Ambulatory Assessment to Study Mobility and Activity Patterns in Healthy Aging Research

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Content

1. Background MOASIS study
2. Data analysis and preprocessing
3. (Re)construction of daily spatio-temporal timeline
4. Activity diary

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1. **Background MOASIS study**
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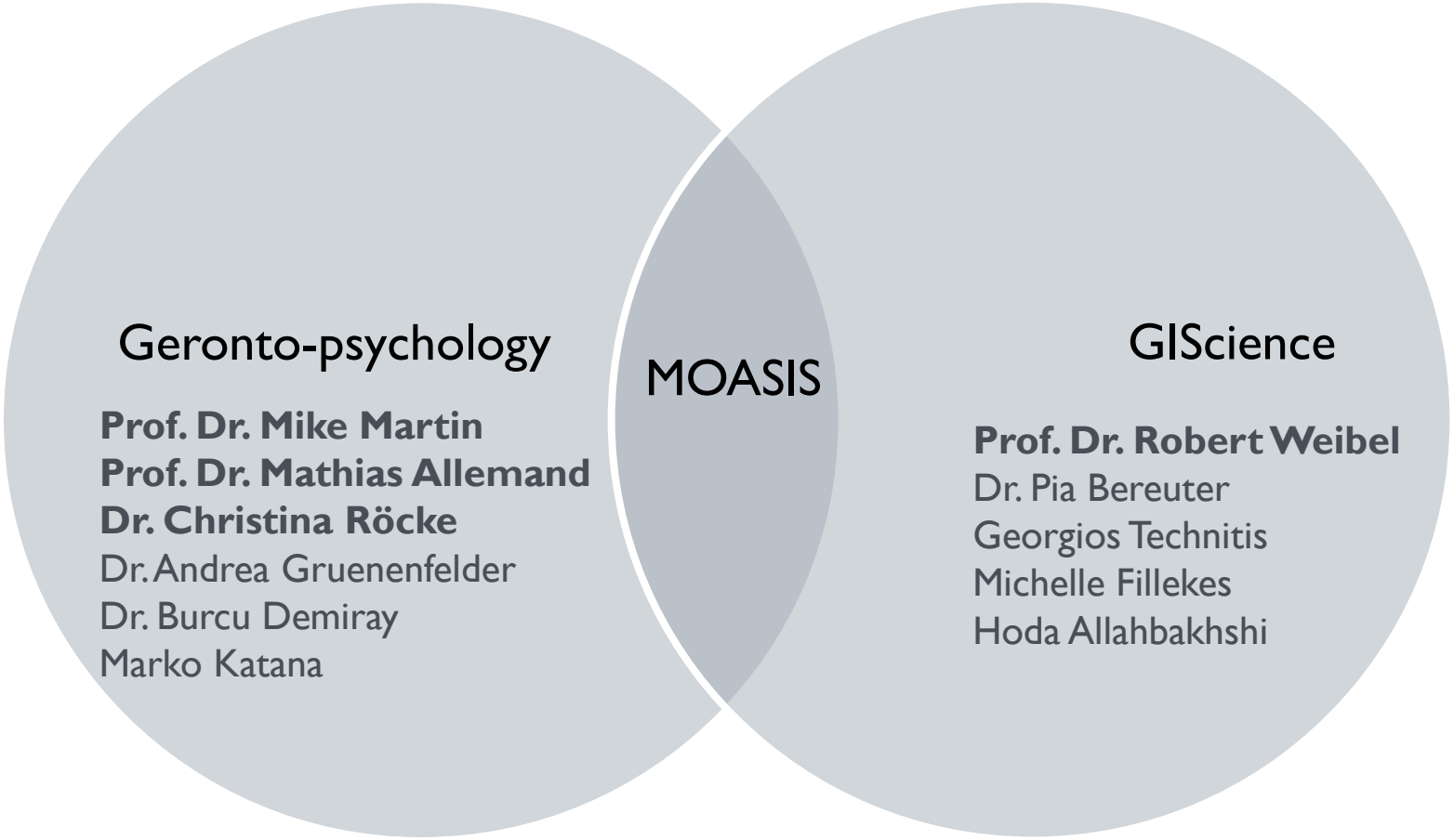
Collaborators within MOASIS

URPP
Dynamics of Healthy Aging



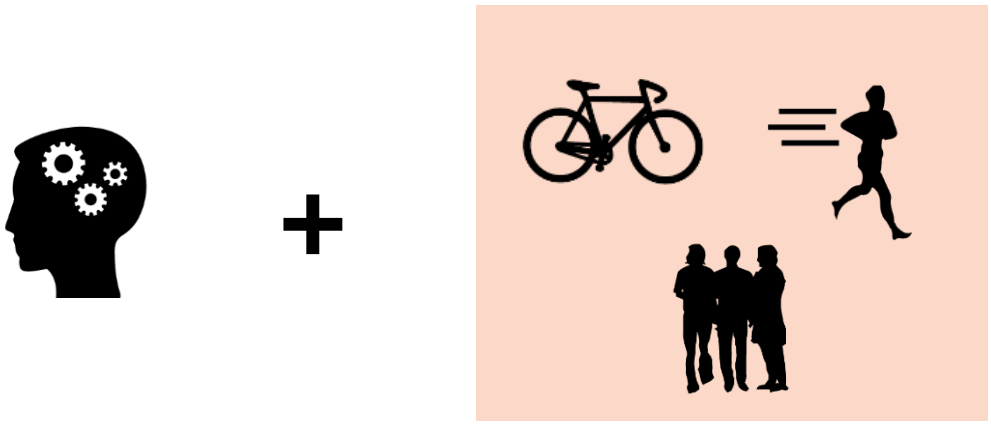
MOASIS –
Mobility, Activity and Social Interaction Study

uTrail

Interdisciplinary study: **geronto-psychology** & **giscience**

Aim of the study

- assess how healthy elder adults move in their environment.
- investigate how daily **mobility**, **activity** and **social** interaction relate to **psychological functions** and **well being**.



MOASIS - Mobility, Activity and Social Interaction Study

Psychological Functions

+

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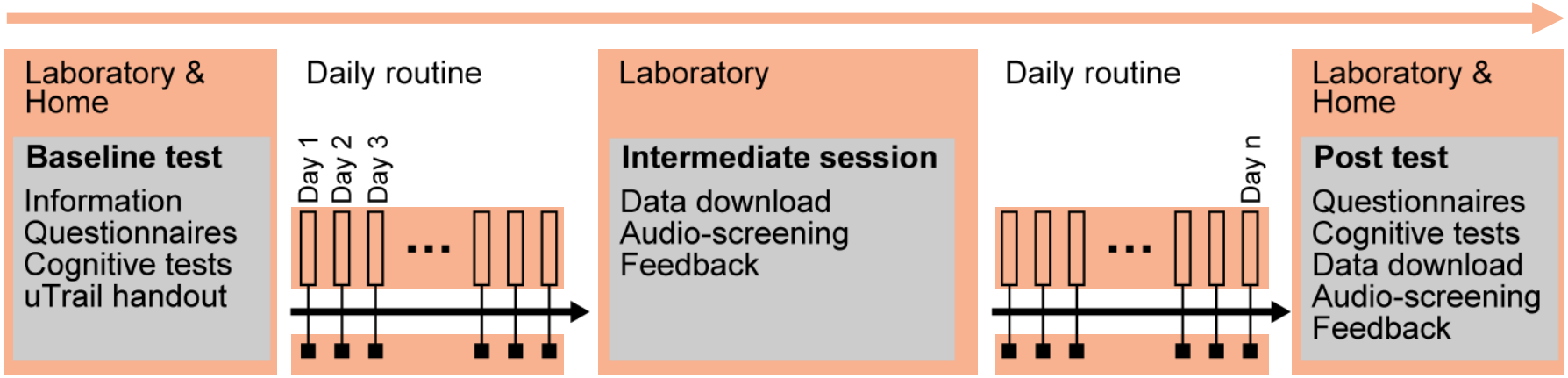
Mobility profile	How the participants move in their environment?	GPS
Activity profile	Which activity profile do they follow?	Accelero-meter
Social profile	How do they interact in their social environment?	EAR / audio

