Performance Comparison of Two Step Segmentation Algorithms using Different Step Activities

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Introduction

Motivation

Insufficient physical activity
= 4th leading risk factor for mortality

Walking → Mostly performed physical activity [1]
Walking → Reflects physical activity

Field of Application

Activity recognition in the field

Classification of movement disorders (e.g. Parkinson's disease)

Robust step segmentation in daily life

What is the best step segmentation algorithm?

Hardware & Preprocessing

2 SHIMMER sensor nodes (204.8 Hz)
- 3-D accelerometer
- 3-D gyroscope

Butterworth filter
- Order: 2
- Type: low-pass
- Cutoff frequency: 17 Hz

Methods

Study Design

15 healthy subjects (8 female, 7 male):

Exercises:
- Walking (twice)
- Jogging (twice)
- Ascending stairs
- Descending stairs

→ **Ba**sic **S**tep **A**ctivity (**BaSA**) dataset

BaSA dataset download [4]: http://www.activitynet.org

Used Gyroscope axis
= angular velocity v_a in sagittal plane

Camera-based ground truth data

Evaluation

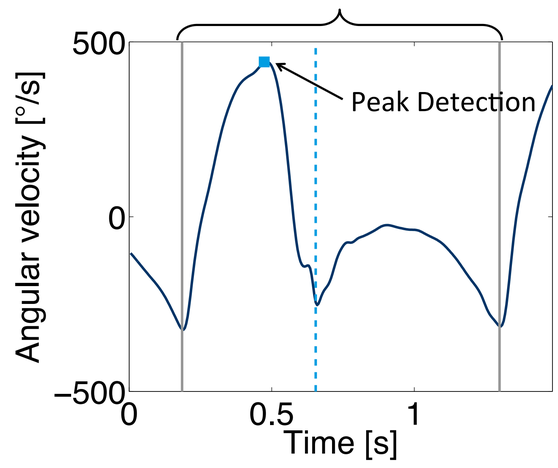
Leave-one-subject-out cross-validation

Performance measure:

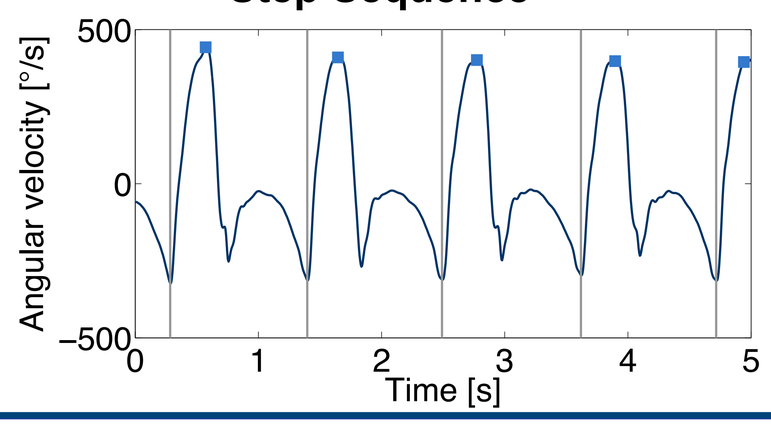
$$\text{Error rate} = \frac{|\#\text{ reference steps} - \#\text{ calculated steps}|}{\#\text{ reference steps}}$$

Statistics:
- Multivariate Analysis of Variance (ANOVA)
- ANOVA with repeated measures
- Post-hoc t-tests with Bonferroni correction

