Intersubjectivity of stress sensation in bicycle traffic
derived from physiological measurements

1 Introduction

For the shift towards sustainable and healthy mobility to succeed, alternative transportation modes need to become more attractive. A major concern for cyclists is the perceived safety and stress level in traffic. Identifying existing stress hot-spots in the built environment is crucial for improving infrastructure. Additionally, routing applications could provide stress-minimizing routes to guide cyclists within the existing bicycle network for an optimized cycling experience.

2 Objectives

- design and conduct case study
- detect moments of stress (MOS) based on physiological measurements
- derive stress index per network element: node (intersection) and edge (road)
- evaluate intersubjectivity of stress perception among case study participants

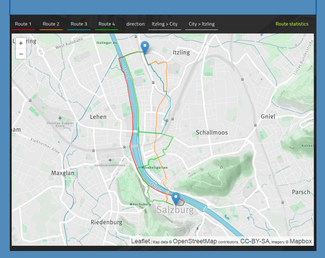
3 Case study

- city of Salzburg, Austria
- four pre-defined routes (4-5 km)
- tracking of galvanic skin response (GSR) and skin temperature using wearable sensor (Empatica E4) and geolocation (GPS)
- survey per trip: environmental conditions, traffic and stress perception

4 Methods

A quantitative approach for assessing subjective perception of the urban environment

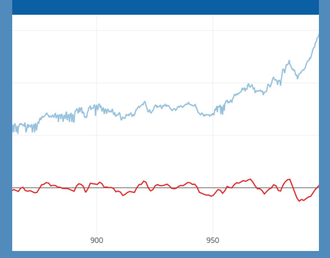
Case study design
- data acquisition plan
- project website
- survey design
- survey development



Data acquisition
- 10 participants
- min. routes 1 and 2 (bi-directional)
- camera for qualitative analysis and validation

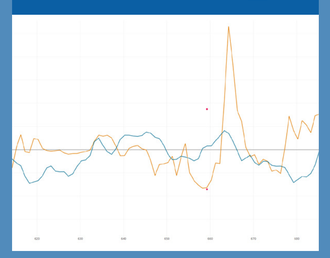
Automated workflow: Python and PostgreSQL/PostGIS

Data preprocessing
- filter
- resample
- geocode
- import to database



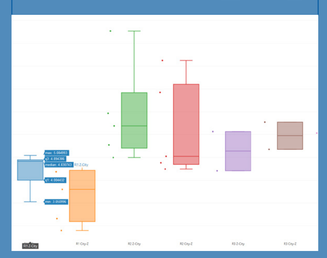
Map matching
- identify route
- clip start and end
- node-based matching (20 m radius)
- exclude detours

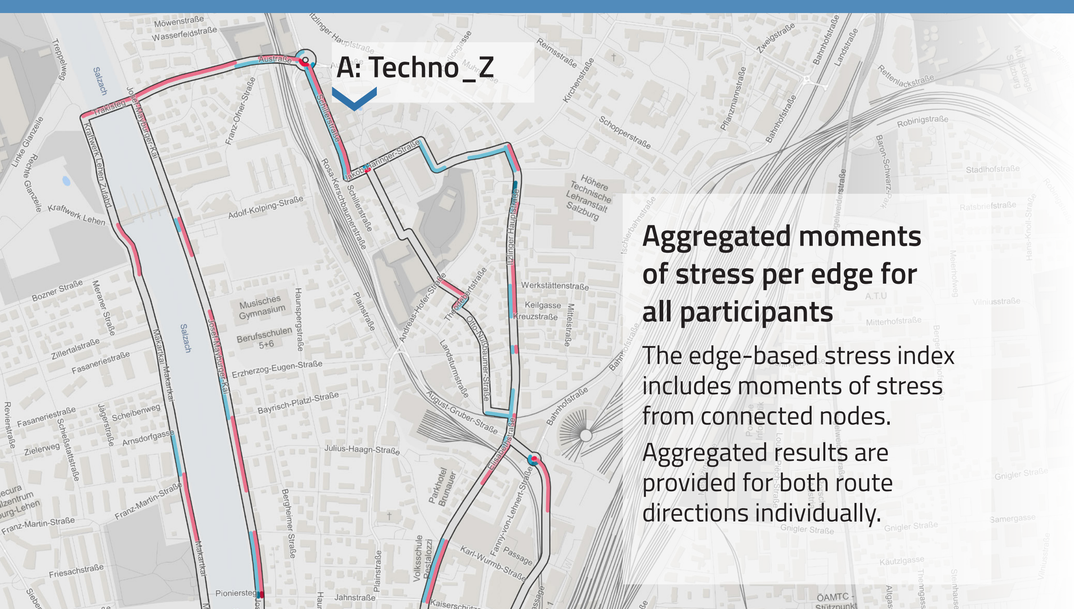
Stress detection
- rise of skin conductivity followed by decline in skin temperature (Zeile et al., 2016)