Timetable and organization of the MOASIS study

Phase	Date	Description
Initialization	Nov. 2015	Sensor tests and ethics approval
Feasibility Study I N = 6, 14 days	Dec. 2015	**First data collection**, focus: hardware tests & improvements
Feasibility Study 2 (2 parts) N = 27, 30 days	Mar – May 2016	**Second data collection**, focus: - sensor specification, sampling rates, data quality - psychological tests & measurement protocols
Main Study N = 150, 30 days	2017	**Main study** with optimized measurement protocols.

MOASIS Study design

Duration: 30 days
Psychological assessment: start and end of the study (emotional, cognitive resources, personality traits and physical & spatial activity)
Data sampling: portable tracker and (bi)weekly download sessions
Self reports: Daily evening dairies



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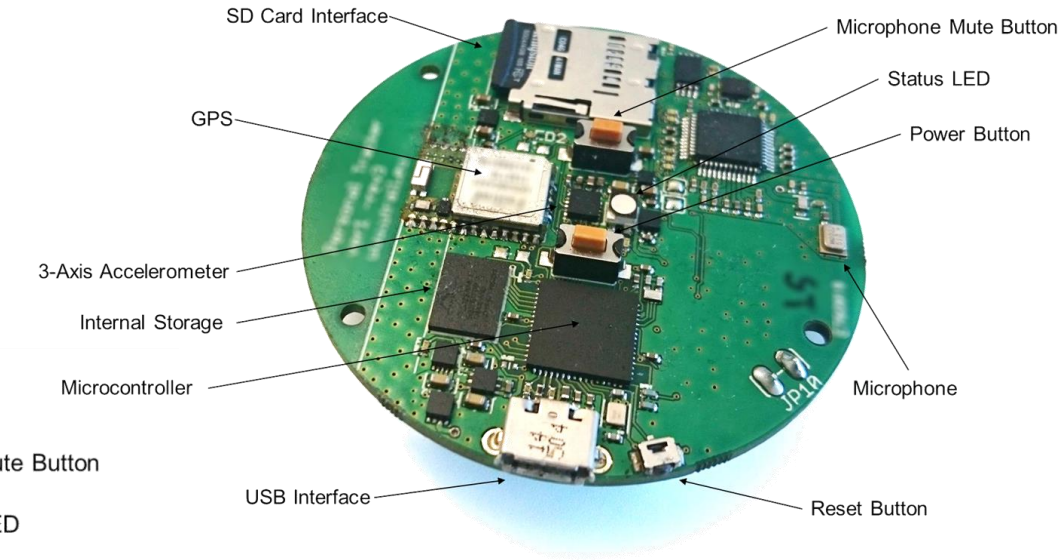
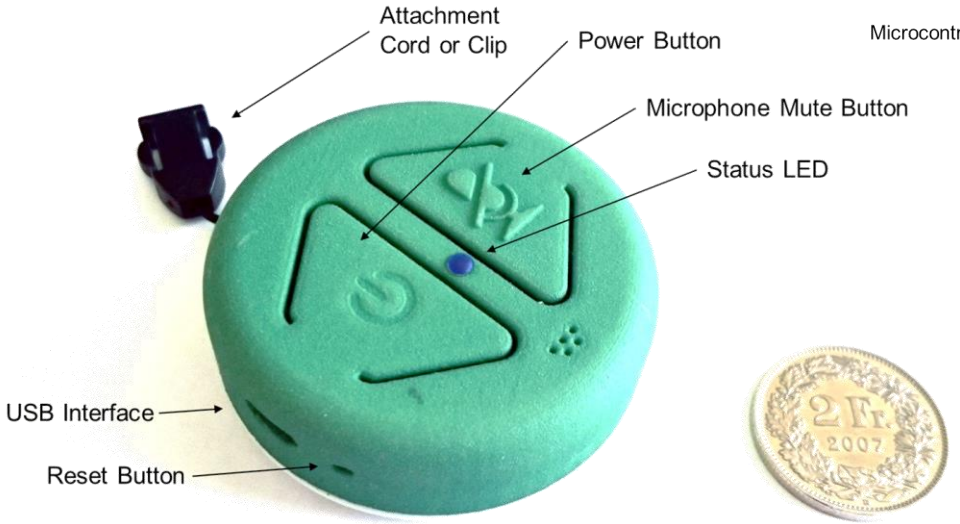


