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.
Properties of dataset

**Participant’s data**

- **Features**
- **Events (time and space)**
- For $i=1$ to $N$, $N=30$

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 $\rightarrow$ Smooth physiological data
Data quantification

Diagram showing the process of data quantification with participant $p_j$ experiencing different environments $e_1^{p_j}, e_2^{p_j}, e_3^{p_j}, \ldots, e_{m_j}^{p_j}$ at various points marked as $r_1^{p_j}, r_2^{p_j}, \ldots, r_{m_j}^{p_j}$. The diagram illustrates the time intervals of $t$ seconds for each environment and the overall duration of $t$ seconds walk from Start to End.
Arousal (nSCR) level detection

Typical signature of an Skin Conductance Response (SCR)


Ledalab for EDA signal analysis
Fusion

Participant's data fusion

Features

Events (time and space)

For $i = 1$ to $N$, $N = 20$

Quantification

$\langle e_1, r_1 \rangle$

$\langle e_2, r_2 \rangle$

$\vdots$

$\langle e_{m_1}, r_{m_1} \rangle$

Attributes of the complied dataset

<table>
<thead>
<tr>
<th>Type</th>
<th>Attributes/Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>Temperature</td>
</tr>
<tr>
<td></td>
<td>Relative humidity</td>
</tr>
<tr>
<td></td>
<td>Brightness/Illuminance</td>
</tr>
<tr>
<td></td>
<td>Isovist area</td>
</tr>
<tr>
<td></td>
<td>Isovist perimeter</td>
</tr>
<tr>
<td></td>
<td>Isovist compactness</td>
</tr>
<tr>
<td></td>
<td>Isovist occlusivity</td>
</tr>
<tr>
<td>Output</td>
<td>Binary/Multiclass/phasic driver</td>
</tr>
</tbody>
</table>
Data labeling

Sense of physiological response (nSCR) labeling

Class 0: A samples' physiological response value = 0
→ Normal physiological state

Class 1: A samples' physiological response value > 0
→ Arousal physiological state

Box plot of nSCR values across all participants
Sensitivity analysis
Inference
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

Optimum set
Participants experience pattern

Clustering of participants' experience

Physiological responses

Feature Map

- Sound
- Dust
- Temperature
- Humidity
- Illuminance
- Area
- Perimeter
- Occlusivity
- Compactness
Fusion of data for Geo referencing

Participants data arrangement

Events (time and space)

Features

Quantification

For $i=1$ to $N$, $N = 20$

Samples

$\{ \langle \epsilon_1, r_1 \rangle, \langle \epsilon_2, r_2 \rangle, \ldots, \langle \epsilon_m, r_m \rangle \}$

Average across all participants
Geo-referenced average arousal

Traffic speed

Building construction year

Walkable space

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 responses.
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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