Aggregation
- per node
- per edge and direction
- combined value per edge (e.g. for routing)

Evaluation
- intersubjectivity
- measured vs. reported stress perception





Aggregated moments of stress per edge for all participants

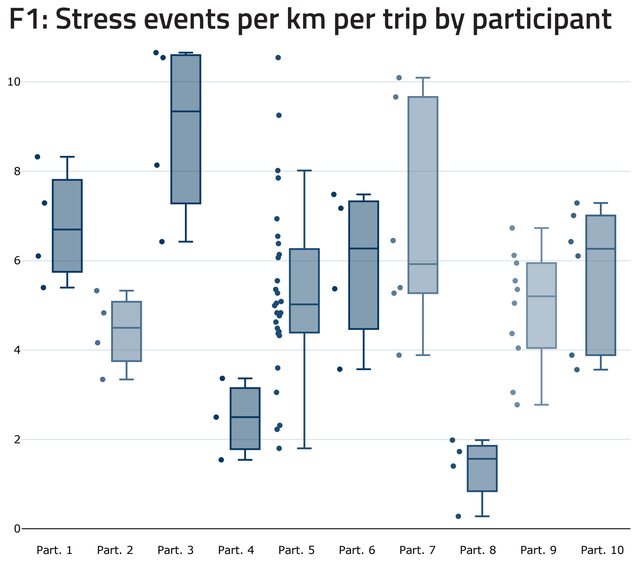
The edge-based stress index includes moments of stress from connected nodes.

Aggregated results are provided for both route directions individually.

5 Results

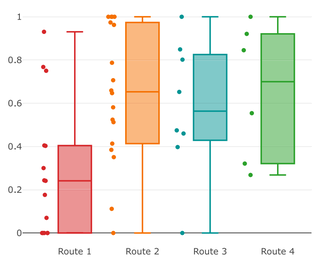
- range of stress perception intensity varies between participants (F1)
- normalization per participant is required (range of stress perception)
- intersubjectivity of stress perception: route 1 is percieved least stressful (F2)
- stress hot spots: map shows spatial accumulation of moments of stress

F1: Stress events per km per trip by participant



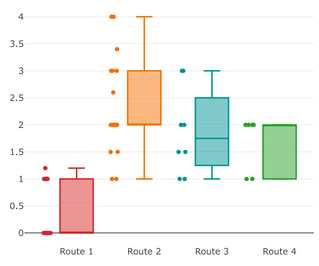
F2: Measured stress

Moments of stress per km per trip by route



F3: Reported stress

Reported overall stress level per trip by route



6 Conclusion

- stress detection algorithm proved successful, but is sensitive to pre-processing parameters
- measured stress and reported stress (in trip survey) generally matching (F2, F3)
- intersubjectivity in per route stress perception and spatial hot spots could be shown
- automated processing enables fast workflow for optimization; foundation for real-time use

Future work:

- incorporating measures for stress intensity
- large-scale data acquisition: higher spatial and temporal coverage for more detailed insights
- comparison with existing bikeability measures
- routing based on stress index
- accompanying qualitative research

References

Zeile, P., Resch, B., Loidl, M., Petutschnig, A., & Dörrzapf, L. (2016). Urban Emotions and Cycling Experience–enriching traffic planning for cyclists with human sensor data. GI_Forum 2016, 1, 204–216.

Map data: OpenStreetMap contributors

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