Machine Learning and its application in Advanced Prostheses

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"All models are wrong, but some are useful."

George Box

Background

Lower-Limb, among most common amputation (Robbins et al., 2008)

Associated with High Mortality Rates, Lower Quality of Life (Robbins et al., 2008)

Active vs Passive

Passive: prosthetic device that does not move on its own

Active: prosthetic device powered in some form by a microprocessor

Active prostheses can aid in mobility and pain-relief (Stokosa, 2021)

Prostheses

✓Aesthetics
✓Advanced Technology
✓Cool…

- Comfortable?
- Painful?
- Functional?

Problem Statement

In view of the pressing need to ***improve the quality of life*** *for individuals with prostheses, specifically for Lower-Limb Amputations, we seek to* ***apply a Neural Network*** *classification algorithm with the objective of integrating to active/assisted prostheses to* ***increase functionality****.*

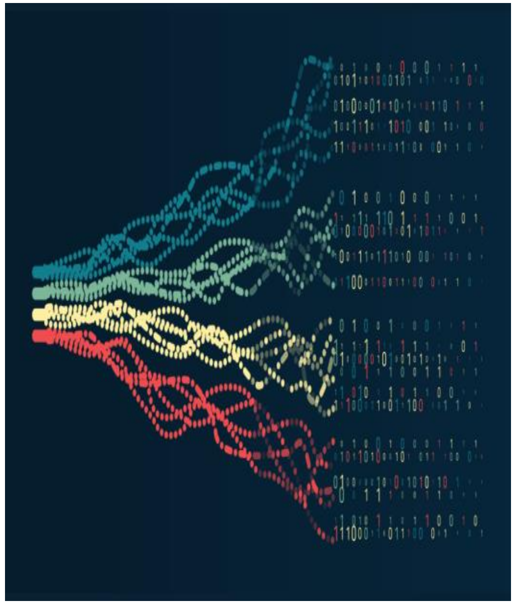
Locomotive Intentions

MAKE THE PROSTHESIS **RESPONSIVE**

Identifying the Activity

Engage in 12 activities ***with sensors***

Collect sensory ***data***



Build classification ***model***

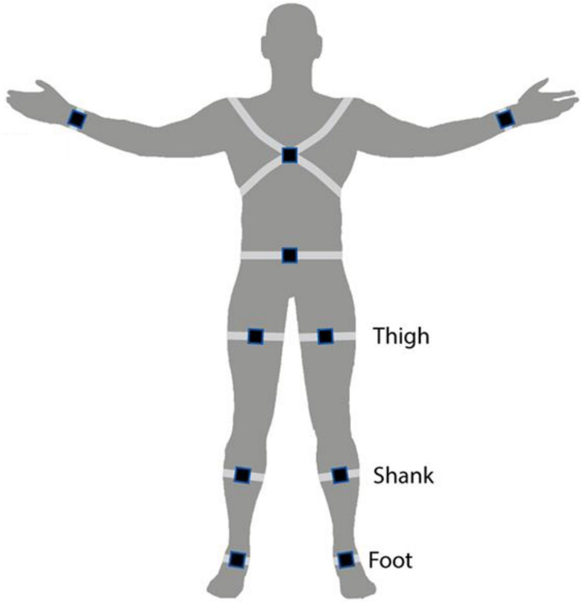
Identifying the Activity

Data

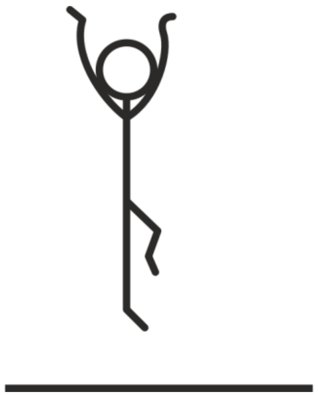
Dataset

HuGaDB: Human Gait Database for Activity Recognition from Wearable Inertial Sensor Networks

- Uses accelerometer, gyroscope, and EMG data
- Over 2 million observations
- 18 individuals --> 12 activities



