



**University of
Zurich^{UZH}**

Department of Geography



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

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URPP Dynamics of Healthy Aging &
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University of Zurich

Content

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

Content

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- 1. Background MOASIS study**
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Collaborators within MOASIS

URPP



Geronto-psychology

Prof. Dr. Mike Martin
Prof. Dr. Mathias Allemand
Dr. Christina Röcke
Dr. Andrea Gruenenfelder
Dr. Burcu Demiray
Marko Katana

MOASIS

GIScience

Prof. Dr. Robert Weibel
Dr. Pia Bereuter
Georgios Technitis
Michelle Fillekes
Hoda Allahbakhshi

MOASIS – Mobility, Activity and Social Interaction Study

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



uTrail

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**



uTrail



Mobility profile

How the participants move
in their environment?

GPS



Activity profile

Which activity profile do
they follow?

Accelerometer



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 1 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.

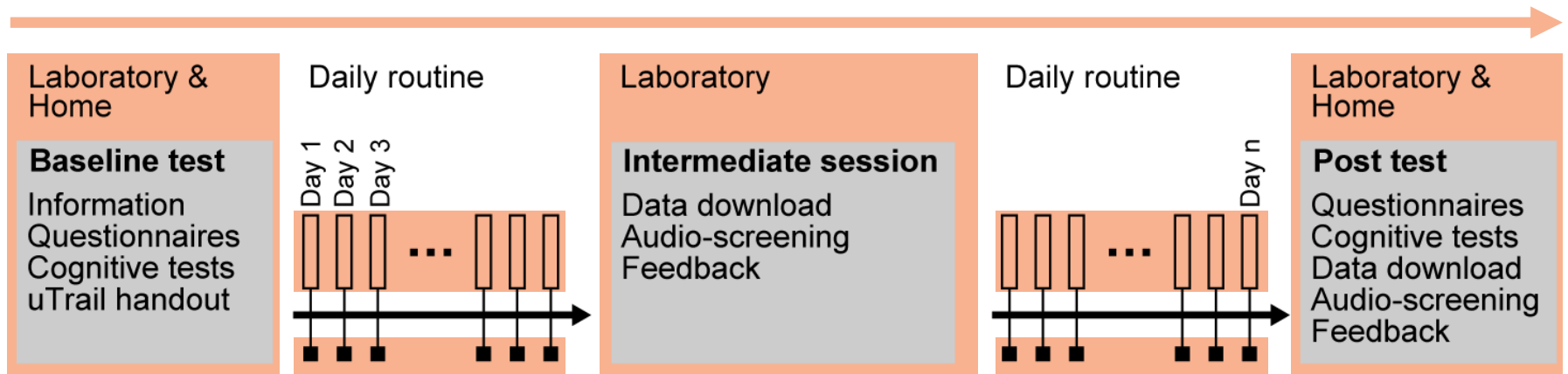
MOASIS Study design

Duration: 30 days

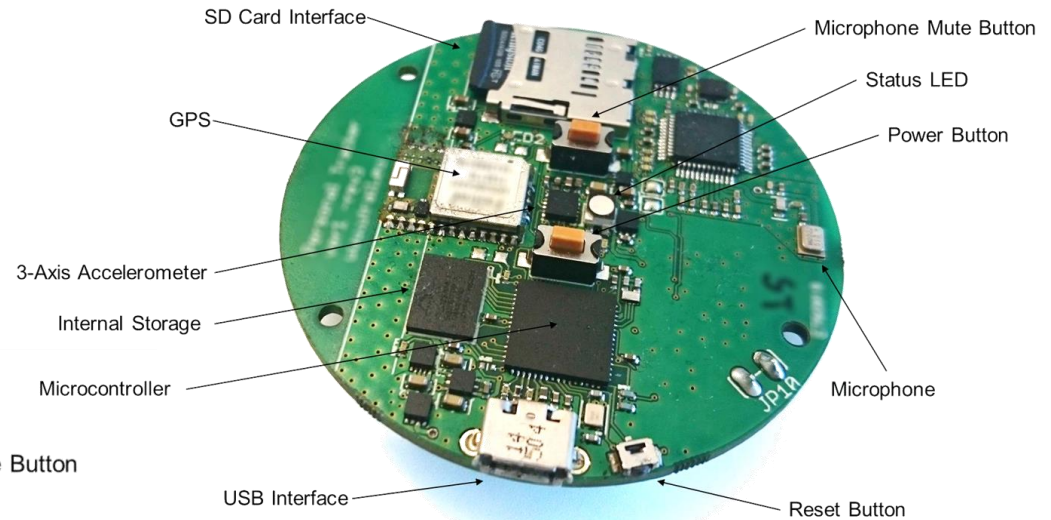
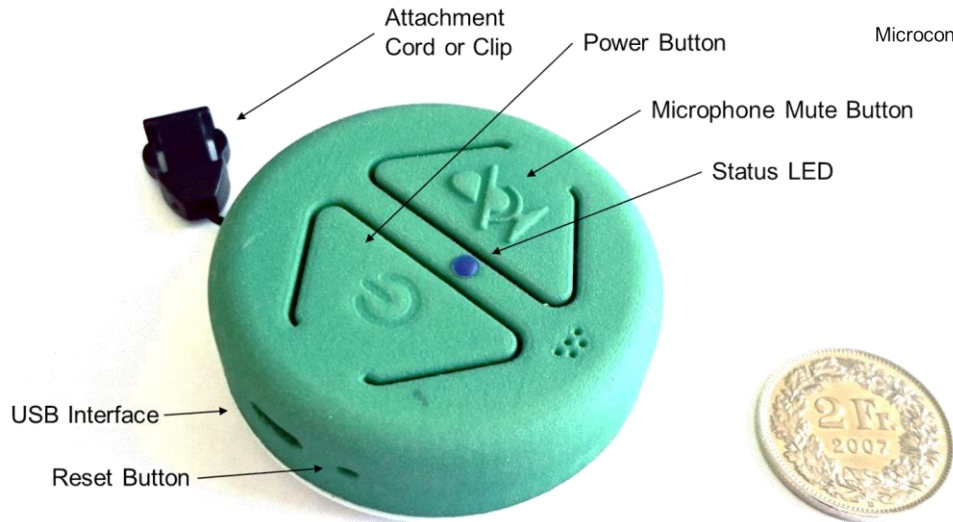
Psychological assessment: start and end of the study (emotional, cognitive resources, personality traits and physical & spatial activity)