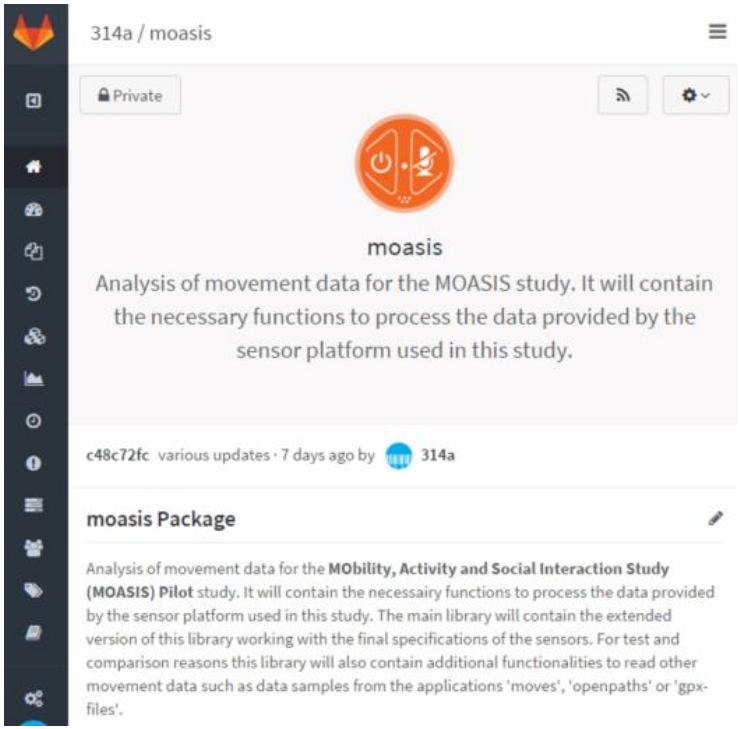


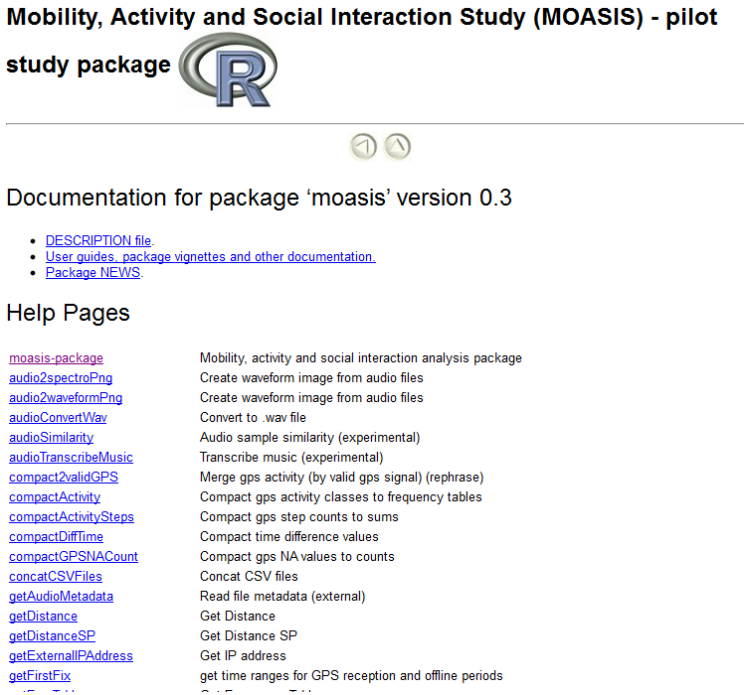
	Sensor	Variable	Sampling rate
Spatial mobility	GPS	Time, latitude, longitude	1 Hz
Physical activity	IMU	Time, acceleration (x,y,z)	3 Hz / 50 Hz
Social interaction	EAR	Time, sound sample (30 secs)	1 per 12.5 min

R Package for analysis

Division of code and data

- Development of a R package for the analysis (Git versioning)
- Report generation and data handling separate





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Data

Location CSV File

```
Date, Time, Longitude, Latitude, Satellites, Recording
25/11/2015, 21:49:59, NA, NA, NA, NA
25/11/2015, 21:50:00, NA, NA, NA, NA
25/11/2015, 21:50:01, 008.549410, 047.397110, 7,  0
25/11/2015, 21:50:02, 008.549407, 047.397108, 7,  0
25/11/2015, 21:50:03, 008.549405, 047.397108, 7,  0
25/11/2015, 21:50:04, Charging, NA, NA, 0
25/11/2015, 21:50:05, Charging, NA, NA, 0
```

IMU CSV File

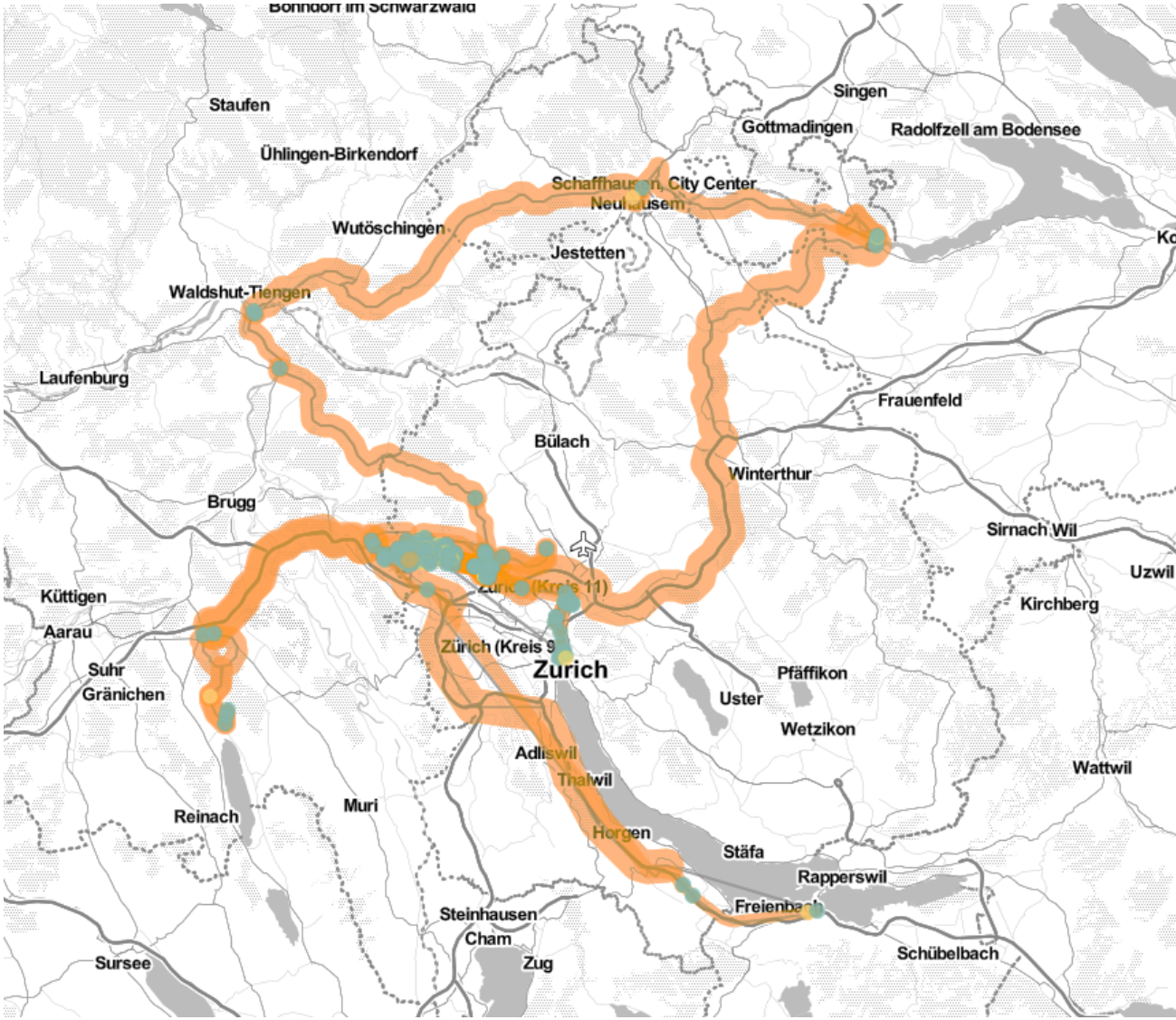
```
Date,  Time,   Acc_X(mg), Acc_Y(mg), Acc_Z(mg)
25/11/2015, 21:45:51:000, 066.368, -011.590, 1102.819
25/11/2015, 21:45:51:320, 067.771, -010.614, 1104.344
25/11/2015, 21:45:51:640, 066.551, -010.675, 1103.368
25/11/2015, 21:45:51:960, 065.026, -010.919, 1104.527
25/11/2015, 21:45:52:280, 064.904, -012.017, 1104.466
25/11/2015, 21:45:52:600, 064.965, -012.932, 1106.479
```

