Human Perception of the Urban Environment

A Machine Learning Approach

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About the study

Urban Environment

Dynamic environmental conditions such as noise, temperature, illuminance, field of view, walkable area and traffic speed have the potential to influence an individual's perception.

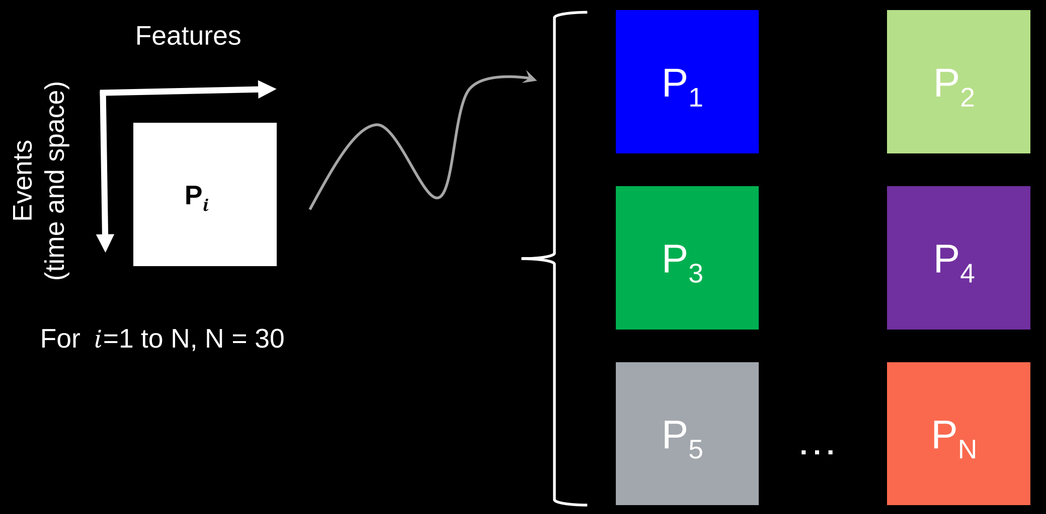
Human perception

Skin conductance responses of participants were measured with an E4 wearable device and processed to detect arousal levels as an indicator of perception.

Wiedikon | Zürich | Switzerland

Properties of dataset

Participant's data



Some facts

Diversity in days (participants walked on different days)

Diversity in experiment day's time slot

Diversity in participant's demographic profile

Uniformity in study location

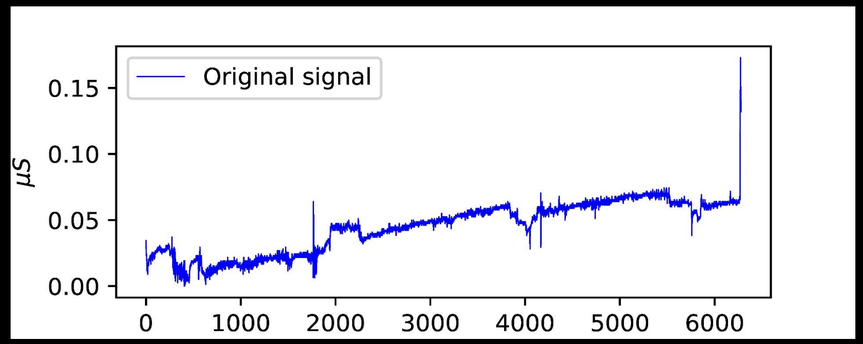
Uniformity in season (month of April)

Data samples have the record of time and place

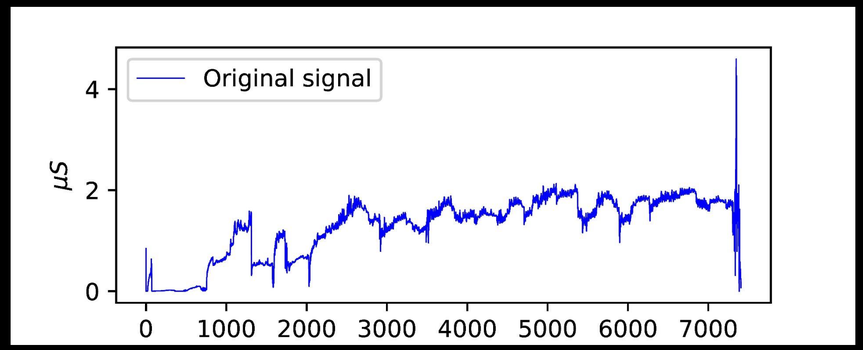
Human perception feature (physiological response) and urban environment features are spatial-temporal data

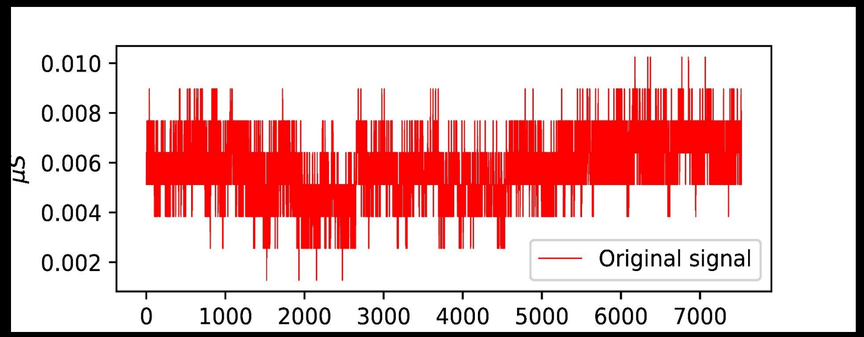
Physiological responses are time-series data, thus need special treatment.

