A Machine Learning Framework for Gait Classification Using Inertial Sensors:

Application to Elderly, Post-Stroke and Huntington's Disease Patients

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Introduction

Gait Assessment

Analysis of physical mobility

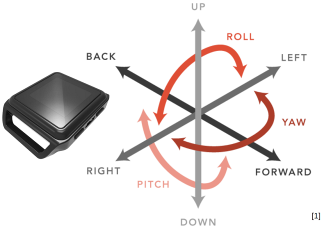
Important because

- ▷ essential for everyday life
- ▷ risk of fall
- ▷ need of a mobility aid
- ▷ success of therapy

$\Rightarrow$ Automatic classification is wanted and needed

Inertial Sensors (IMUs)

Accelerometer + Gyroscope



- minimal discomfort
- useable in everyday life

Research so far I

Machine Learning applications

- classification of walking/jogging
- walking type (level/inclined/stair climb)
- gesture recognition
- user authentication

Research so far II

Methods

- Hidden Markov Models (HMM)
- Support Vector Machines (SVM)
- Artificial Neural Networks (ANN)

Research

Goals of this research

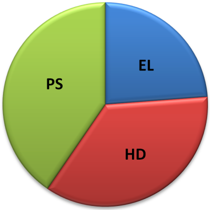
- machine learning framework for feature definition
- combination of HMM and SVM
- classification of pathological gaits (post-stroke & Huntington's)

Future
⇒ embedded gait assessment for early detection

The Study

42 Patients

- ▶ 15 Post-Stroke (PS)
- ▶ 17 Huntington's Disease (HD)
- ▶ 10 Healthy Elderly (EL, control group)



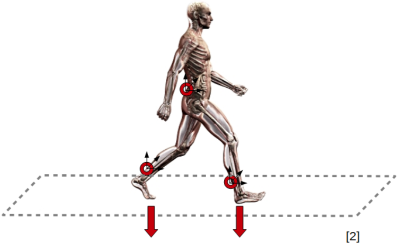
Data generation

3 IMUs

- ▷ left & right shank
- ▷ waist
- ⇒ 5Hz low-pass filtered

7m gait pressure mat

- ▷ foot strike
- ▷ toe off
- ⇒ synchronization with IMUs



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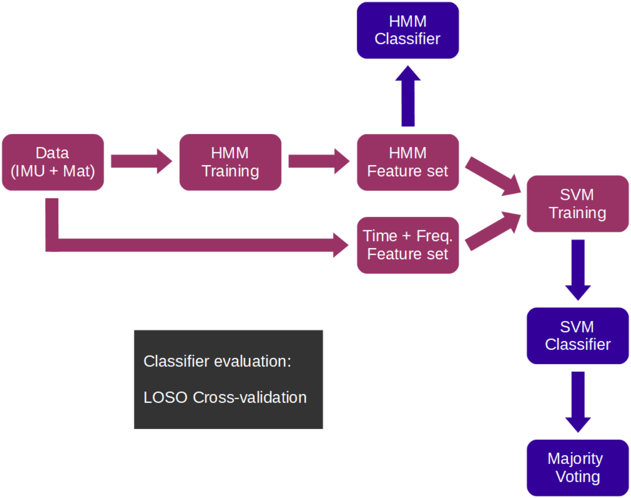
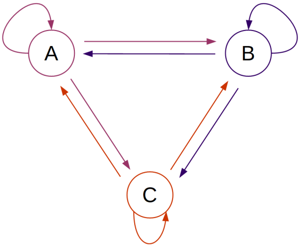
Classification strategy



Hidden Markov Models (HMM)

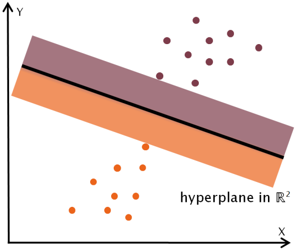
- statistic based classifier
- 1 HMM for each class trained
- probability that sensor data fits one specific class

$\Rightarrow$ 66.7% accuracy



Support Vector Machine (SVM)

- geometric classifier
- division of feature space
- decision based on position to hyperplane



SVM accuracies

HMM-features only
$\Rightarrow$ 71.5% accuracy

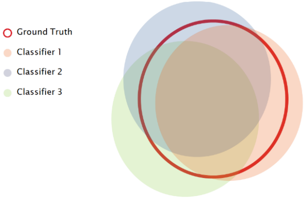
time and frequency domain features only
$\Rightarrow$ 71.7% accuracy

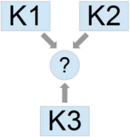
both feature sets
$\Rightarrow$ 73.3% accuracy

Majority Voting

- aggregation of classifiers
- 1 vote per classification
- votes generated by passages

$\Rightarrow$ 90.5% accuracy





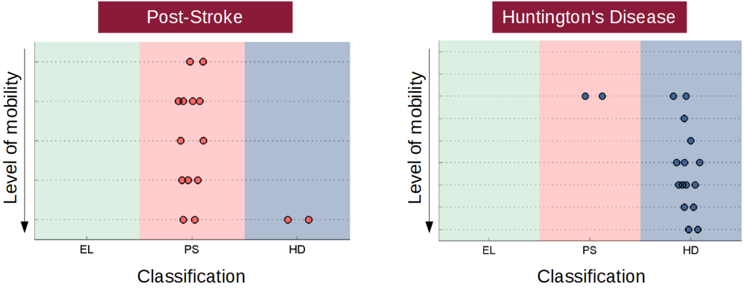
Conclusion

Comparison

Accuracy of classification methods

Classifier	Accuracy [%]
HMM	66.7
SVM (full feature set)	73.3
Majority Vote	90.5

Misclassifications



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⇒ for PS and HD, only between pathologic groups

Improvements

- weighted votes based on classification uncertainty
- further pathology groups to validate the framework
- useage of spatial feature sets

Thanks for your attention!

Questions?

Sources

[1] - https://www.apdm.com/wearable-sensors/ (23.05.2018)
http://kilograph.com/virtual-reality-6dof/ (23.05.2018)
[2] - https://www.gettyimages.de/detail/video/male-body-walking-stock-videomaterial/618598925?esource=SEO_GIS_CDN_Redirect (23.05.2018)
[3] - A Machine Learning Framework for Gait Classification Using Inertial Sensors: Application to Elderly, Post-Stroke and Huntington's Disease Patients: A. Mannini and D. Trojaniello and A. Cereatti and A. M. Sabatini, 21.01.2016 in Sensors 2016,16,134