EAR MP3 File

MA20-000.MP3

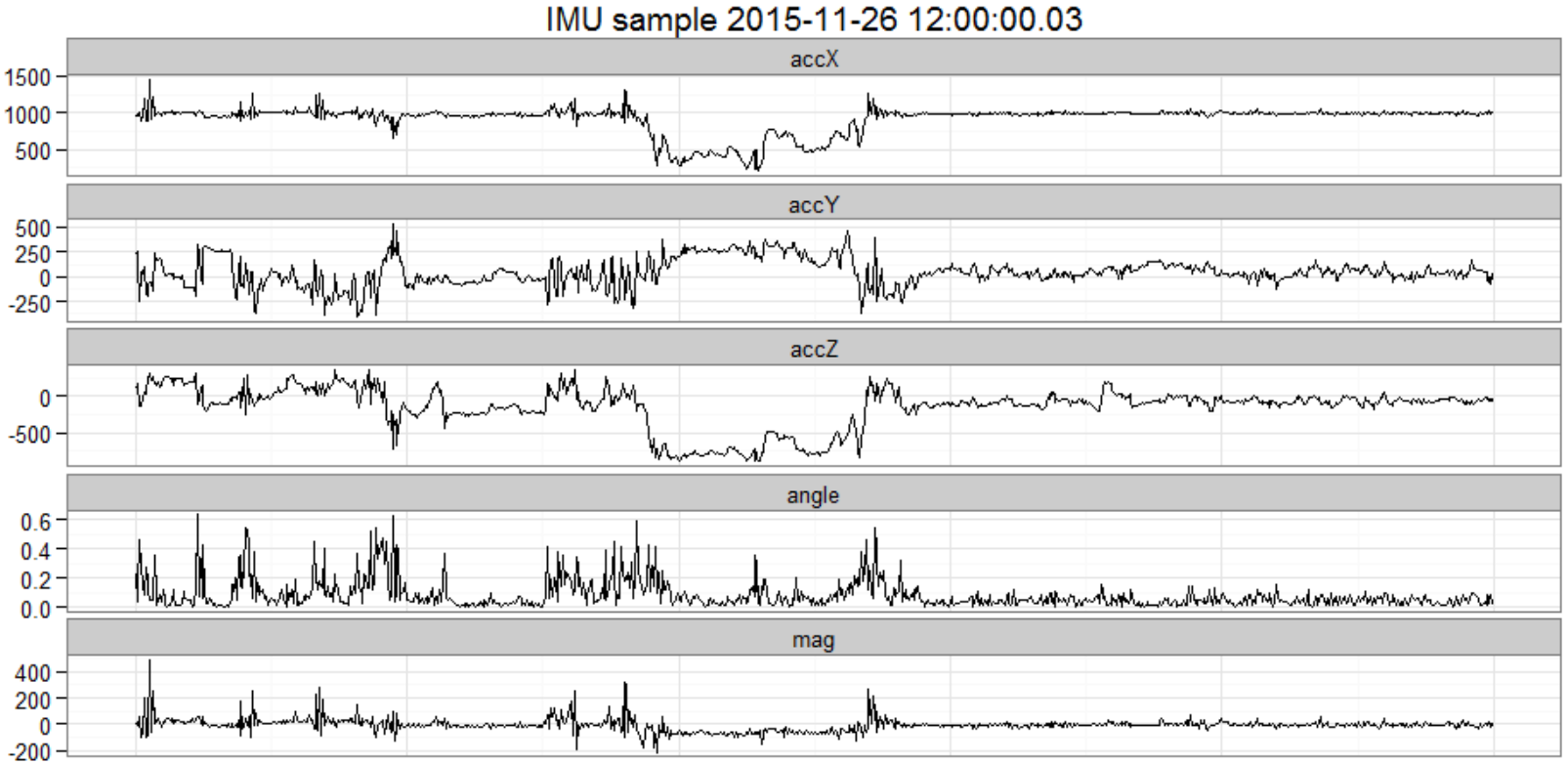
GPS

Data example of a participant over the entire study period



Accelerometer

Sampling rate 3 Hz (→ 50Hz)