Data sampling: portable tracker and (bi)weekly download sessions

Self reports: Daily evening dairies



uTrail

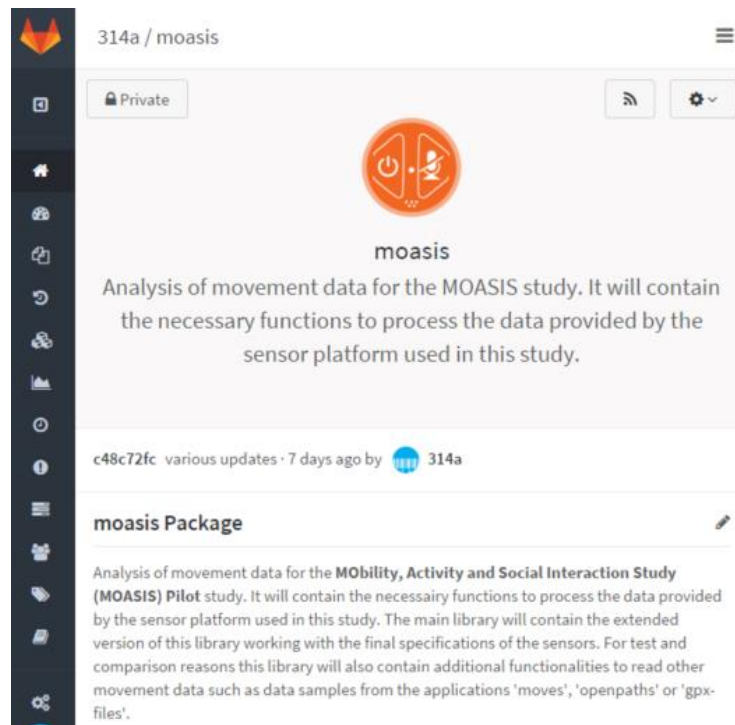


	Sensor	Variable	Sampling rate
Spatial mobility	GPS	Time, latitude, longitude	1 Hz
Physical activity	IMU	Time, acceleration (x,y,z)	3 Hz / 50 Hz
Social interaction	EAR	Time, sound sample (30 secs)	1 per 12.5 min

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



Mobility, Activity and Social Interaction Study (MOASIS) - pilot study package



Documentation for package 'moasis' version 0.3

- [DESCRIPTION file.](#)
- [User guides, package vignettes and other documentation.](#)
- [Package NEWS.](#)

Help Pages

[moasis-package](#)
[audio2spectroPng](#)
[audio2waveformPng](#)
[audioConvertWav](#)
[audioSimilarity](#)
[audioTranscribeMusic](#)
[compact2validGPS](#)
[compactActivity](#)
[compactActivitySteps](#)
[compactDiffTime](#)
[compactGPSNAcount](#)
[concatCSVfiles](#)
[getAudioMetadata](#)
[getDistance](#)
[getDistanceSP](#)
[getExternalIPAddress](#)
[getFirstFix](#)

Mobility, activity and social interaction analysis package
Create waveform image from audio files
Create waveform image from audio files
Convert to .wav file
Audio sample similarity (experimental)
Transcribe music (experimental)
Merge gps activity (by valid gps signal) (rephrase)
Compact gps activity classes to frequency tables
Compact gps step counts to sums
Compact time difference values
Compact gps NA values to counts
Concat CSV files
Read file metadata (external)
Get Distance
Get Distance SP
Get IP address
get time ranges for GPS reception and offline periods