Data cleaning

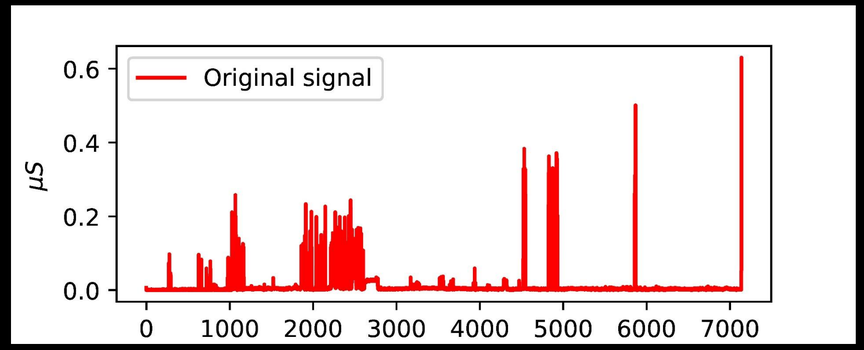


Examples of accepted physiological data for processing



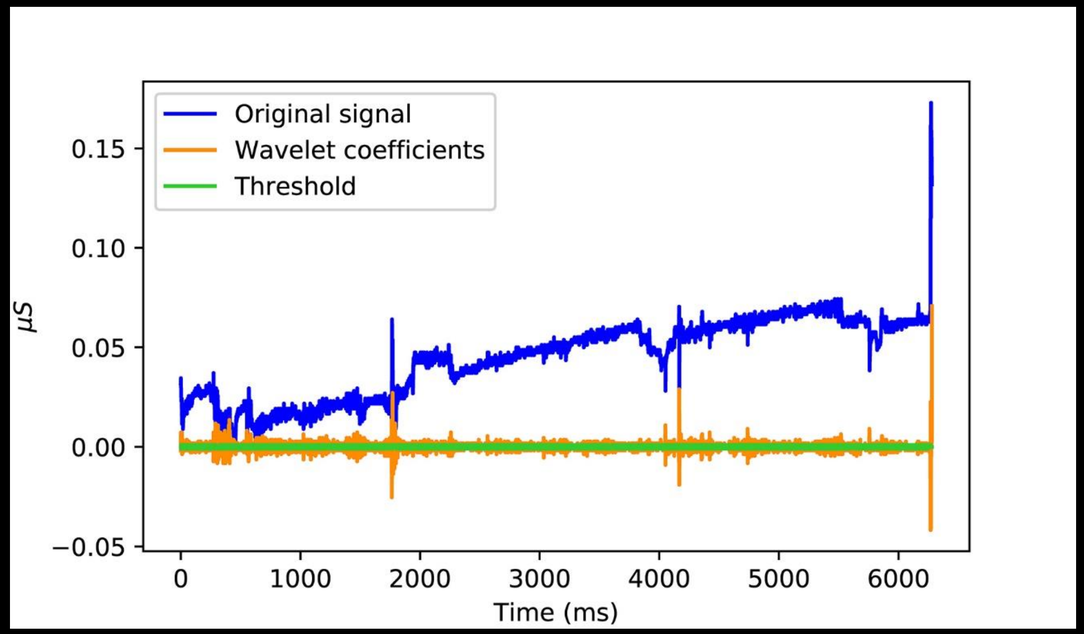


Examples of rejected physiological data

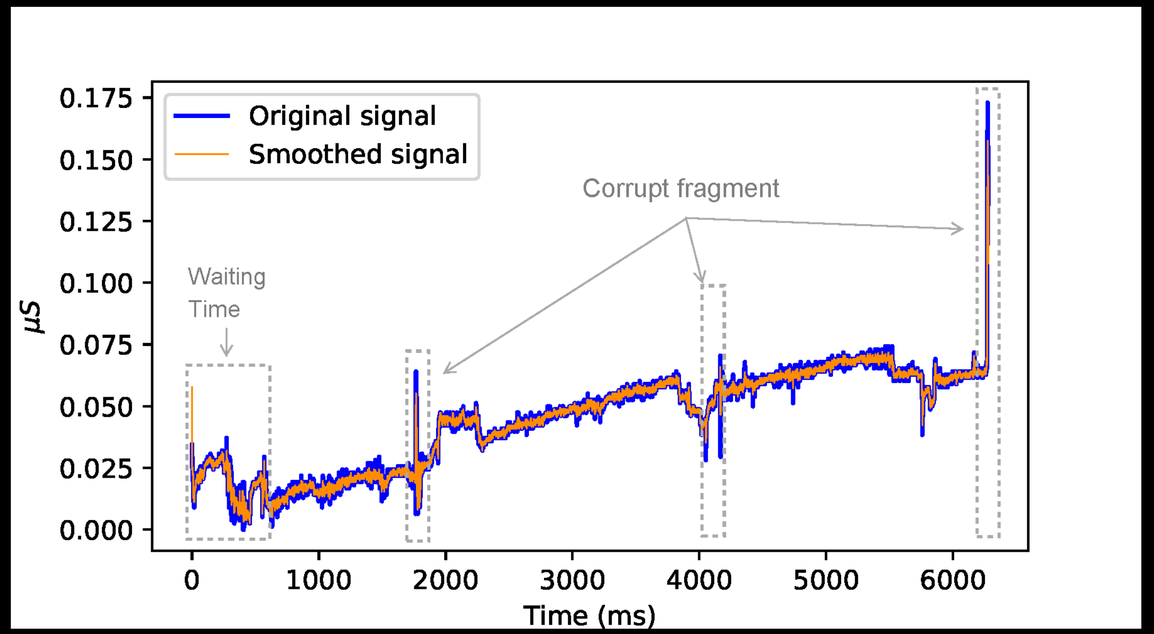


Data smoothing and filtering

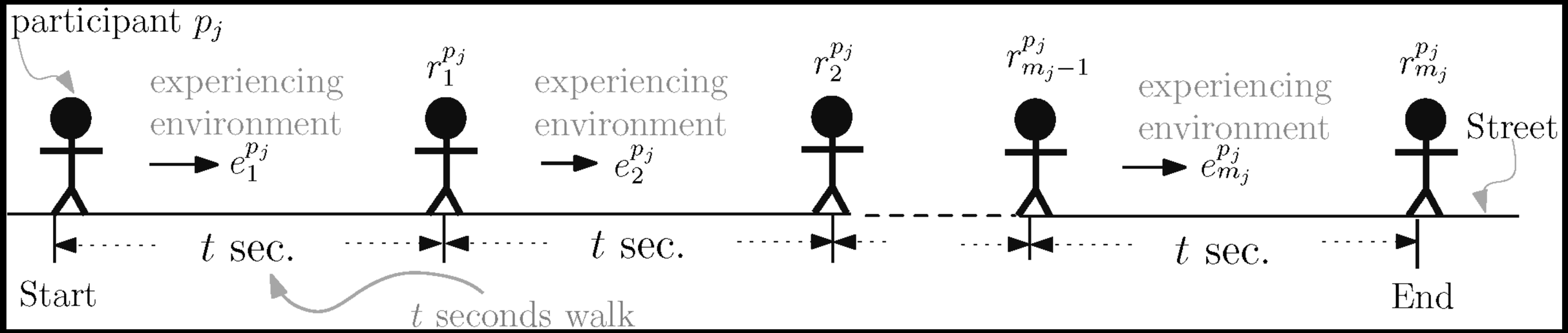
Stationary Wavelet Transform



Original physiological data → Smooth physiological data