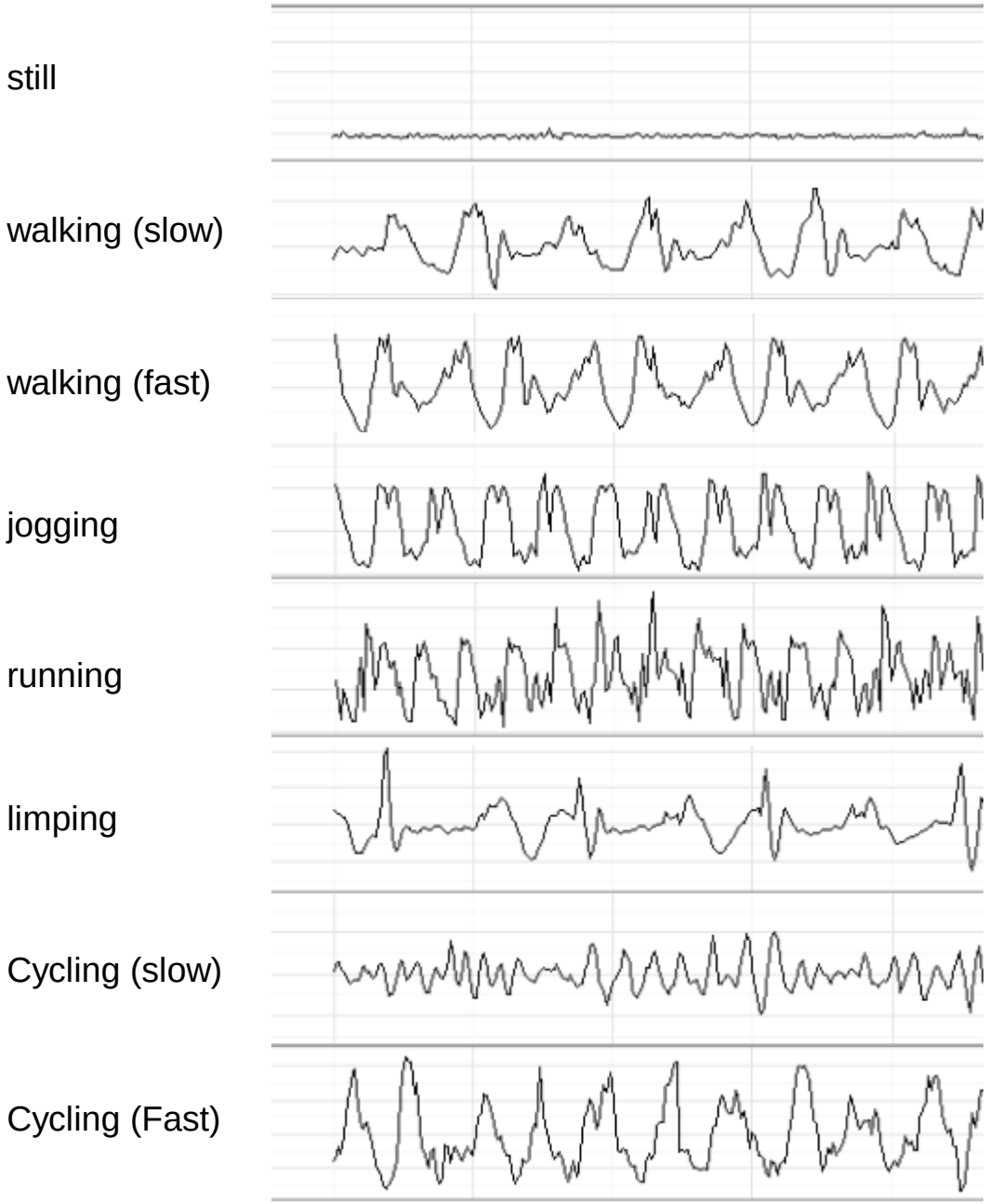


Accelerometer

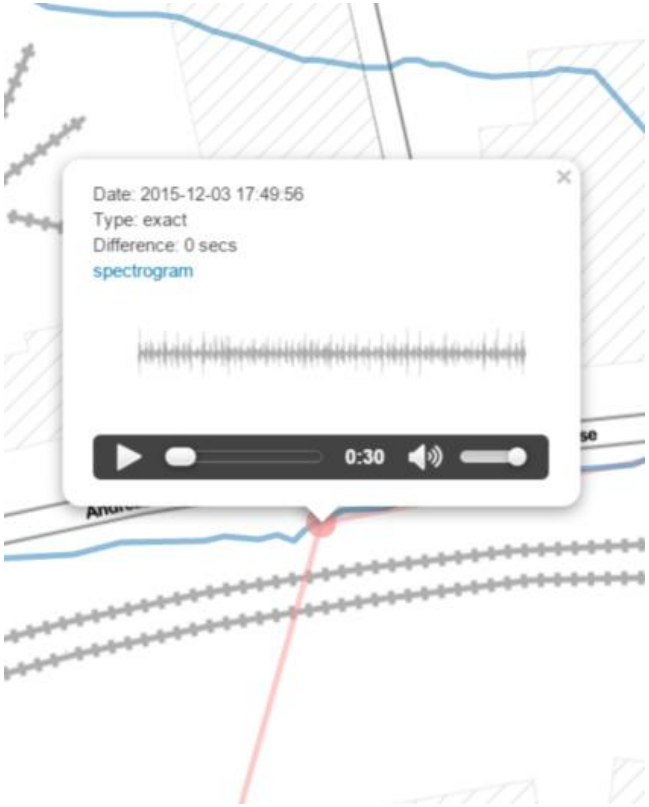
Sampling rate tests:
3, 5, 10, 50, 200 Hz

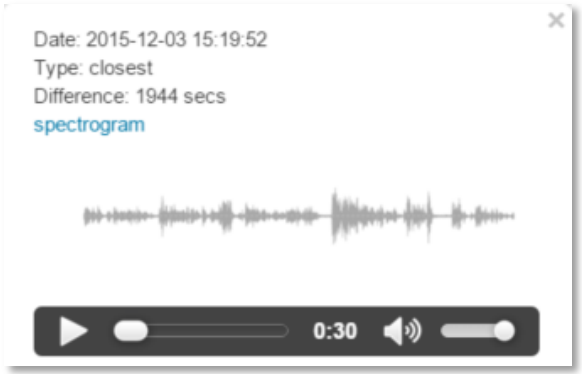
Motion mode:
still, walking (slow, fast), jogging, running, ascending, descending, limping, sitting (calm, active), standing (calm,active), lying, cycling (slow, fast)