Content

- 
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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
```

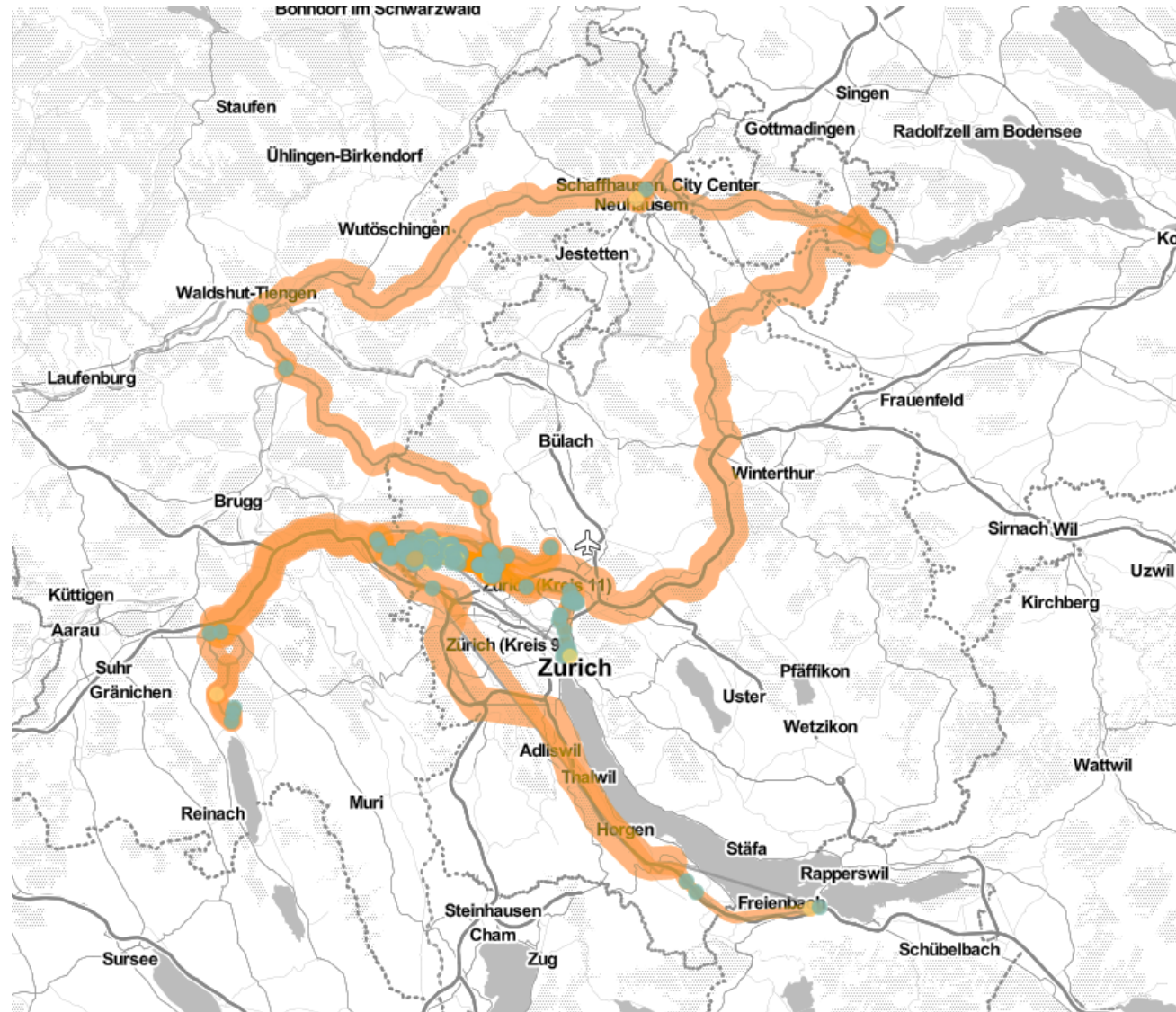
EAR MP3 File



MA20-000.MP3

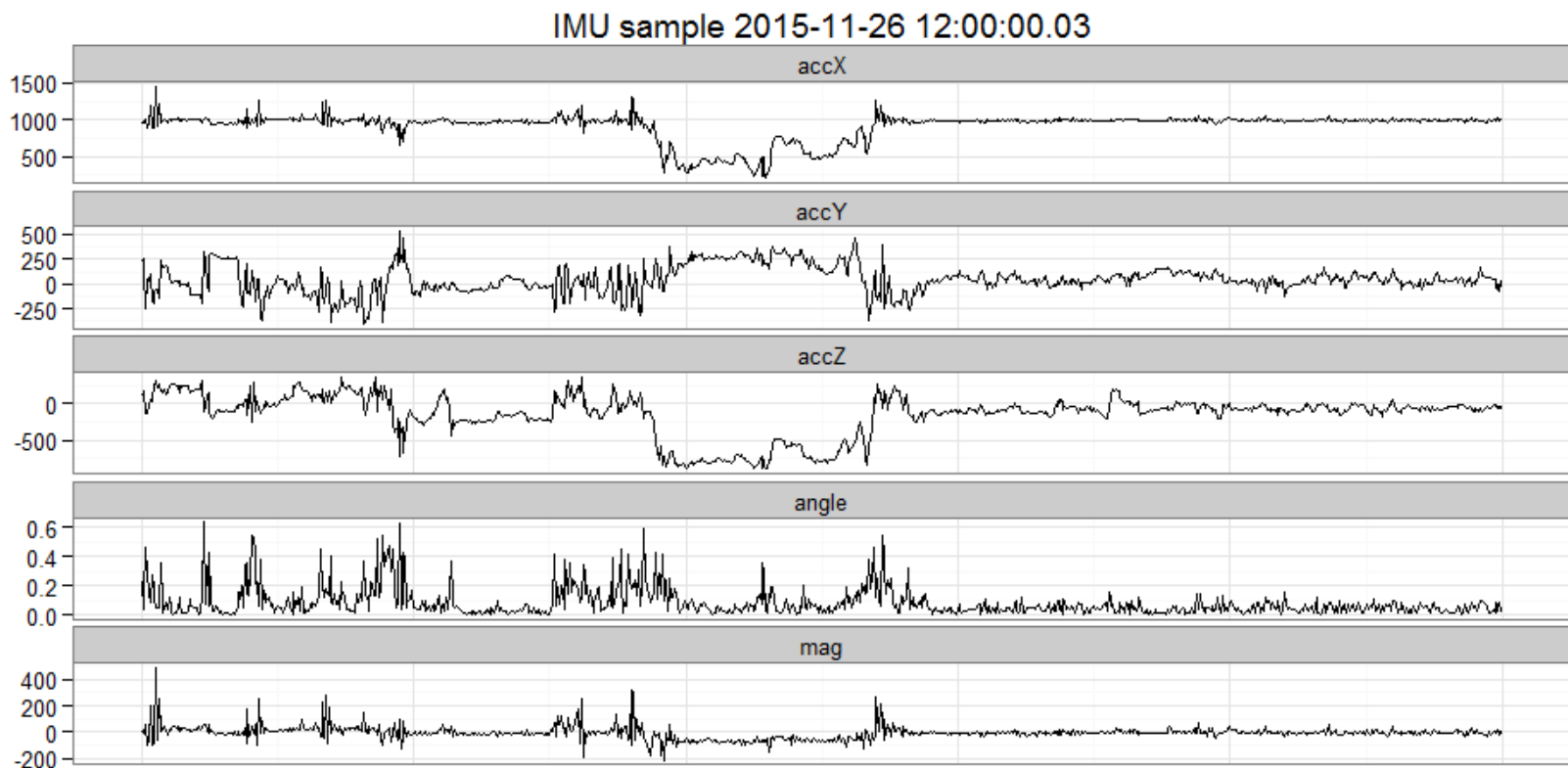
GPS

Data example of
a participant over
the entire study
period



Accelerometer

