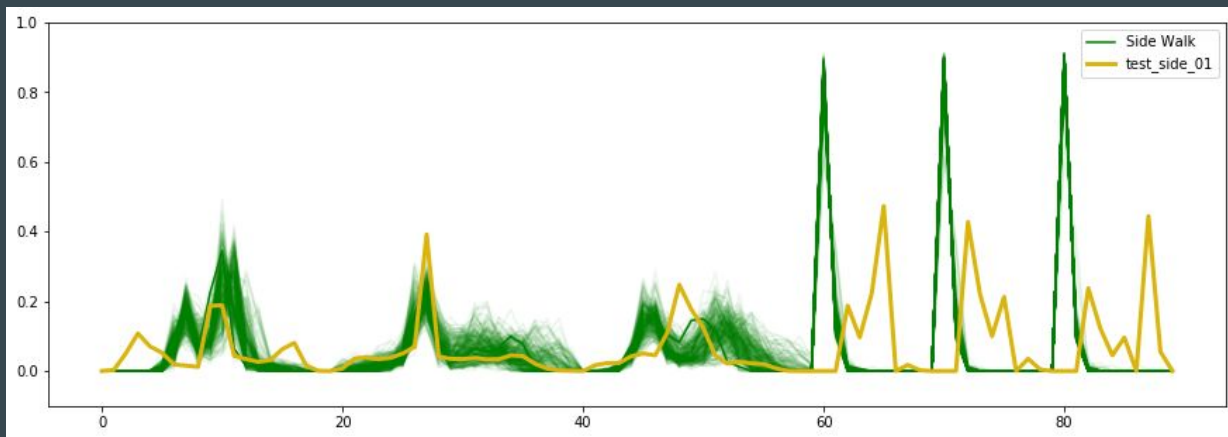
Algorithm

- Feature Engineering
 - Dimension Reduction: Principal Component Analysis (PCA)
 - Distribution Feature: Histogram
 - Frequency Feature: FFT



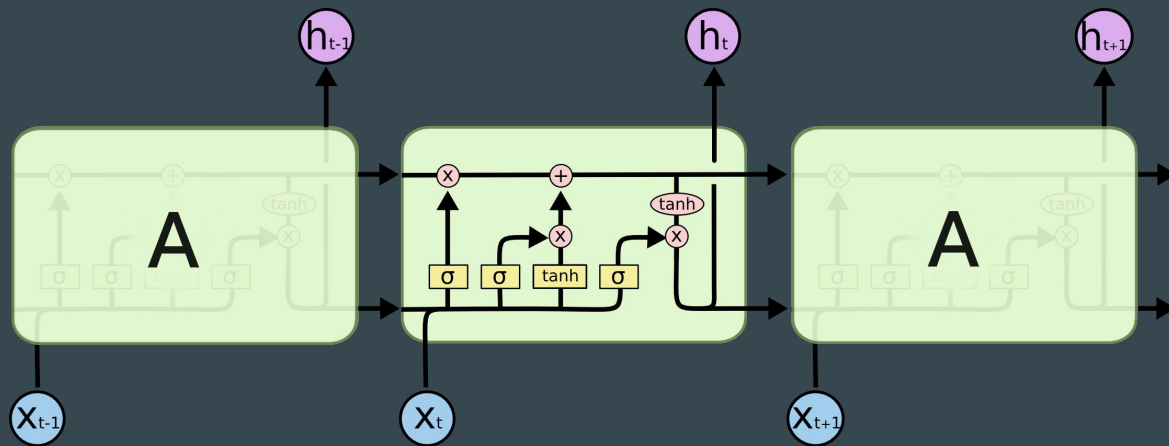
Algorithm

- Feature Engineering
 - Dimension Reduction: Principal Component Analysis (PCA)
 - Distribution Feature: Histogram
 - Frequency Feature: FFT



Algorithm

- Long Short-Term Memory RNN

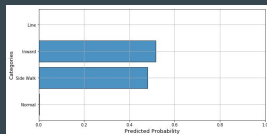
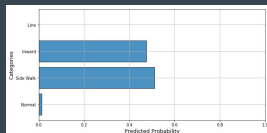
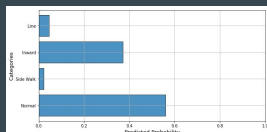
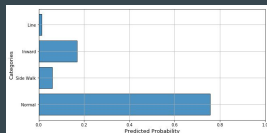


Algorithm

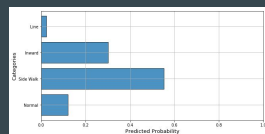
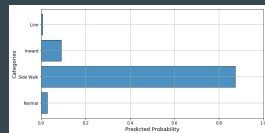
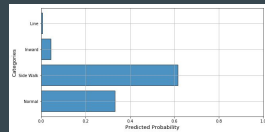
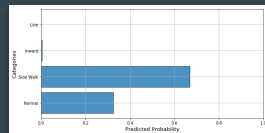
Outward



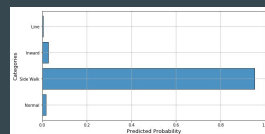
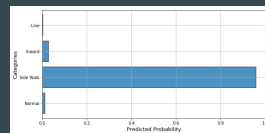
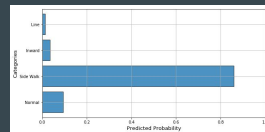
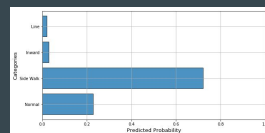
- Feature Engineering + Logistic Regression



- Feature Engineering + SVM Platt Scaling



- LSTM RNN



Interface

- Use instructions with caveats
- Interpretable diagnosis result
 - diagnosis results
 - Example videos of certain abnormality to help understanding
 - Potential solution
 - Caveats

Summary

- Importance of gait abnormality
- Hardware and experiment
- Algorithm and experiment
- Future work: interface

Collaboration

- The gait phase state machine approach is implemented collaboratively with YuanKai Zhu.

Reference

- B. Minor, Lloyd. Stanford Medicine 2017 Health Trends Report: Harnessing the Power of Data in Health. 2017, Stanford Medicine 2017 Health Trends Report: Harnessing the Power of Data in Health, med.stanford.edu/content/dam/sm/sm-news/documents/StanfordMedicineHealthTrendsWhitePaper2017.pdf.
- I. P. Pappas and et al., "A reliable gait phase detection system," IEEE Transactions on neural systems and rehabilitation engineering, no. 9.2, pp. 113-125, 2001.
- Zhang, Yinlong, et al. "PCA & HMM based arm gesture recognition using inertial measurement unit." Proceedings of the 8th International Conference on Body Area Networks. ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering), 2013.
- Lipton, Zachary C., et al. "Learning to diagnose with LSTM recurrent neural networks." arXiv preprint arXiv:1511.03677 (2015).
- Verghese, Joe, et al. "Neurological gait abnormalities and risk of falls in older adults." Journal of neurology 257.3 (2010): 392-398.
- Latif, Siddique, Muhammad Usman, and Junaid Qadir Rajib Rana. "Abnormal Heartbeat Detection Using Recurrent Neural Networks." arXiv preprint arXiv:1801.08322 (2018).

Github: <https://github.com/vacous/GaitDiagnosisML>

Thank You