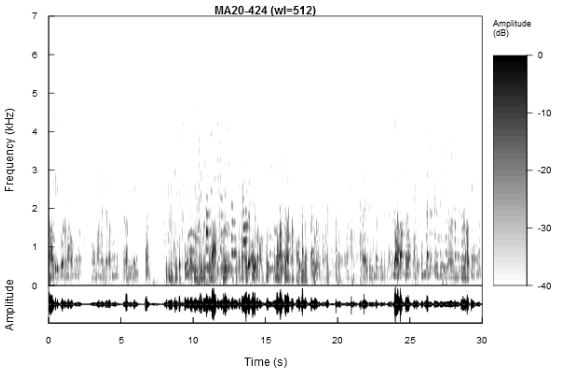
Selected sampling rate:
50 Hz

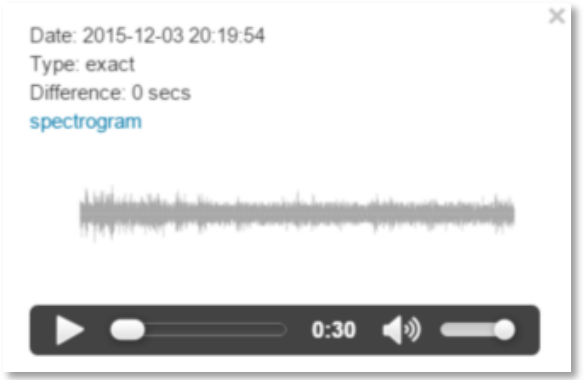


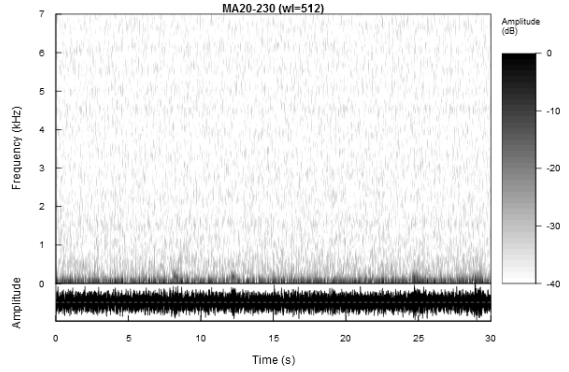
Audio example



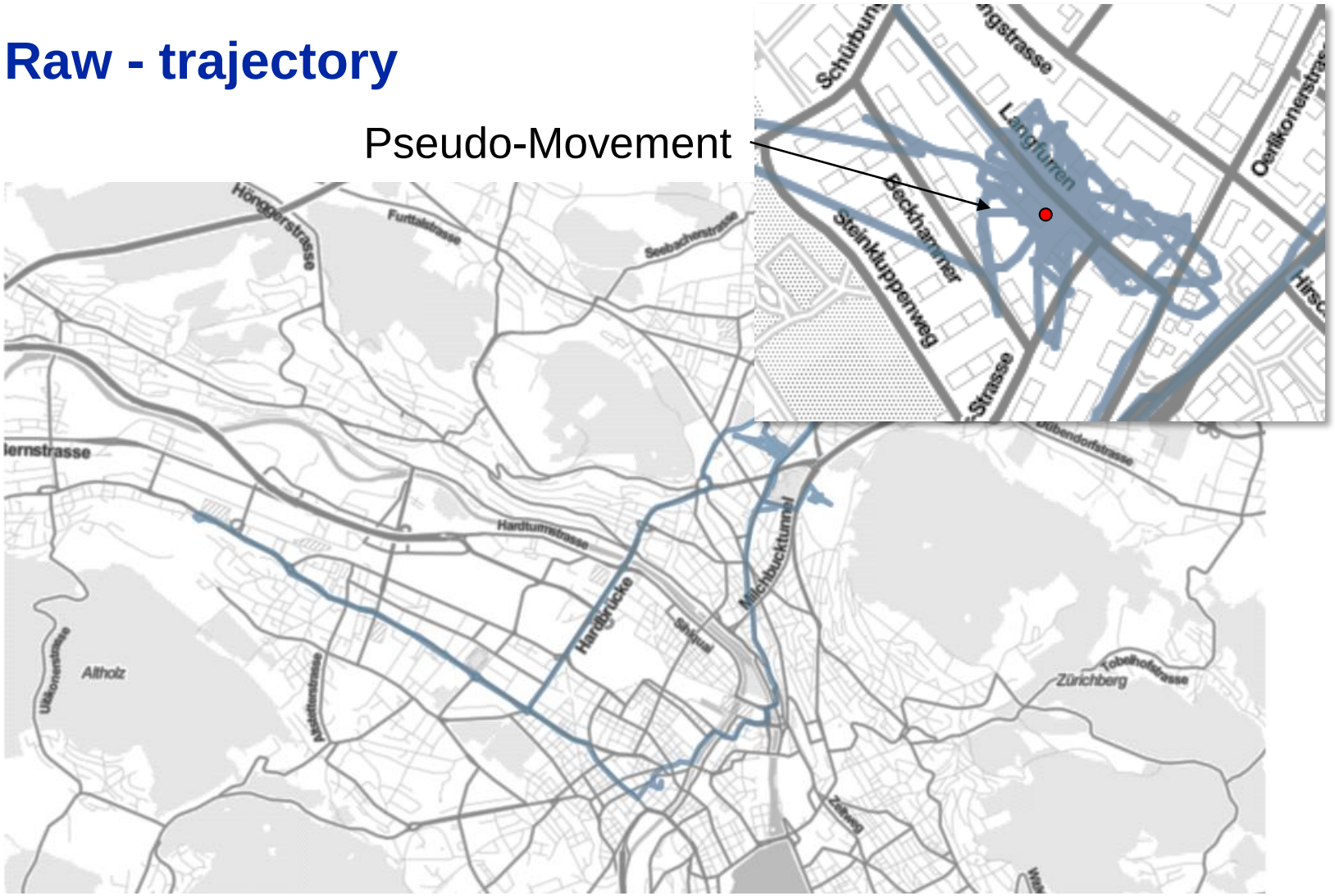








Raw - trajectory



Clustering

Density-based clustering – trajectory subsampling

Segmentation

Segmentation based on average speed and heading angle

Gschwend C, 2015, Relating Movement to Geographic Context - Effects of Preprocessing, Relation Methods and Scale. PhD, University of Zurich

Audio trajectory

Merge audio sample with GPS

Pilot study II

N: 27 participants
Duration: 4 weeks (March – May, 2016)

Average data size per sensor per participant	
GPS	81 Mb
Acceleration	257 Mb
Audio EAR	1046 Mb
Total	1423 Mb

[1] Participant dropped out of the study after the first 14-day assessment period.
[2] Participant device exchange for the second half of the study and improvement of handling instruction.

uTrail total operating hours

Participant	Hours %
1	92.2
2	93.1
3	78.5
4	89.3
5	85.2
6	85.4
7[1]	95.0
8	91.2
9	64.5[2]
10	77.0
11	86.2
12	81.1
13	73.9