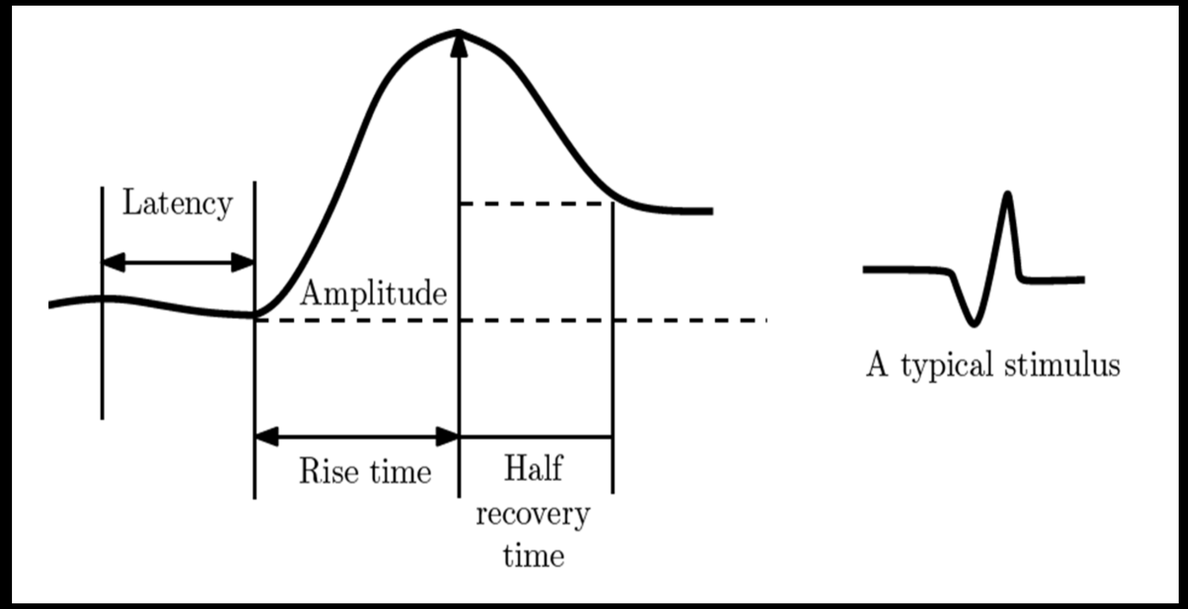


Data quantification



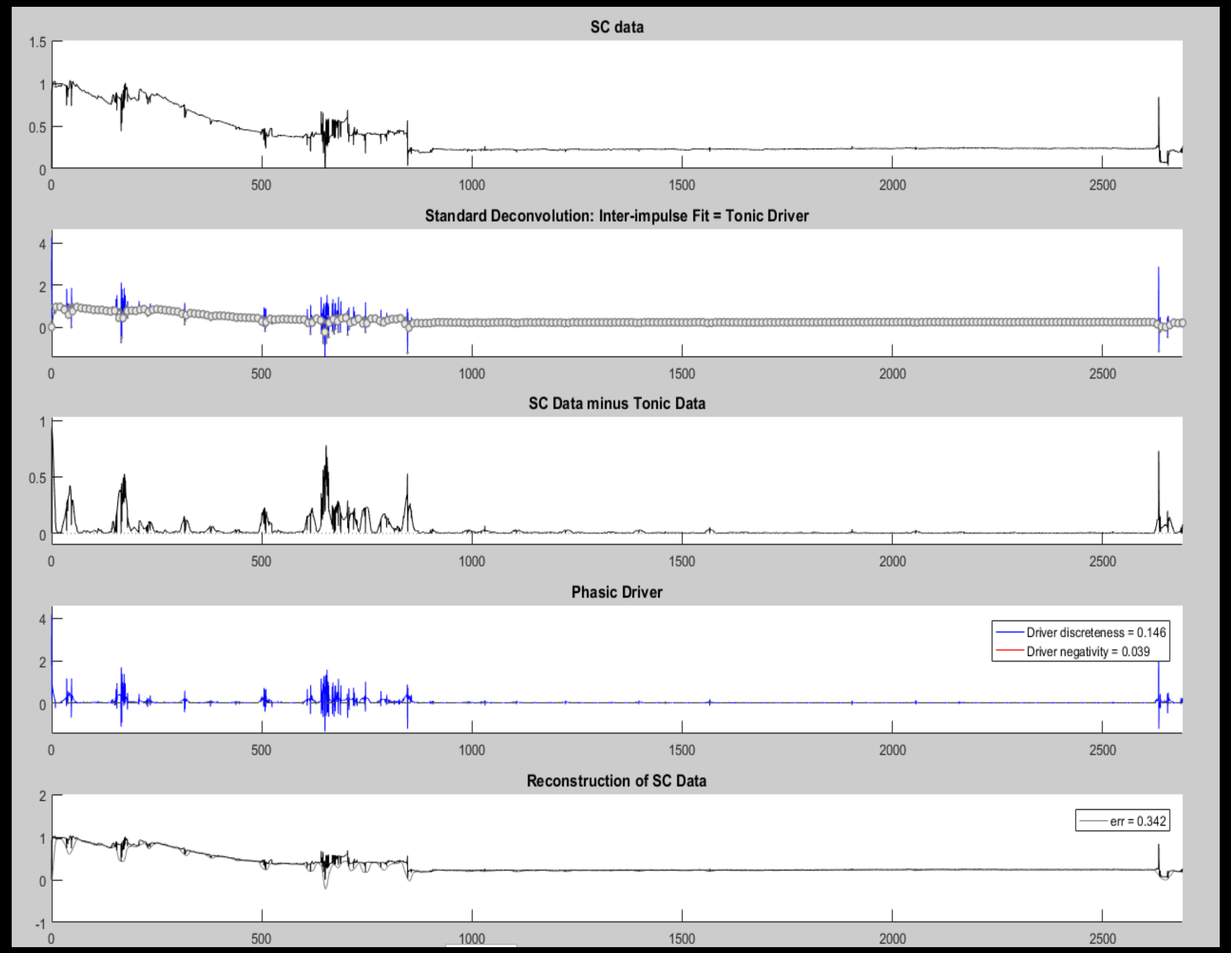
Arousal (nSCR) level detection

Typical signature of an Skin Conductance Response (SCR)



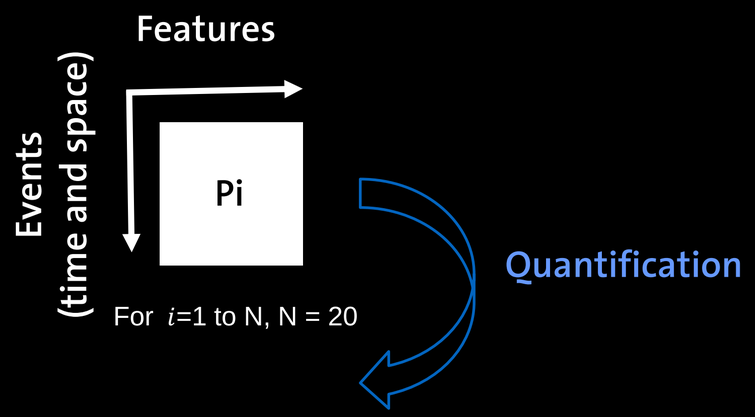
Source: Braithwaite, J. J., Watson, D. G., Jones, R., & Rowe, M. (2013). A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments. Psychophysiology, 49, 1017-1034.

