

UTRECHT UNIVERSITY

DOCTORAL THESIS

Human Activity Recognition Using Accelerometer Data

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*A thesis submitted in fulfilment of the requirements
for the degree of Master of Science*

in the

Research Group Name

Department or School Name

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Declaration of Authorship

I, R.Q. VLASVELD, declare that this thesis titled, 'Human Activity Recognition Using Accelerometer Data' and the work presented in it are my own. I confirm that:

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- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
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- I have acknowledged all main sources of help.
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“Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism.”

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Abstract

Faculty Name

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Master of Science

Human Activity Recognition Using Accelerometer Data

by R.Q. VLASVELD

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

Acknowledgements

The acknowledgements and the people to thank go here, don't forget to include your project advisor...

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Abbreviations

LAH List Abbreviations **H**ere

PCA Principle Component **A**nalysis

Physical Constants

Speed of Light $c = 2.997\,924\,58 \times 10^8 \text{ ms}^{-\text{s}}$ (exact)

Symbols

a	distance	m
P	power	W (Js^{-1})
ω	angular frequency	rads^{-1}

For/Dedicated to/To my...

Chapter 1

Introduction

1.1 Outline

- Context of research (human activity recognition), real-world applications
- Current methods, wrapper vs. filter methods
- Problem statement with current filter methods (which follows from Chapter [3](#) which goes in-depth with methods).
- Purpose of this research. E.g. "Find a better algorithm for short-activity segmentation"
- Relate to real-world applications

Chapter 2

Literature review

2.1 Outline

- Literature review about Temporal Segmentation (previous draft was more about classification)
- Consider methods for the context of filter-methods for classification
- Take a look at 3-4 different kind of methods for change detection:
 - Dimensionality reduction
 - Density-ratio estimation
 - Support Vector Machines (?) - if there are more sources about this
 - CUSUM - or other more traditional methods
- With each method, shortly look at characteristics, strengths and weaknesses and consider applicability to accelerometer sensor data

2.2 Change-detection by Dimensionality Reduction / Covariance structure

2.3 Change-detection by Density-Ratio Estimation

2.4 Change-detection by Support Vector Machines

Introduced by Vapnik [1, 2], Support Vector Machines offer a way to segment, and classify, linear separable data. When combined with a mapping function, which maps

the data from the input space I to a higher dimension feature space F , the input data can be non-linear separable. The linear hyperplane, which segments the data in the feature space F , yields to a non-linear segmentation in the lower-dimensional input space I . Instead of explicitly mapping the input data to the higher dimensional space, a kernel function can be used. This kernel function can calculate values of the feature space directly, without the need to first map the input values to this space. This process is referred to as the kernel trick.

*** Let sigma be a mapping from I to F such that the dot product in F can be computed using some simple kernel ***

2.4.1 One-class Support Vector Machine

The proposed method of Camci [3] uses a one-class support vector machine to segment time series data. One-class SVMs are used to describe the current data under consideration, by assuming all data points are from the same class [4]. The class is described by a spherical boundary around the data with center c and radius r , such that the volume is minimized. Following the definition of Camci [3], the class description is obtained by minimizing r^2 :

$$\text{Min } r^2 \quad (2.1)$$

$$\text{Subject to : } \|\mathbf{x}_i - \mathbf{c}\|^2 \leq r^2 \quad \forall i, \quad \mathbf{x}_i : i\text{th data point} \quad (2.2)$$

To be able to handle outliers in the input data, a penalty cost function ε_i for each outlier can be added.

*** Add new function and constraints? ***

Using this one-class SVM formulation, differences between two (consecutive) windows of data points with size w can be obtained. The first window is used as the input set, h_1 and the second as the test set h_t . For the first window a one-class SVM is constructed, yielding in a representation by c_1 and r_1 . When the data points of the second window belong to the same class, the representation of that one-class SVM would equal the first:

$$c_1 = c_2, r_1 = r_2 \quad (2.3)$$

*** First tell more about (underlying) probability density functions, to relate to other methods ***

In case the second window of data points does not belong to the same class, i.e. the probability density function that describes the data differs from the first, the describing

values of the second window will differ from the first. The amount of difference can be expressed by a dissimilarity measure over the representations. When the dissimilarity between the two windows exceeds some predefined threshold th , there exists a change point between the windows.

Note that a difference in the SVM center c or radius r represent a change in the mean and variance, respectively.

2.5 Change-detection by Cumulative Sum

Chapter 3

Change detection by Density-Estimation

3.1 Outline

- In-depth analysis on one of the methods of Chapter 2
- This method (e.g. Density-Ratio estimation) will be the basis for the real research
- Explain why this methods seems worthy and interesting
- Look at problems when applied to accelerometer sensor data
- *The problems discovered here will give rise to the problem statement at the Introduction / beginning of research*
- Opens the possibility for own method

Chapter 4

Proposed method

4.1 Outline

- Based on the problem statement with current research as stated in [Chapter 3](#)
- Adjust method to needs
- Explain using graphs, pseudo-algorithms. Make clear distinction in origin of ideas and why to apply

Chapter 5

Result

5.1 Outline

- Compare proposed method with methods of Chapter [2](#)
- Provide plots, tables, graphs, error rates, precision, etc.
- Apply to a multiple of data, to compare to previous research - use that data
- Give theoretical analysis about performance. Big-O, memory, run-time, precision.
- This sections needs programmed implementations of own method and the ones compared

Chapter 6

Real-world applications

6.1 Outline

- Apply proposed method to real-world applications, such as
 - Daily life activity recognition (as the original context of this thesis is)
 - PowerHouse sensor data
 - Stock data?
- Relate back to filter vs. wrapper methods - give results with different methods?

Appendix A

Appendix Title Here

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Bibliography

- [1] Vladimir Vapnik. Statistical learning theory. 1998, 1998.
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- [4] David MJ Tax. One-class classification. 2001.