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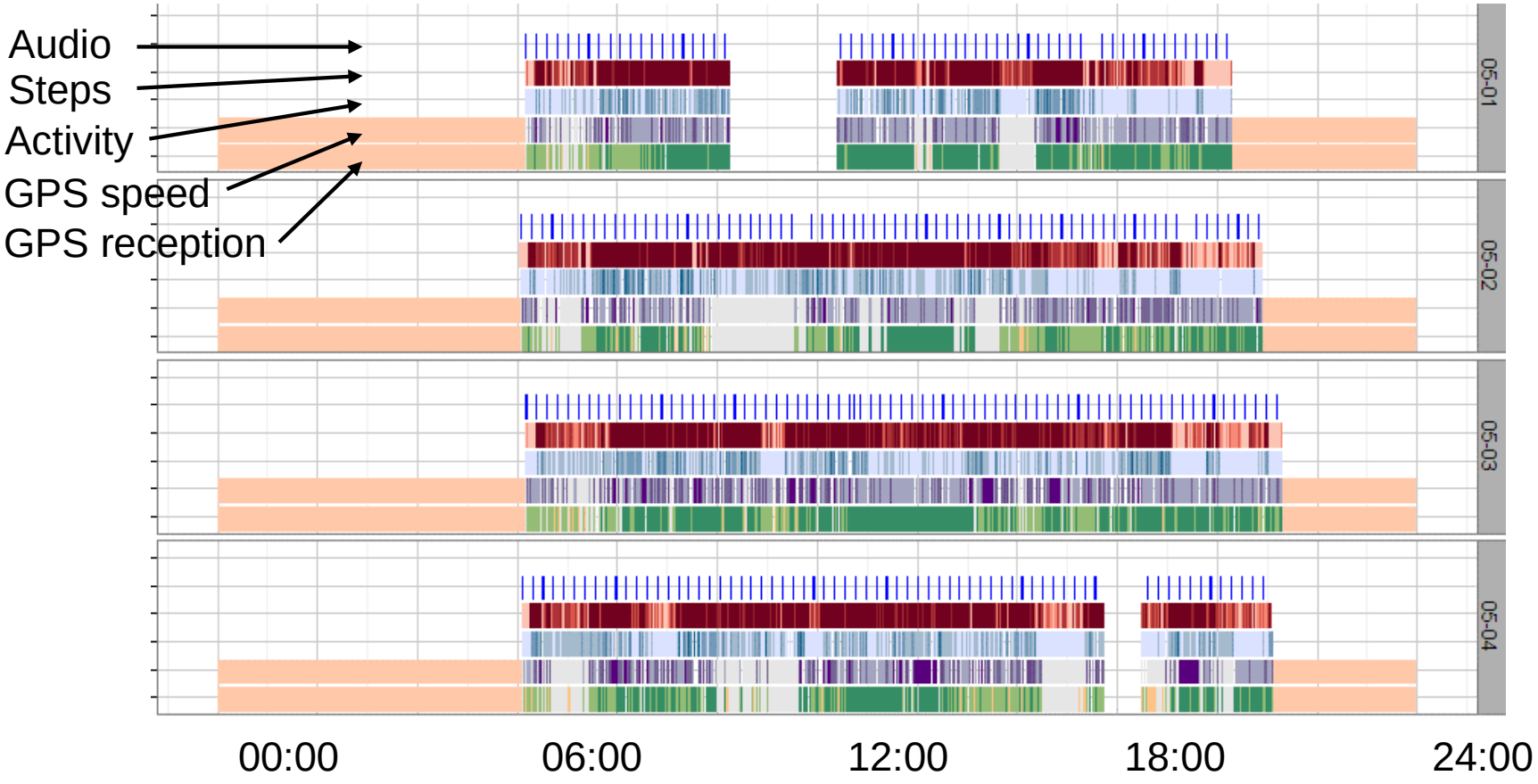
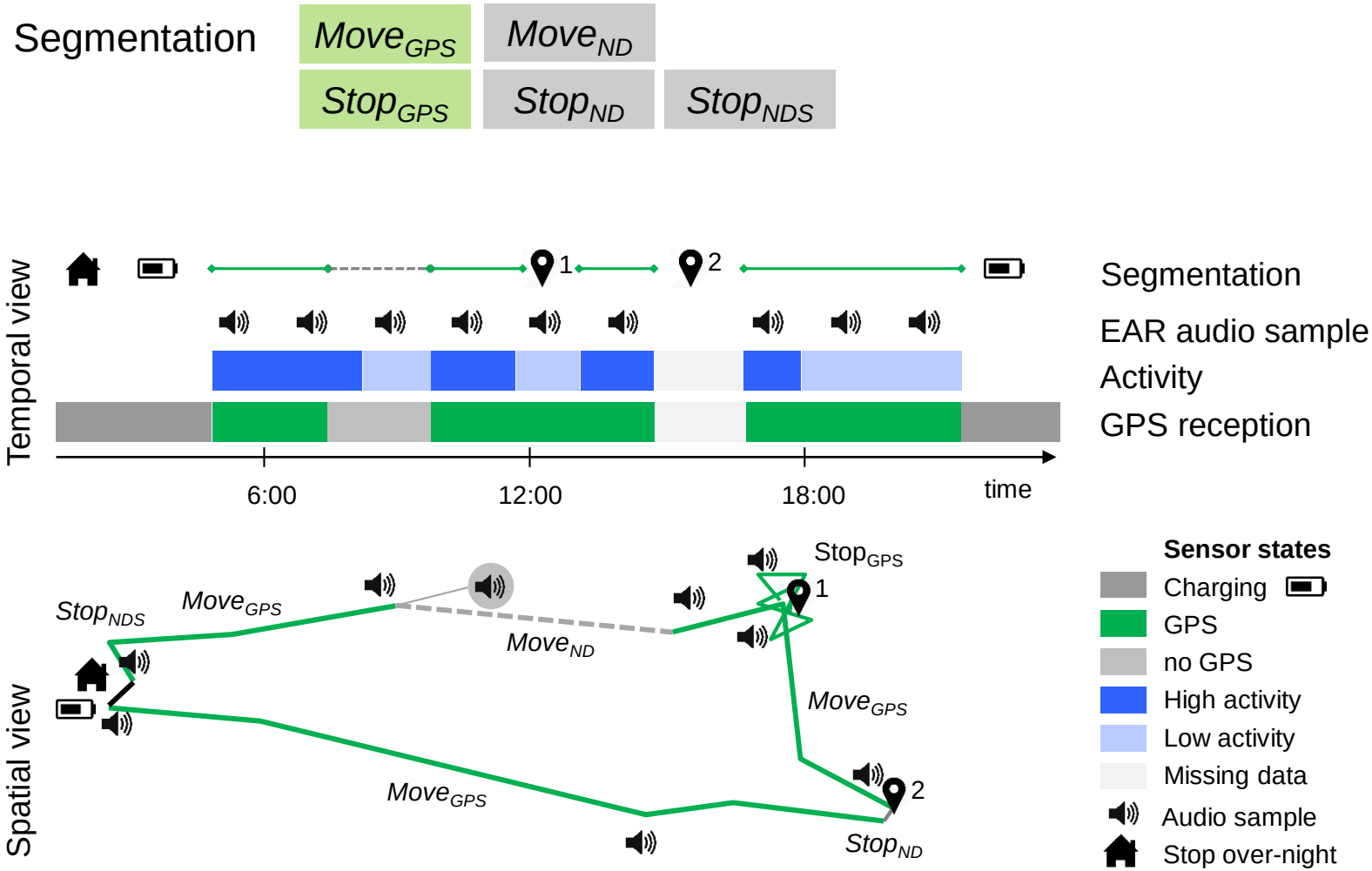
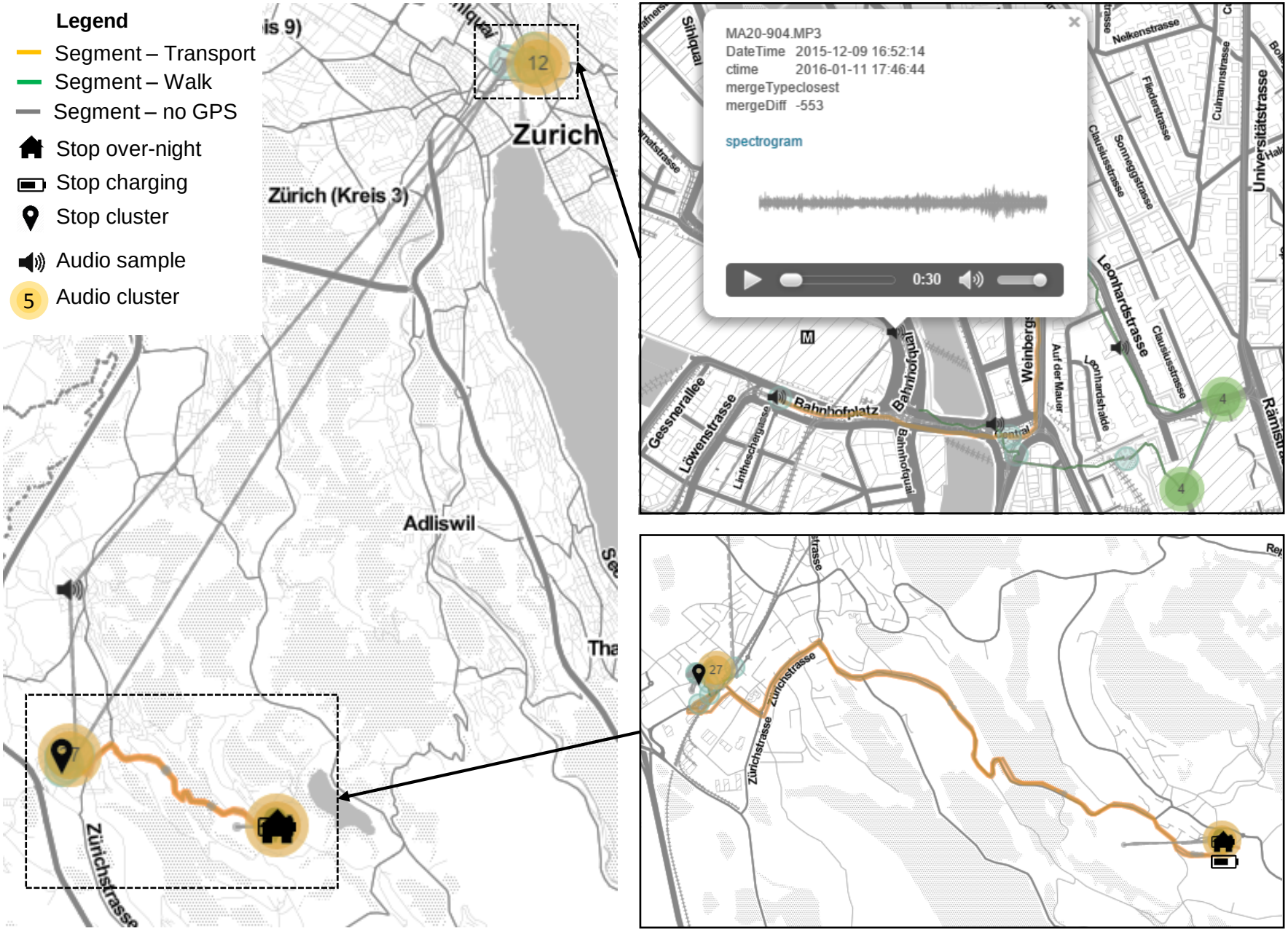
Timeline

