"Sleep-in-a-box": Algorithmic approach to extract rest phases with mobile accelerometry

This paper suggests a knew approach for analysing inactive phases in long term measurements using mobile accelerometry attached to a human body. The goal of the work is to provide a commandline tool to automaticaly parse a timestamped list of acceleration data in order to extract the phases that represent the sleeping periods. Justified on the fact that the data collection is motivated more in a healthcare environment than in a detailed sleeping research the methods do not concentrate on getting exact differentiation between real sleeping and awake lying periods. Detecting a significant long period with an inactivity pattern that permits the assumption that the received recovery quality is similar to the effects of sleeping on the human body will be enough to classify it as restphase. Furthermore the algorithm is not designed to find the exact amount of time that can be related to this classification. Finding enough of the relevant periods to provide a good view on the quantity and quality of inactive rest the observed human body gets should satisfy the task.

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"Sleep-in-a-Box": Algorithmic approach to extract Restphases with mobile accelerometry

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Abstract

A new approach for analysing inactive phases in long term measurements using mobile accelerometry attached to a human body

- automatically parse a timestamped list of acceleration data in order to extract the phases that represent the resting periods
- motivated more in a health-care environment than in a detailed sleeping research
- no concentration on getting exact differentiation between real sleeping and awake lying periods
- significant long period with an certain inactivity pattern is enough to classify it as Restphase
- provide a good view on the quantity and quality of inactive rest the observed human body gets

Motivation

- observing the rest of a patient without influencing his average behavior
- handling long term measurements to get information about daily rest rhythm
- respecting privacy by abstracting sensible data
- easy comparison of different measurements through quick visualization of the analysis results
- suitable for automatic and structured offline analysis of huge data sets

Workflow

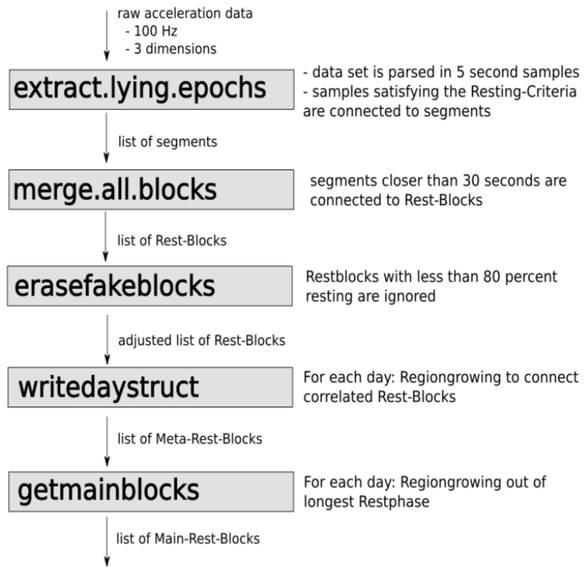
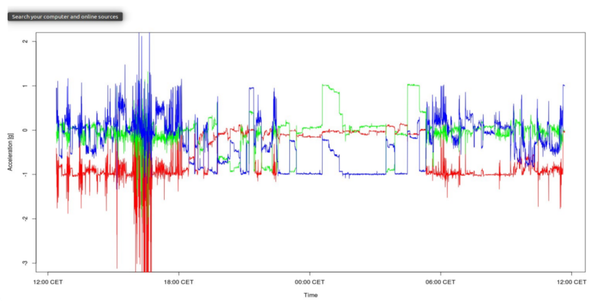


Figure 1: R-functions of the algorithm

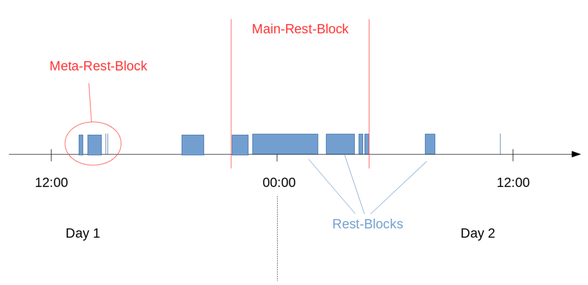
Measurement

- monitoring of human acceleration vectors with an actibelt©
- 100 3D-acceleration values per second
- sensor is directly attached to the hip (body center of mass)
- recording of 10 days (RCT1) or more than 4 weeks (RCT2) nonstop
- Unix timestamp provides relation of every acceleration vector to a 10 milliseconds period in the chosen timezone

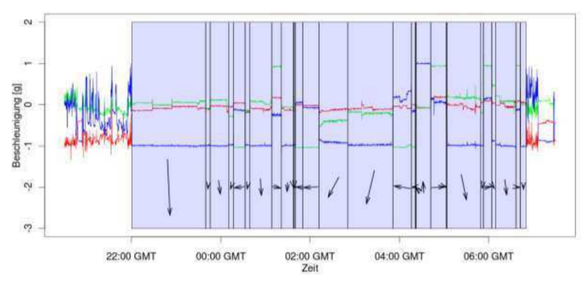
Raw acceleration data



Classification Rest-Blocks



Analysis of Main-Rest-Block



"Sleep-in-a-Box"

Parameters of Main-Rest-Block:

- average start and end time of Main-Rest-Block
- average duration of Main-Rest-Block
- Number of strong interruptions (e.g standing up, longer period with higher activity)
- Interrupt-Ratio: proportion of the actual Restphases (without interruption) to the duration of the Main-Rest-Blocks

Average Location of Main-Rest-Block	Average Duration of Main-Rest-Block
start: 23:02 CET end: 07:21 CET	8,14 hours
Number of Interruptions	**Interrupt-Ratio**
day1: 1 day2: 3 day3: 0 day4: 3 day5: 0	0,99 0.96 1 0,95 1

External links

www.actibelt.com
www.trium.de
Roenneberg T.- The human sleep project

References

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[2] Kruis E. Fernberg W. Staude G. Scholz M. Daumer M., Thaler K. *Steps towards a miniaturized, robust and autonomous measurement device for the long-term monitoring of the activity of patients: ActiBelt*. *Biomedizinische Technik/Biomedical Engineering 52*.

Future Work

- average analysis duration: 15 seconds per parsed day with 100 acceleration values per second
- implementation in C recommended
- validation of the algorithm with a video study

Big Data Handling

Automatic extraction of the Main-Rest-Block allows usage of additional algorithms e.g analysis of:

- lying angle
- number and speed of position changes
- correlation of the resting behavior with other week-in-a-box parameters

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