Ledalab for EDA signal analysis



Fusion

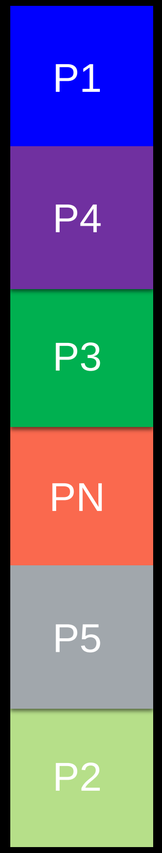
Participant's data fusion



<event - response>

Samples

$$\left\{ \begin{array}{l} < e_1, r_1 > \\ < e_2, r_2 > \\ \vdots \\ < e_{m_1}, r_{m_1} > \end{array} \right\}$$

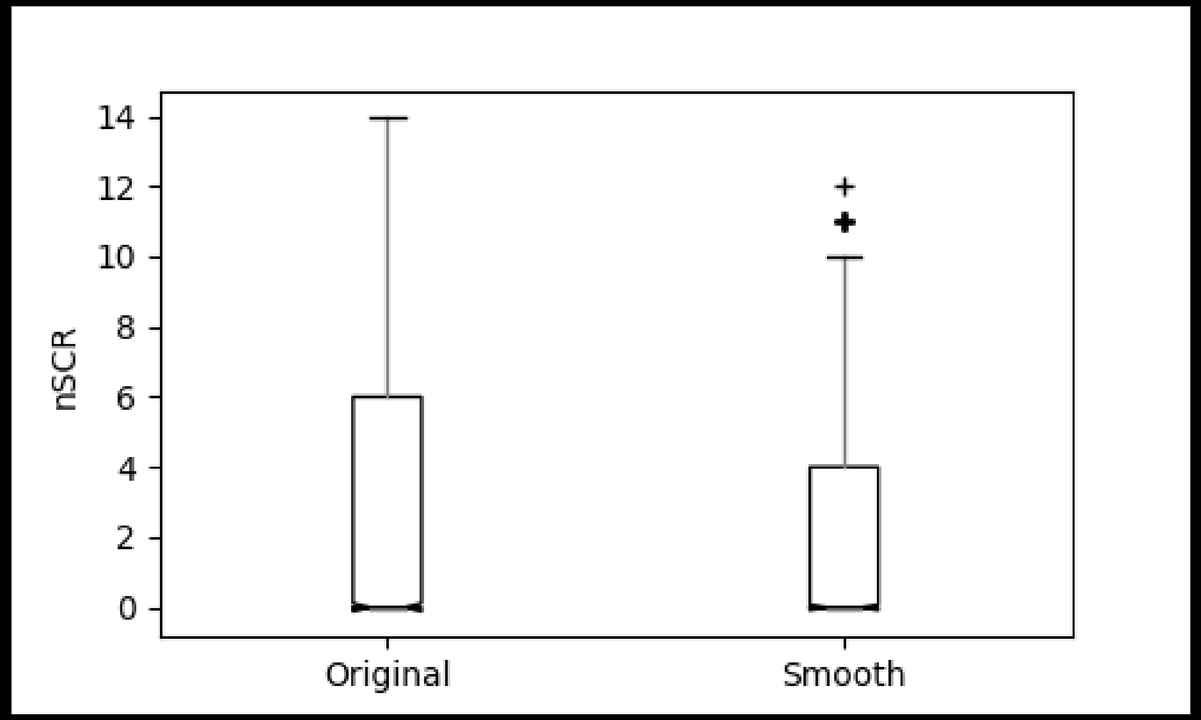


Attributes of the complied dataset

Type	Attributes/Features
Input	Participant ID
	Timestamp
	Longitude
	Latitude
	Noise
	Dust
	Temperature
	Relative humidity
	Brightness/Illuminance
	Isovist area
	Isovist perimeter
	Isovist compactness
	Isovist occlusivity
Output	Binary/Multiclass/phasic driver