Activities



Activity	Observations
Walking	679,073
Running	328,655
Going up	241,756
Going down	180,573
Sitting	156,560
Sitting down	131,604
Standing up	116,637
Standing	89,144
Bicycling	71,653
Up by elevator	69,729
Down by elevator	24,112
Sitting in car	22,373

Methods

Compare 3 optimized models

Embed model to IMU device for proof-of-concept

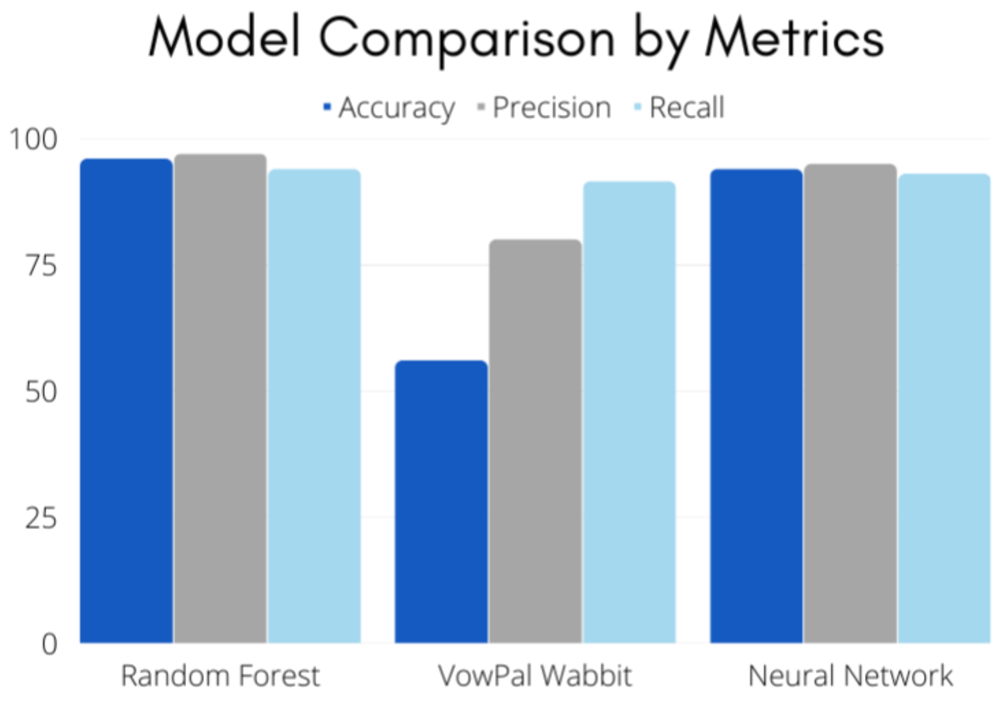
The Classification Models

Random Forest

Neural Network

Vowpal Wabbit

Results



Model Comparison by Metrics
Accuracy
Precision
Recall
100
75
50
25
0
Random Forest
VowPal Wabbit
Neural Network

Discussion/Ethics

Evaluative Metrics

Limitations

Autonomy and Privacy

Conclusions

What we knew:

- Lower-limb amputations are among the most common
- Mobility and quality of life is affected

What we found:

- Machine learning can be part of the process
- After exploring several models...

Conclusions

<u>**NEURAL NETWORK WAS THE MOST USEFUL!!!**</u>

Further study and implementation is necessary and encouraged!

Applying the Model

Questions

What questions came to mind during our presentation?

Citations

•Robbins, J. M., Strauss, G., Aron, D., Long, J., Kuba, J., & Kaplan, Y. (2008). Mortality Rates and Diabetic Foot Ulcers. Journal of the American Podiatric Medical Association, 98(6), 489–493. https://doi.org/10.7547/0980489

•Stokosa, J., (2022). Limb Prosthesis Preparation. Merck Manual Professional Version. Accessed from: https://www.merckmanuals.com/professional/special-subjects/limb-prosthetics/options-for-limb-prostheses