Sampling rate 3 Hz ($\rightarrow$ 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

still

walking (slow)

walking (fast)

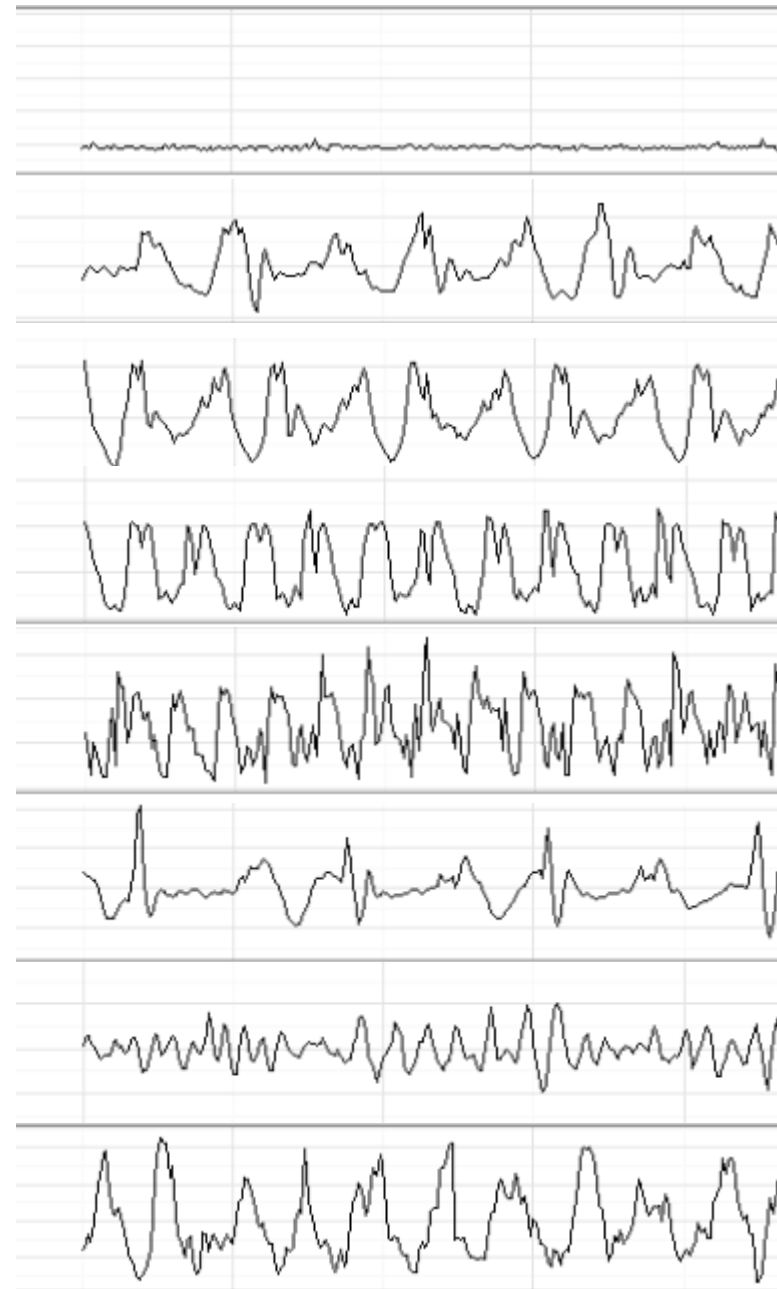
jogging

running

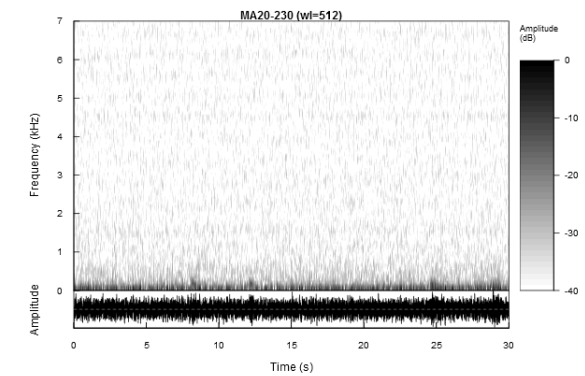
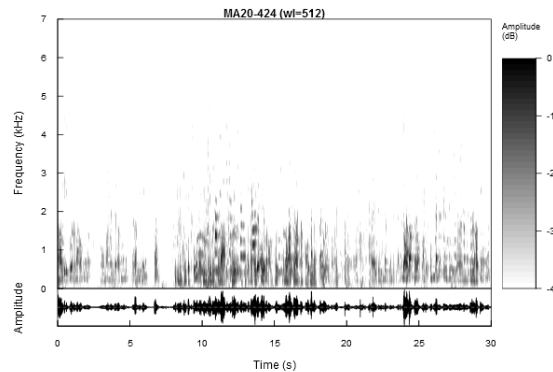
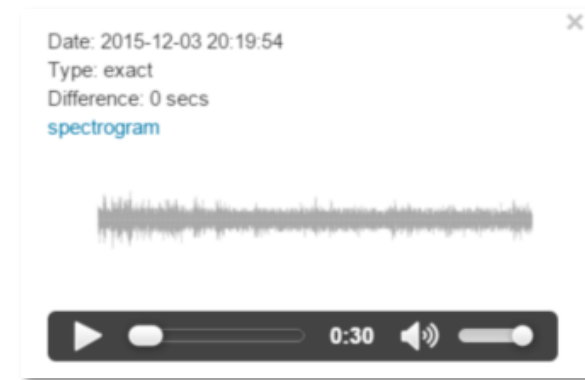
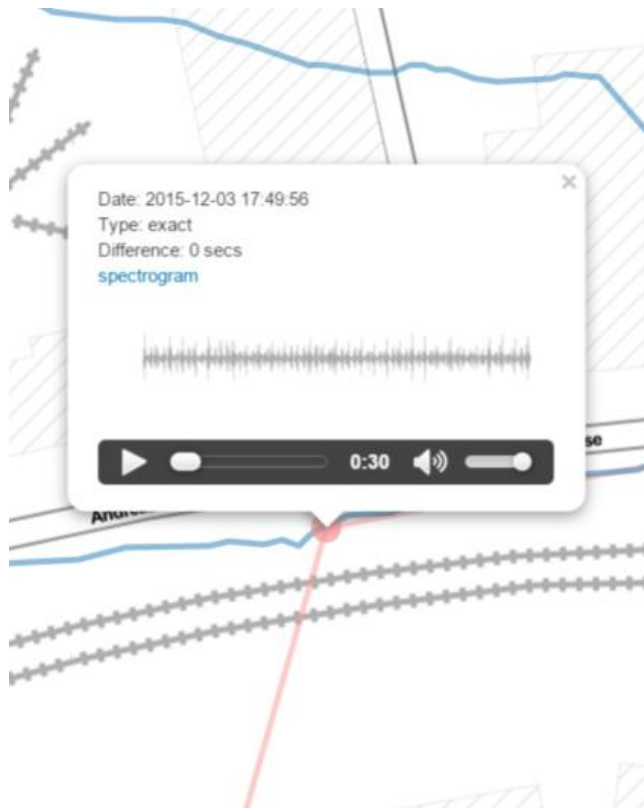