Data labeling

Sense of physiological response (nSCR) labeling



Box plot of nSCR values across all participants

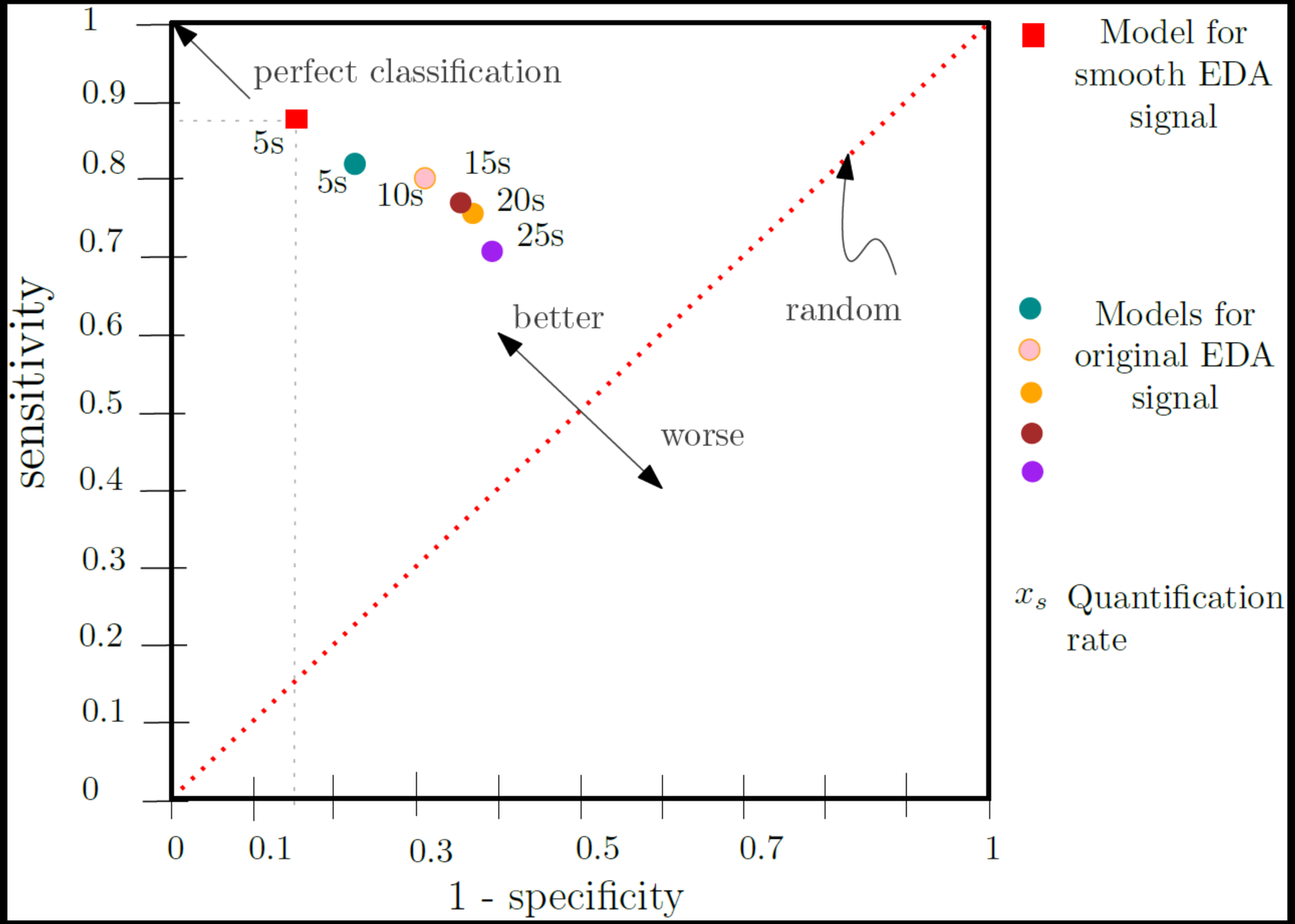
Class 0 : A samples' physiological response value = 0

→ Normal physiological state

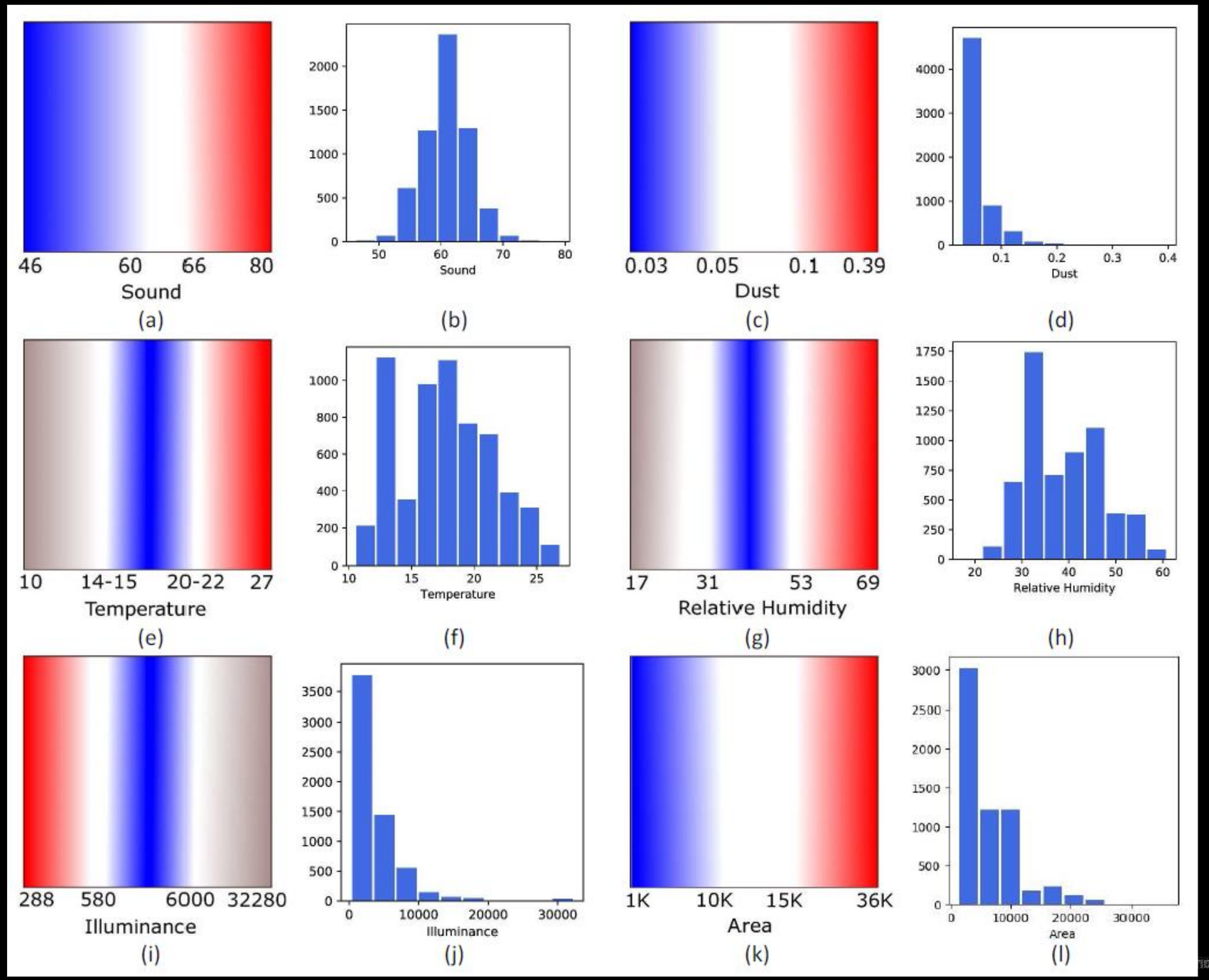
Class 1 : A samples' physiological response value > 0