Temporal coverage



Reconstruction of a daily spatio-temporal timeline





Leaflet | Map tiles by Stamen Design, CC BY 3.0 – Map data OpenStreetMap

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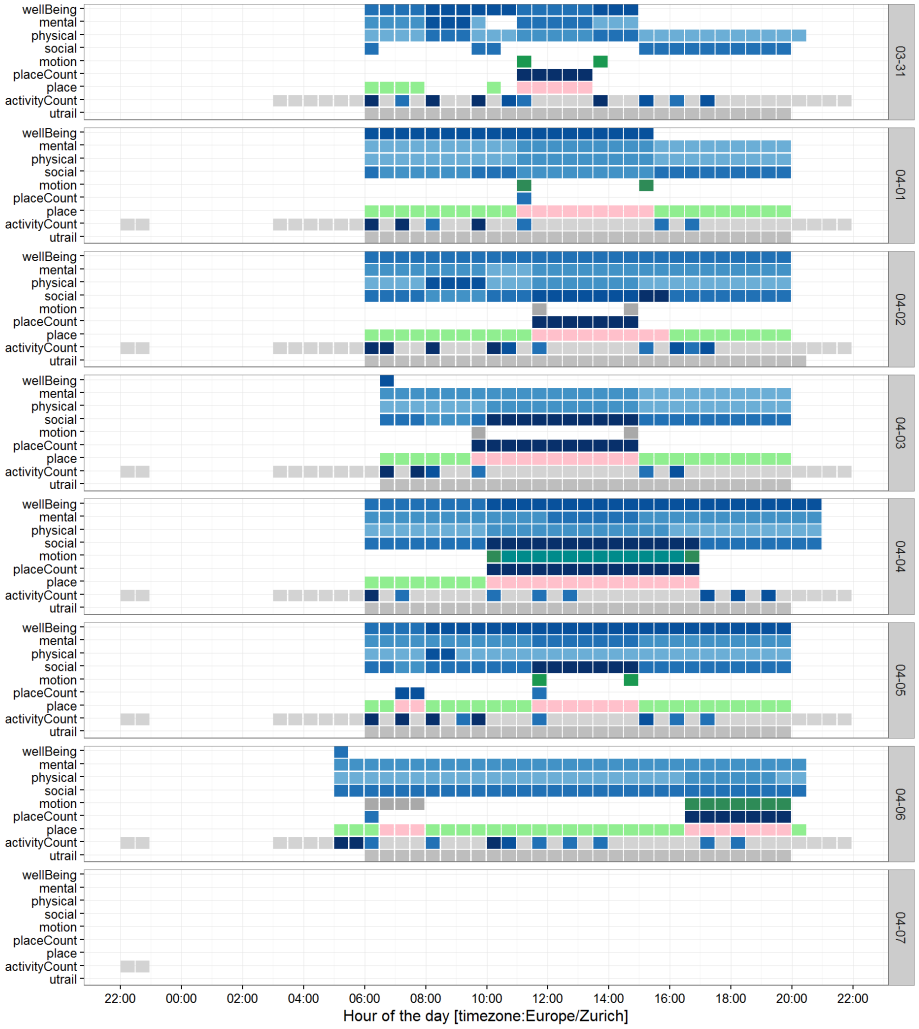
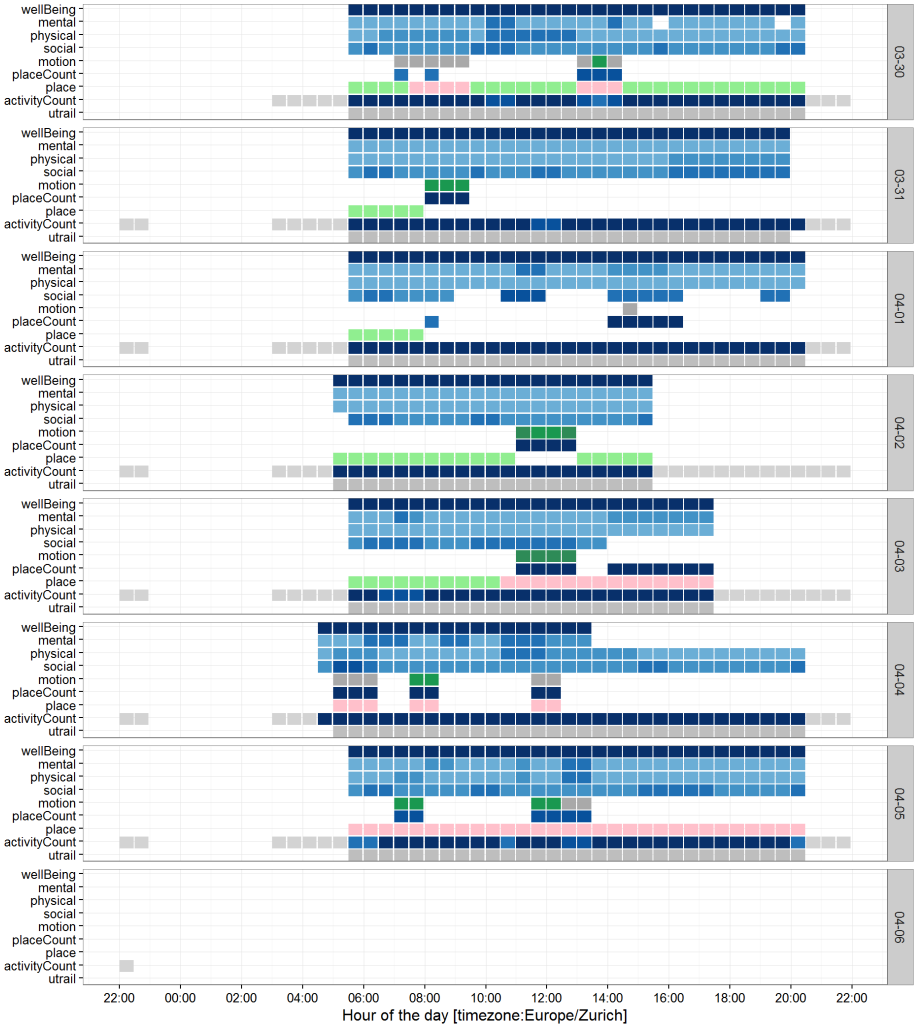
Activity diary (self-reported)





Reported activities

Summary

- Large part of our daily life happens indoors (no GPS)
- Temporal synchronisation allows for sensor integration that less depend on signal reception (such as accelerometer, EAR).
- Sensor integration enables and enriches the (re)construction of the participants lifeline
- Semantics of mobility is hidden and requires knowledge of domain and context

Next steps

- Further semantic annotation of moves & stops
- Inclusion of context data and sequence analysis
- Validation with self-reporting and diary data
- Development of improved probability-based estimations of activity spaces (aka home ranges)

Thank you!

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URPP "Dynamics of Healthy Aging" &
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Dynamics of Healthy Aging

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