limping

Cycling (slow)

Cycling (Fast)



Audio example



Raw - trajectory

Pseudo-Movement



Clustering

Density-based clustering – trajectory subsampling



Segmentation

Segmentation based on average speed and heading angle

Time window

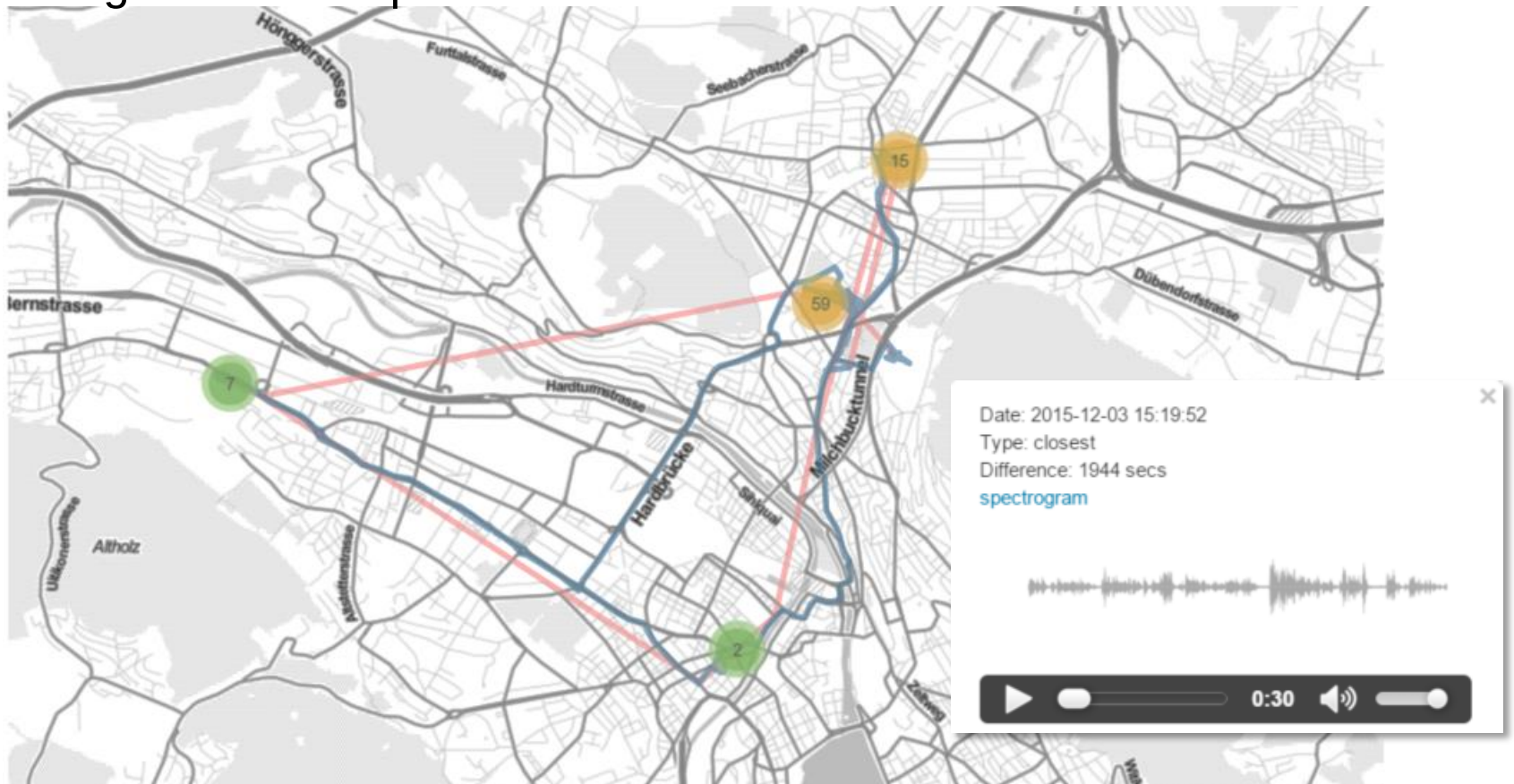
- Average speed
- Average heading angle