→ Arousal physiological state

Sensitivity analysis



Inference


46 60 66 80
Sound
(a)
2000 1500 1000 500 0
50 60 70 80
Sound
(b)
0.03 0.05 0.1 0.39
Dust
(c)
4000 3000 2000 1000 0
0.1 0.2 0.3 0.4
Dust
(d)
10 14-15 20-22 27
Temperature
(e)
1000 800 600 400 200 0
10 15 20 25
Temperature
(f)
17 31 53 69
Relative Humidity
(g)
1750 1500 1250 1000 750 500 250 0
20 30 40 50 60
Relative Humidity
(h)
288 580 6000 32280
Illuminance
(i)
3500 3000 2500 2000 1500 1000 500 0
0 10000 20000 30000
Illuminance
(j)
1K 10K 15K 36K
Area
(k)
3000 2500 2000 1500 1000 500 0
0 10000 20000 30000
Area
(l)

Feature's importance

Environment measures:

S – Sound

D – Dust

T – Temperature

R – Humidity

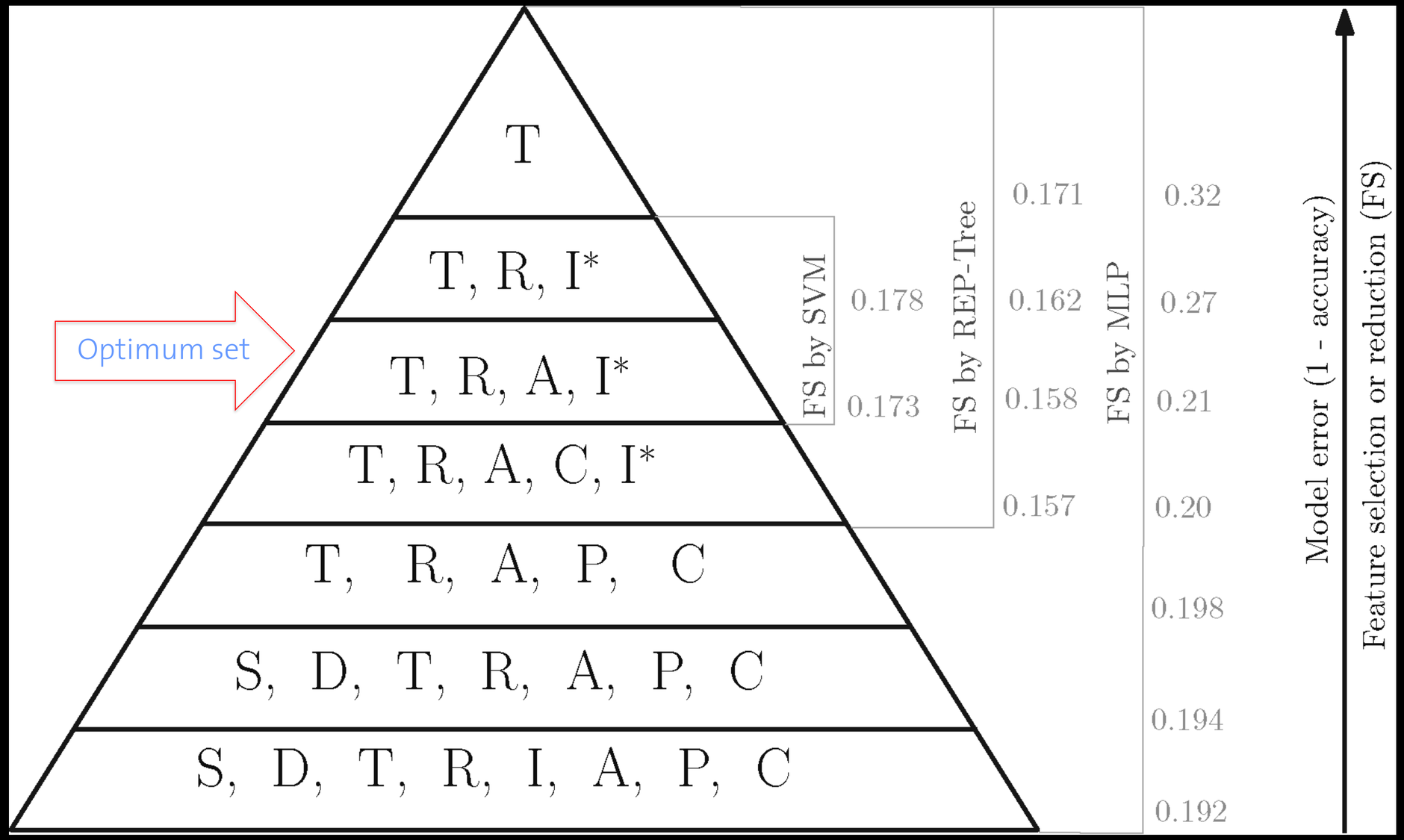
I – Illuminance

Field of view measures:

A – Area

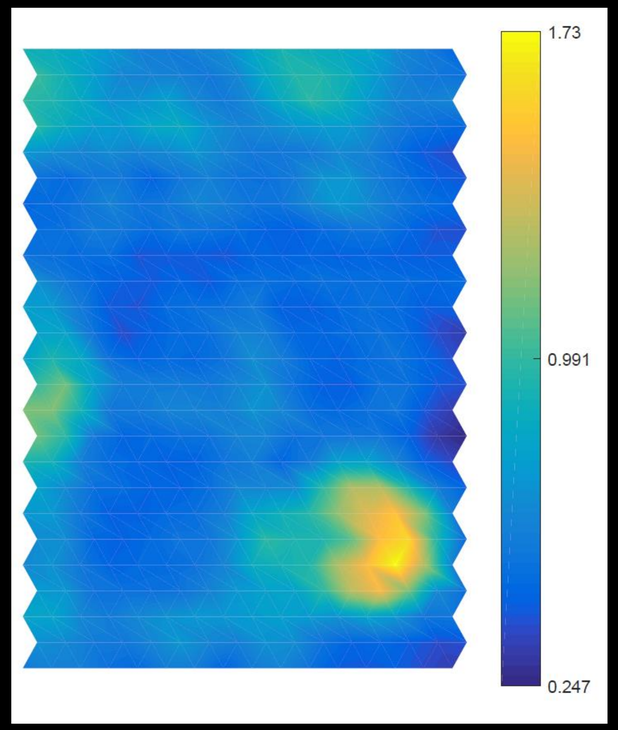
P – Perimeter

C – Compactness



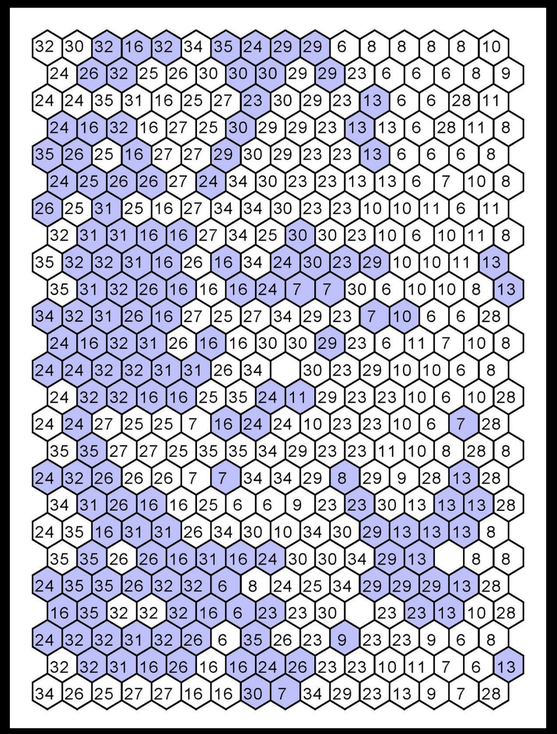
Participants experience pattern

SOM – 2D Map



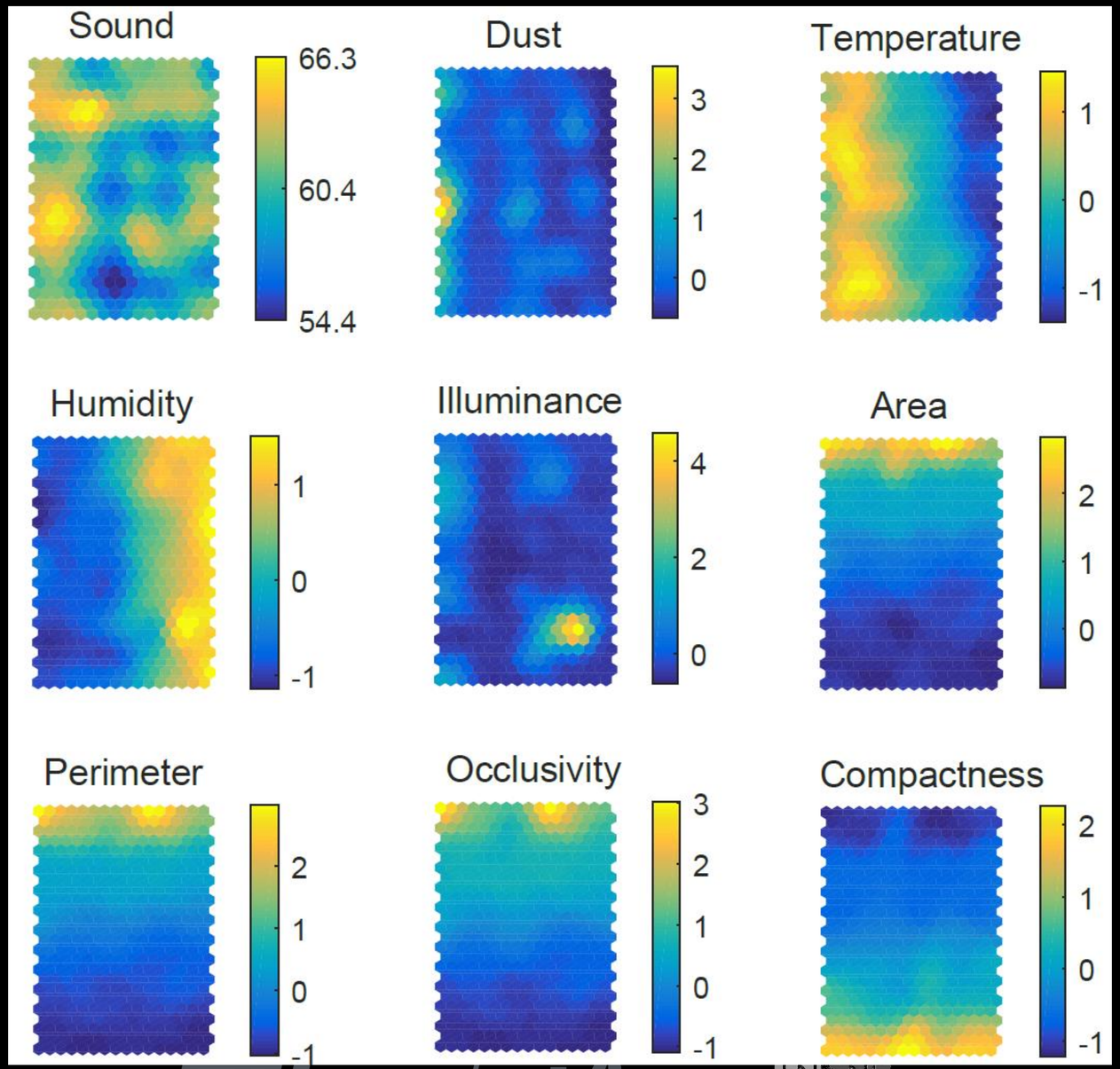
Clusters of participant's experience

Label Map



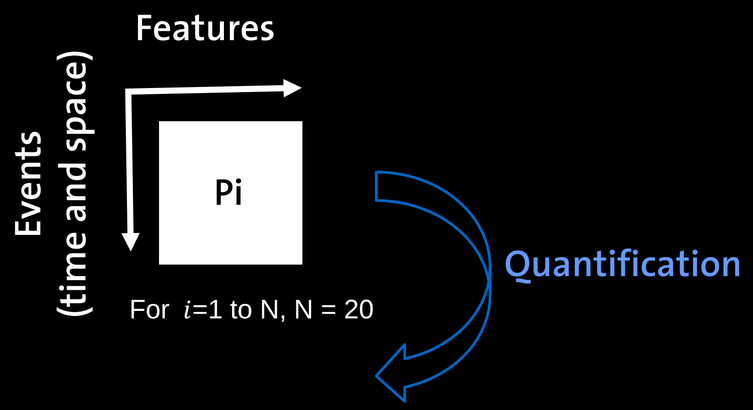
Physiological responses

Feature Map

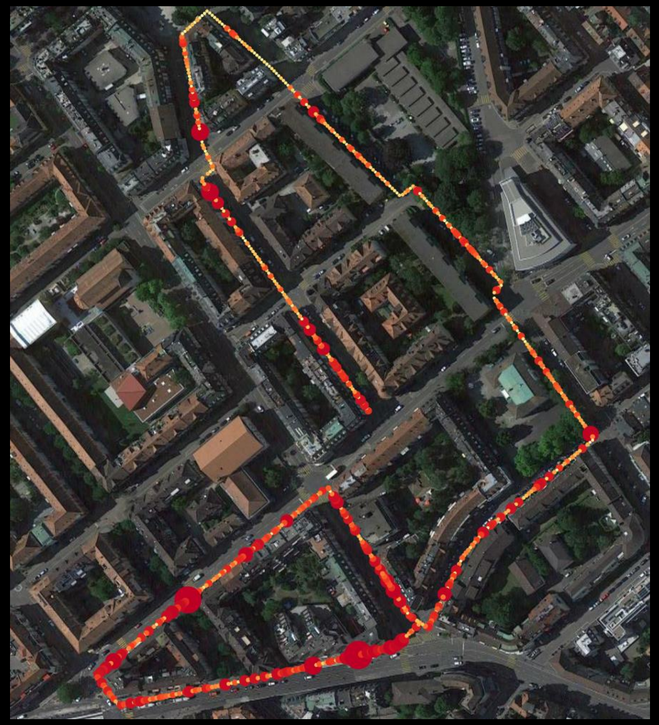


Fusion of data for Geo referencing

Participants data arrangement



Average across all participants

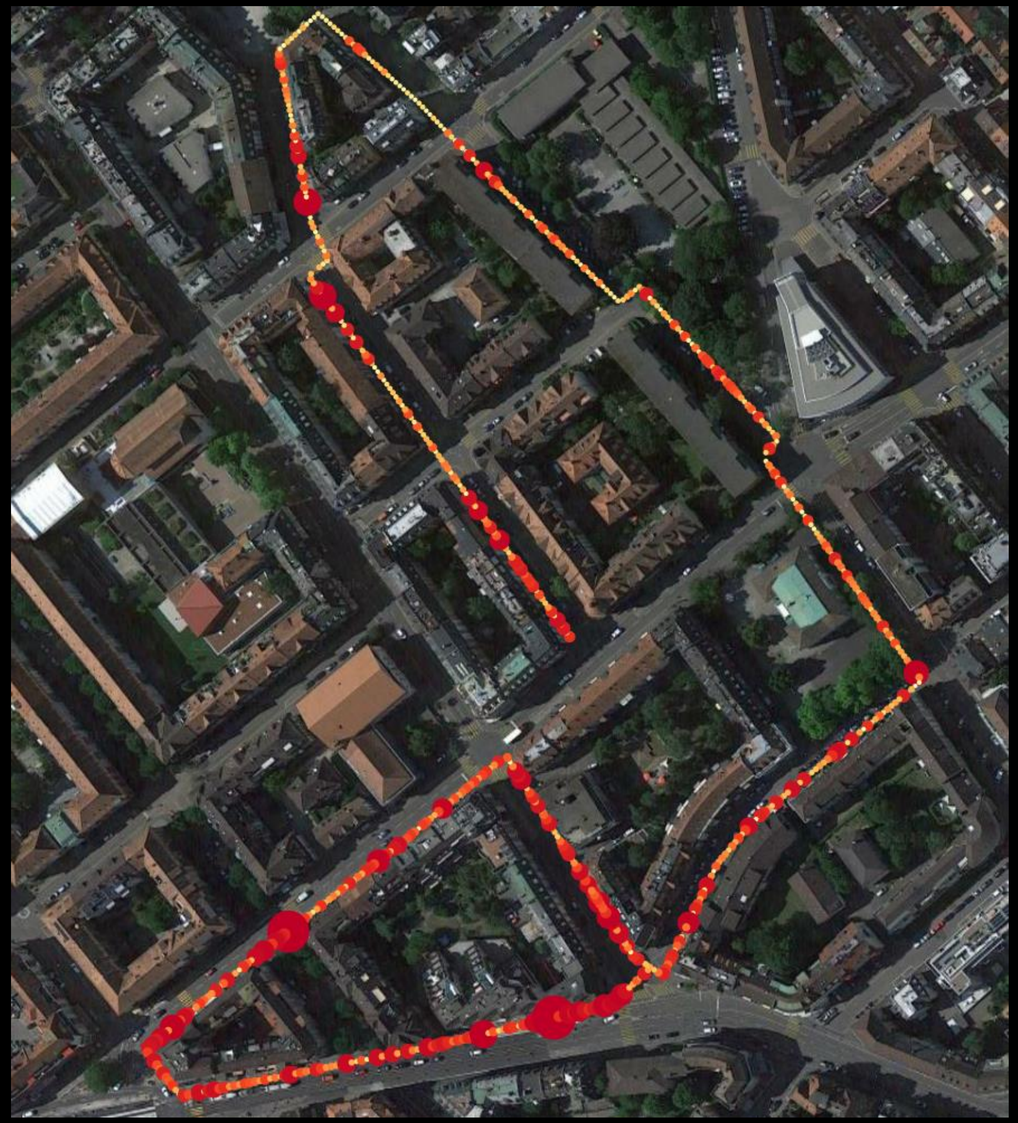


<event - response>

Samples

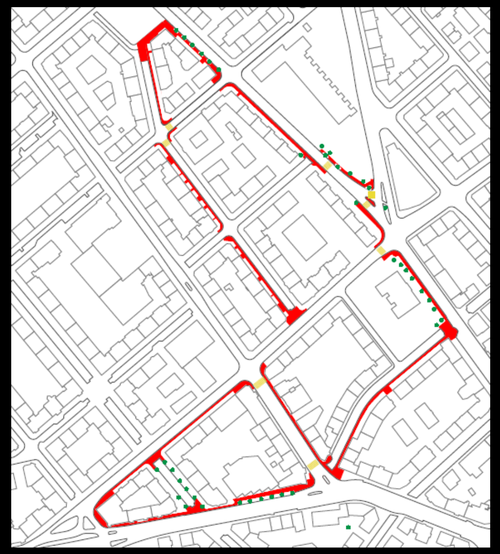
$$\left\{ \begin{array}{l} < e_1, r_1 > \\ < e_2, r_2 > \\ \vdots \\ < e_{m_1}, r_{m_1} > \end{array} \right\}$$

Geo-referenced average arousal



Traffic speed

Walkable space



Building construction year

Façade color

Conclusions

1. Conducted a real-life study to understand how human perceive their urban environment.

2. Perform fusion of information from multiple sensors responsible for recording environmental features and human physiological respoonses.

3. Machine learning analysis affirmed that participants physiological responses were sensitive to slightest change in urban environment.

4. Machine learning analysis discovered that all the participants experienced similar environmental conditions, responded in a similar physiological arousal state.

5. Geo-referencing of participants physiological state enabled us to study further what was relation between participants physiological responses are dynamic urban environment such as traffic speed.

Thank you

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