One Step

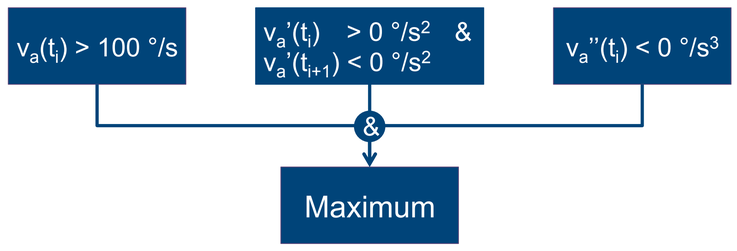


Step Sequence

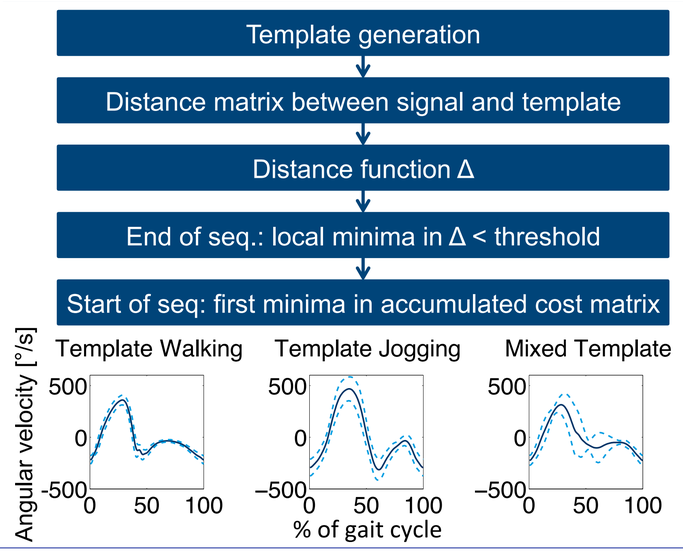


Peak Detection Algorithm

Detection of steps:
- Threshold-based maxima determination
- Minimum time (iteratively adapted)

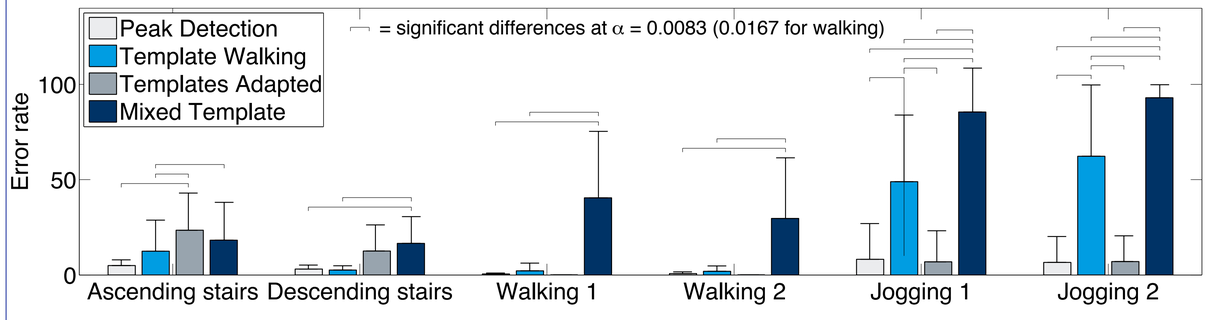


Subseq. Dynamic Time Warping [3]



Results

Error Rates



Templates Adapted: specialized templates to the corresponding activity

Mixed Template: combination of activities for template generation

Discussion

Lowest error rates for **walking**: peak detection algorithm and sDTW (Template Walking)
- Most steps in walking activities
- Template Walking has lowest SD around mean performed similarly

Highest error rates with Mixed Template:
- Jogging and walking temporal phases differ considerably
- No representation of normal step or a jogging step

Comparison of calculated steps with total number of steps

Summary & Outlook

BaSA dataset with realistic and natural movements

Peak detection and sDTW algorithm with **equal performance**

→ Comparison of calculated steps with identical steps

→ Investigate performance in transitions (e.g. walking → jogging)

→ Adaptive approach according to activity

References

[1] P. Z. Siegel et al.: "The epidemiology of walking for exercise: implications for promoting activity among sedentary groups", Am J Public Health, vol. 85(5), pp. 706-10, 1995.
[2] J. Klucken et al.: "Mobile biometrische Ganganalyse," Nervenarzt, vol. 82(12), pp. 1604-11, 2011.
[3] J. Barth et al.: "Subsequence dynamic time warping as a method for robust step segmentation using gyroscope signals of daily life activities," Proc: 35th Annual International Conference of the IEEE EMBC, pp. 6744-7, 2013.
[4] H. Leutheuser et al.: "Hierarchical, multi-sensor based classification of daily life activities: Comparison with state-of-the-art algorithms using a benchmark dataset," PLOS ONE, vol. 8(10), e75196, 2013.

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