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

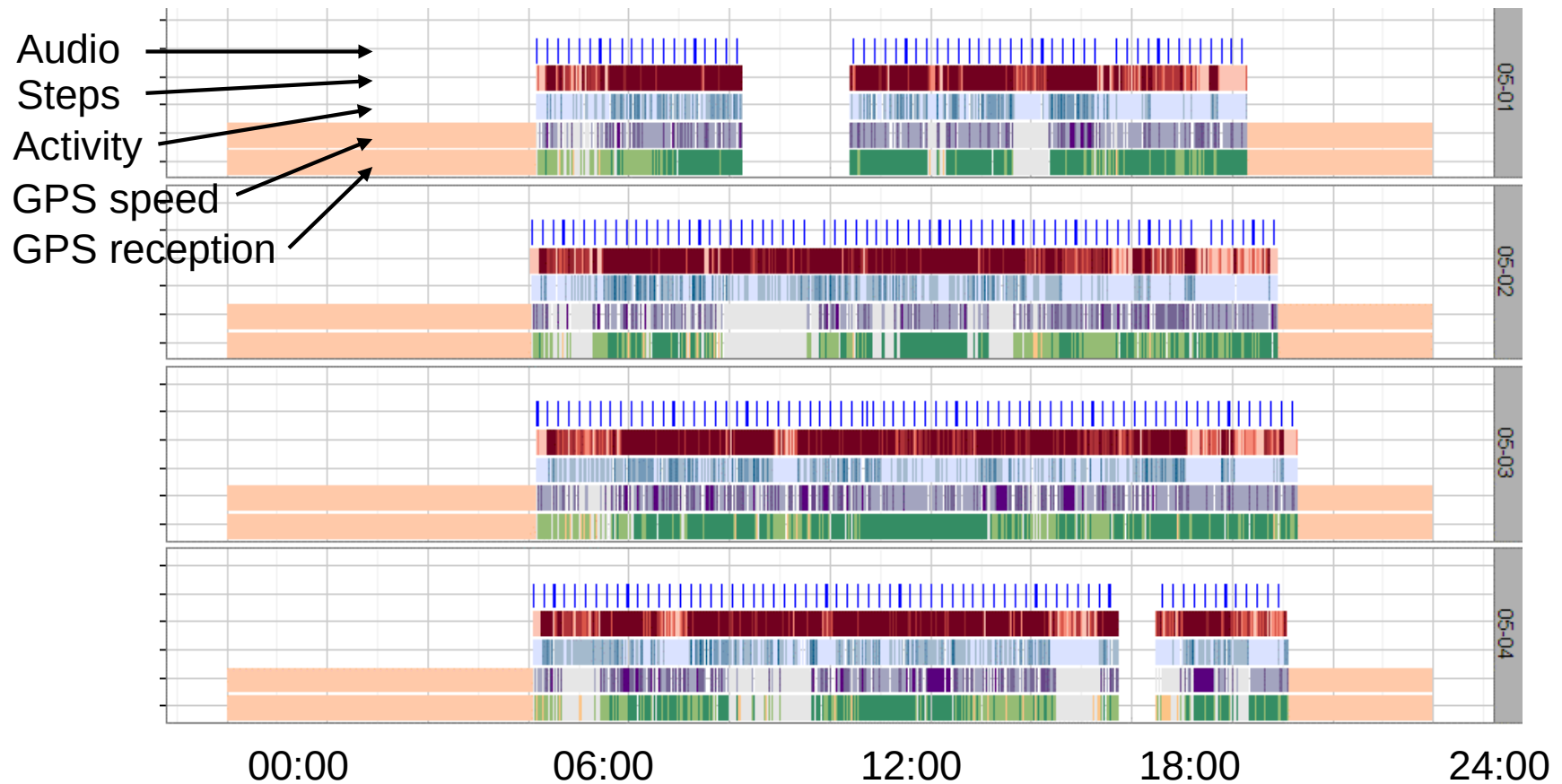
Participant	Hours %
1	92.2
2	93.1
3	78.5
4	89.3
5	85.2
6	85.4
7 ¹	95.0
8	91.2
9	64.5 ²
10	77.0
11	86.2
12	81.1
13	73.9

Content

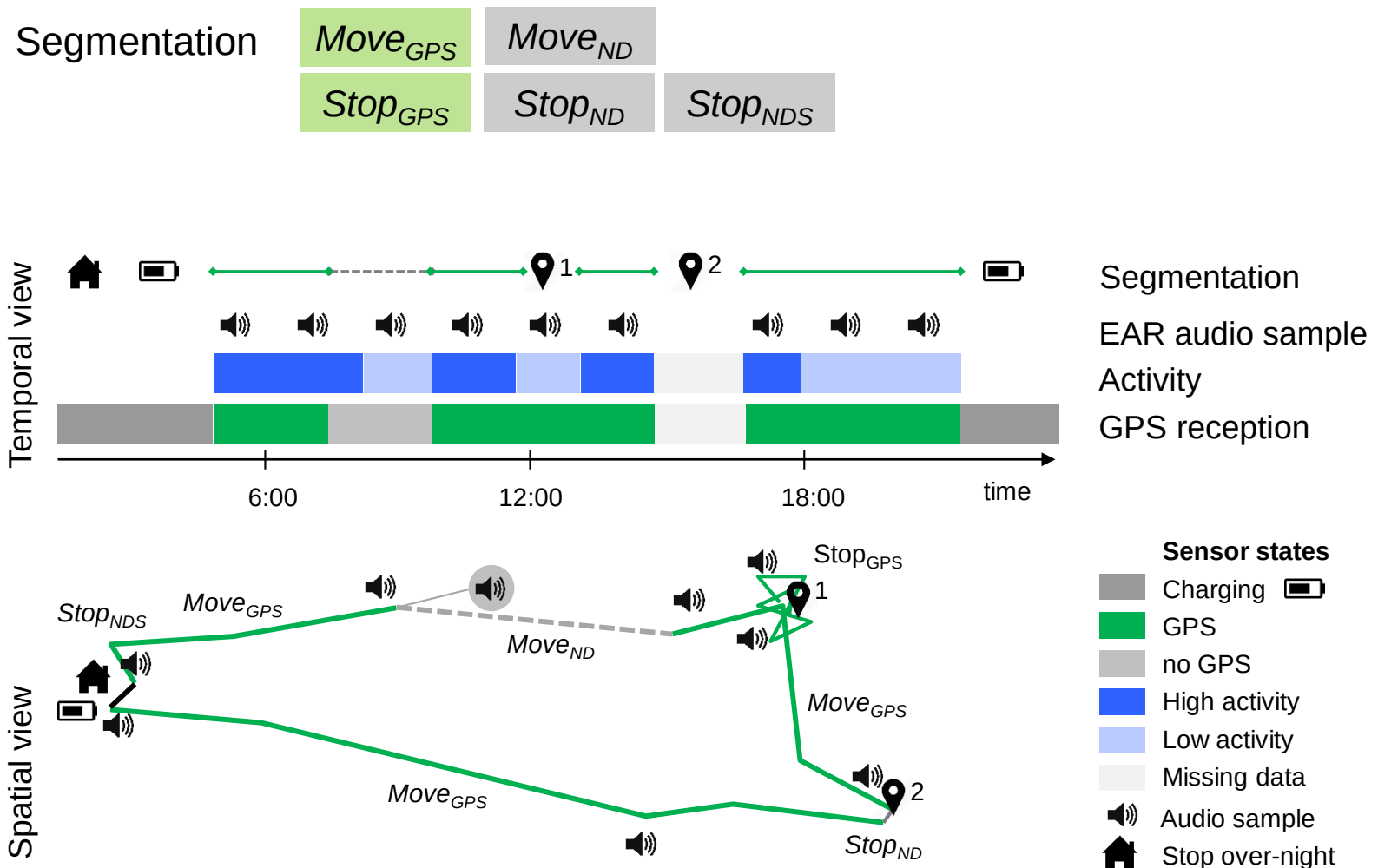
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Timeline

Temporal coverage

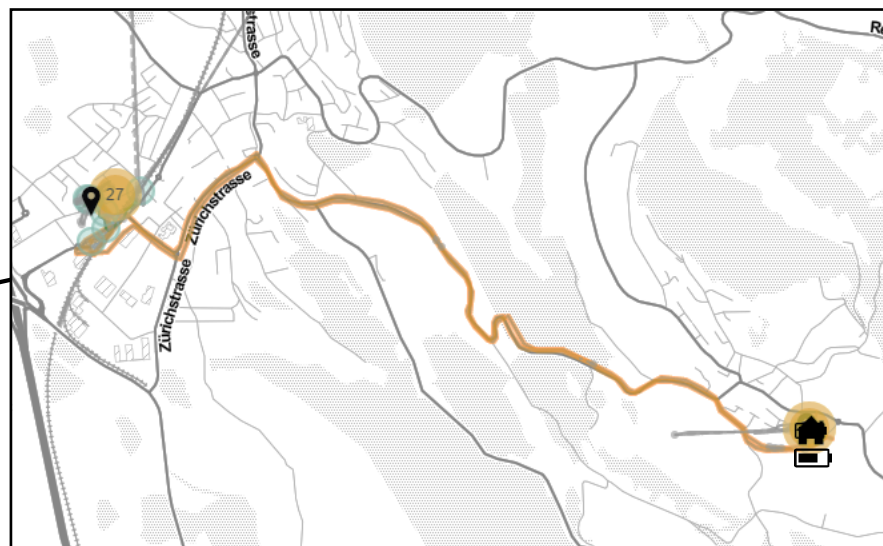
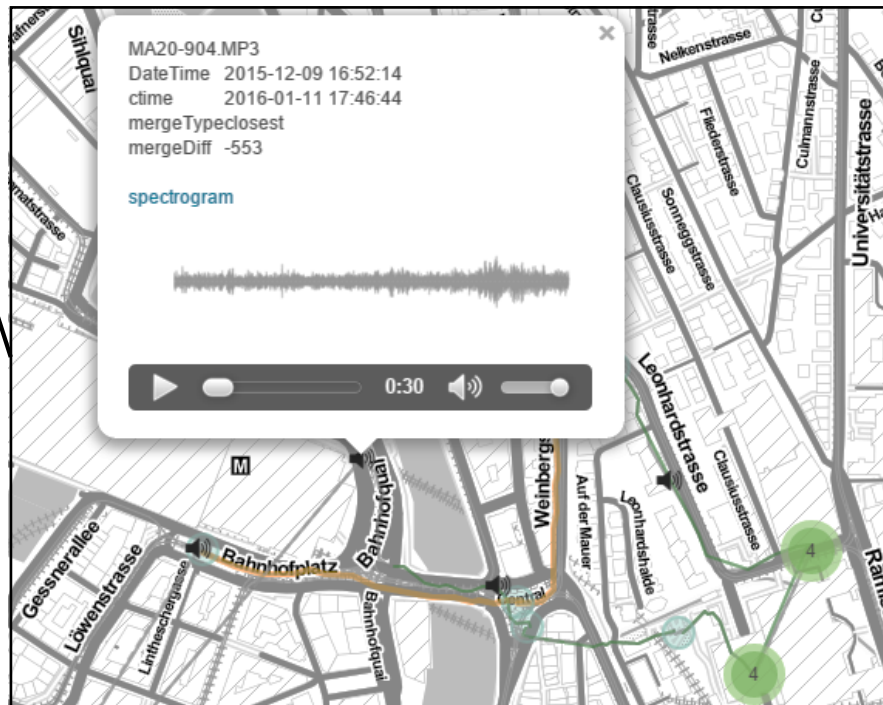
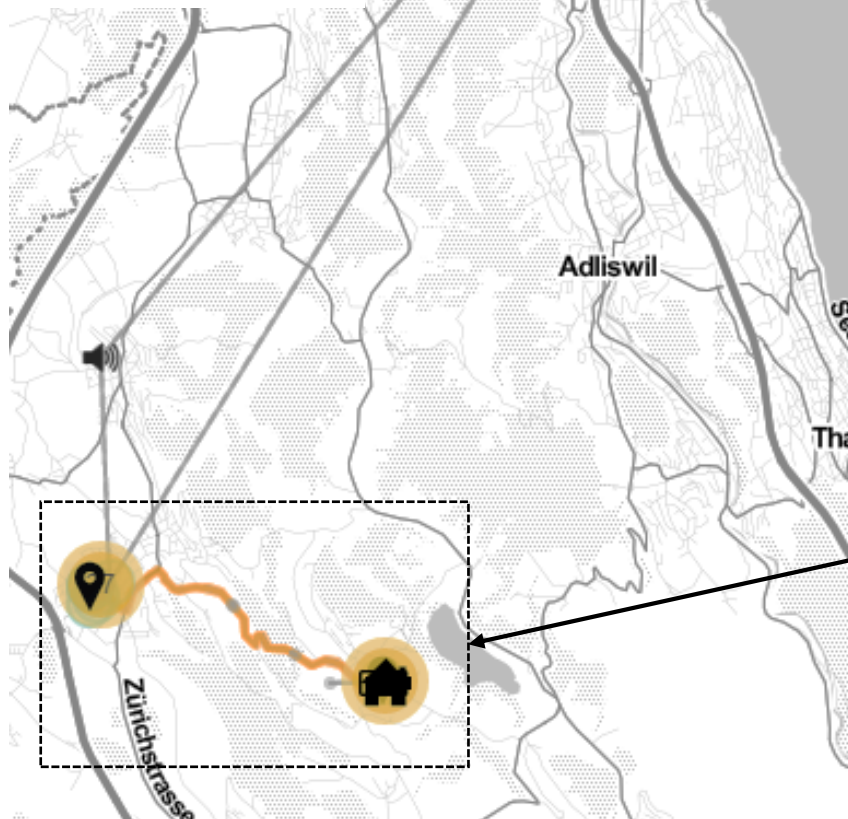


Reconstruction of a daily spatio-temporal timeline



Legend

- Segment – Transport
- Segment – Walk
- Segment – no GPS
-  Stop over-night
-  Stop charging
-  Stop cluster
-  Audio sample
- 5 Audio cluster

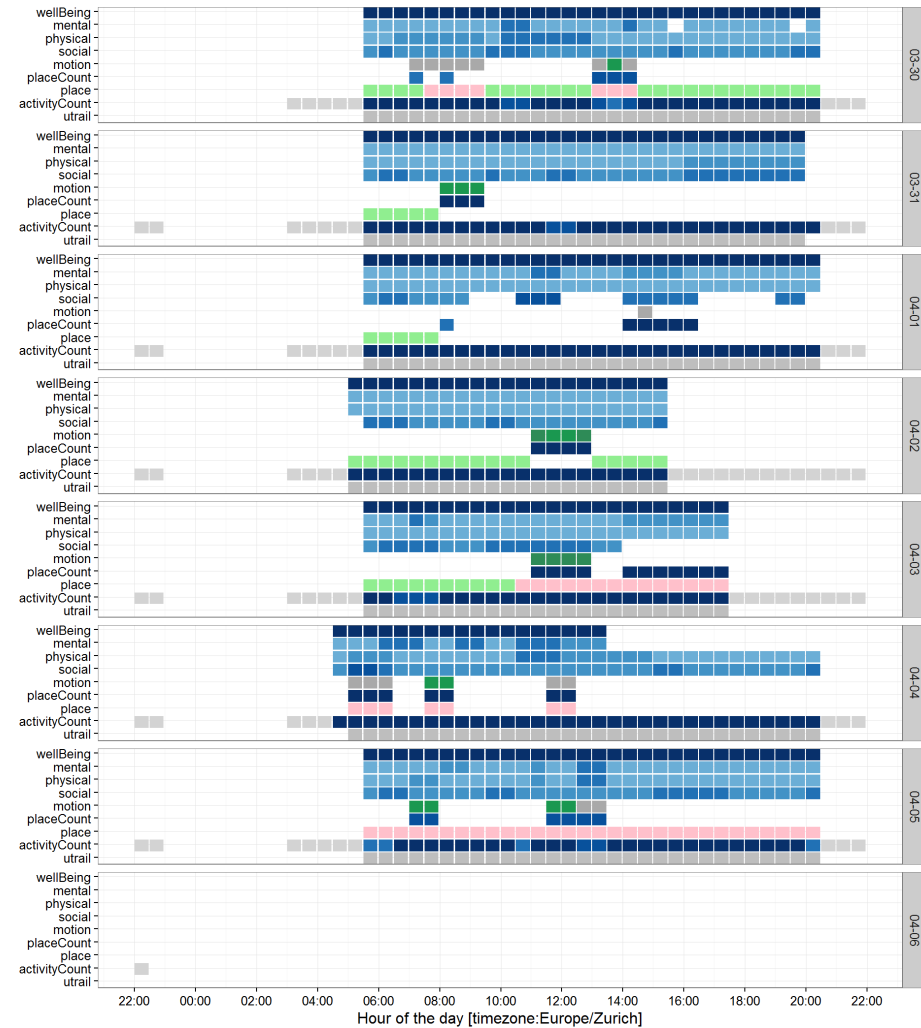
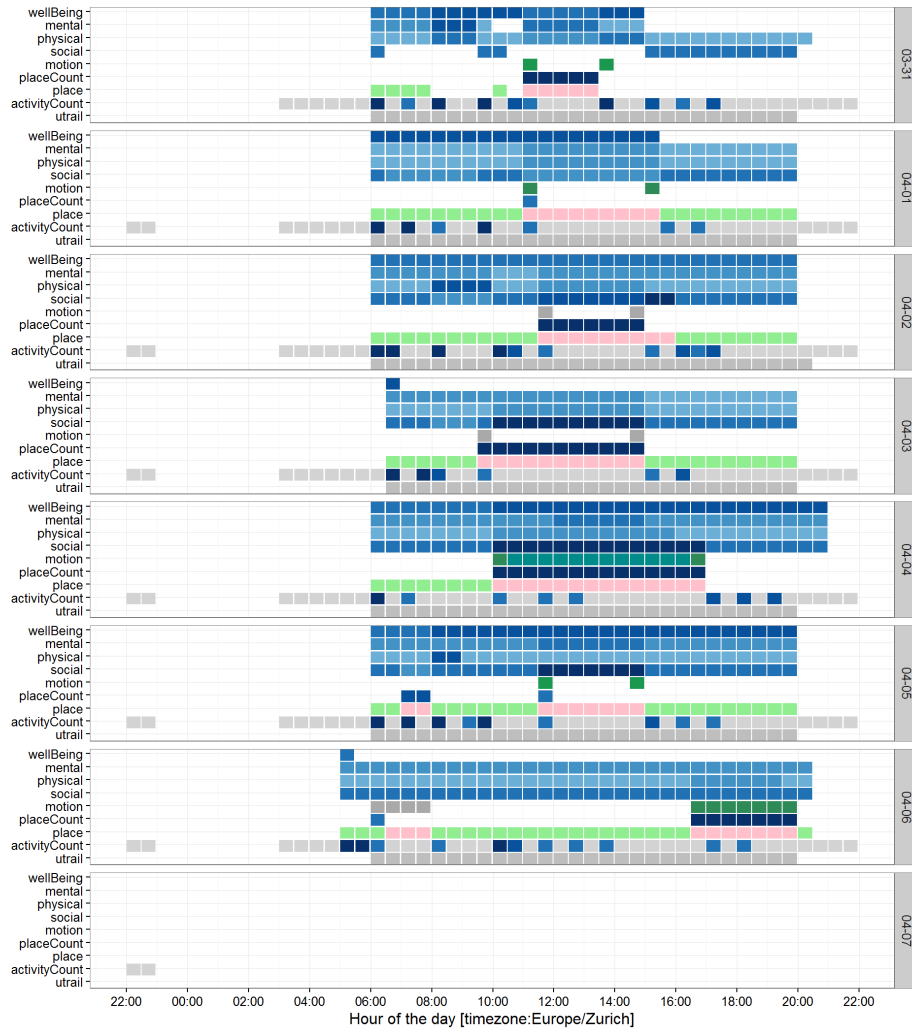


Leaflet | Map tiles by Stamen Design, CC BY 3.0 – Map data OpenStreetMap

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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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VELUX STIFTUNG