Multi-modal bio-sensing of physical and psychological distress of pedestrians: an interdisciplinary approach

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Motivation

- Smart Cities make the best use of information technology to create efficient built environment that ensures people's safe mobility.
- Mobility can be affected by the condition of physical and built environmental factors.
- Pedestrians' physiological responses may reveal how they feel and react to the environment.
- Wearable sensors are widely used for capturing sensory responses.
- Knowledge from crowd-sourced physiological responses in the built environment can help us design a better walkable built environment.

Useful Bio-signals

Gait patterns   Electrodermal activity (EDA)   Heart rate
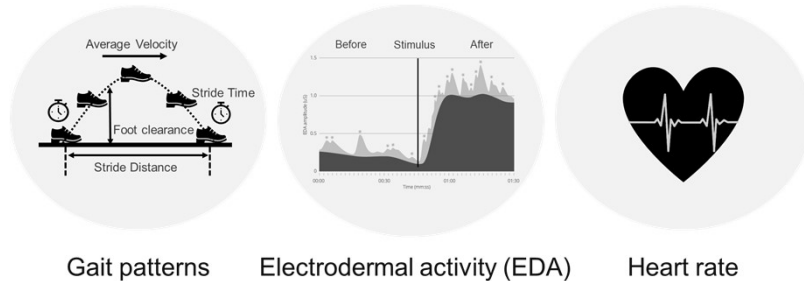
Experiments

- Different sets of experiments have been performed where participants walked a designated path wearing physiological sensors.
- Path contains negative stimuli that can elicit physiological responses.
- Participants provided retrospective self-reports of walkability.
- Study sites include
  - University area in College Station in TX (n=31)
  - Neighborhood in Lincoln, NE (n=30)
  - Downtown in Bryan, TX (n=9)


Action cam
Wrist sensor
Smartphone
IMU
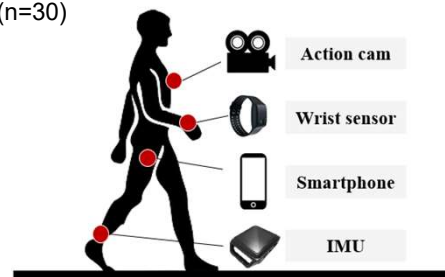
Examine Usefulness of Bio-signals
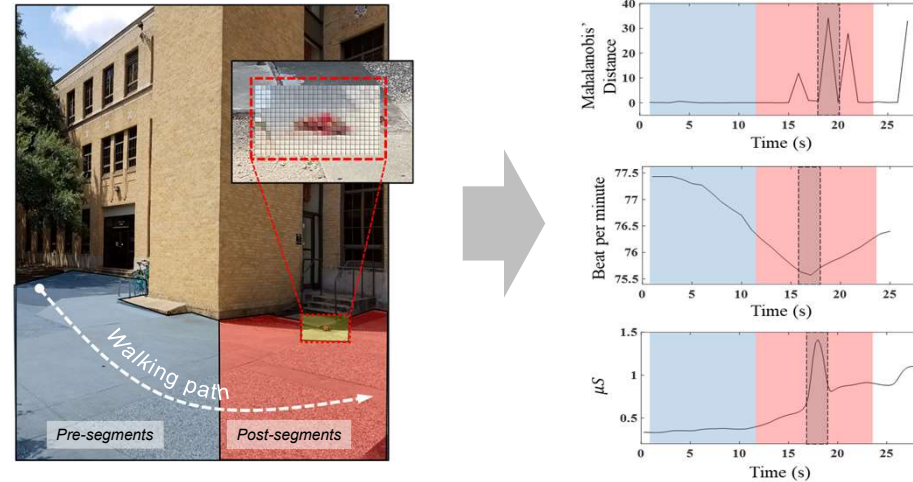
The effect of negative environmental stimuli on EDA and gait patterns was confirmed by the comparison between pre- and post-segments.

Develop Signal Processing Technique

- Signal noise and artifacts make it hard to identify the stimulus in entire data-stream.
- Additional data processing, saliency detection analysis, was proposed to mitigate the exposure of uncontrollable confounding factors.

Segmentation → Feature Extraction → Saliency Detection → Saliency Aggregation
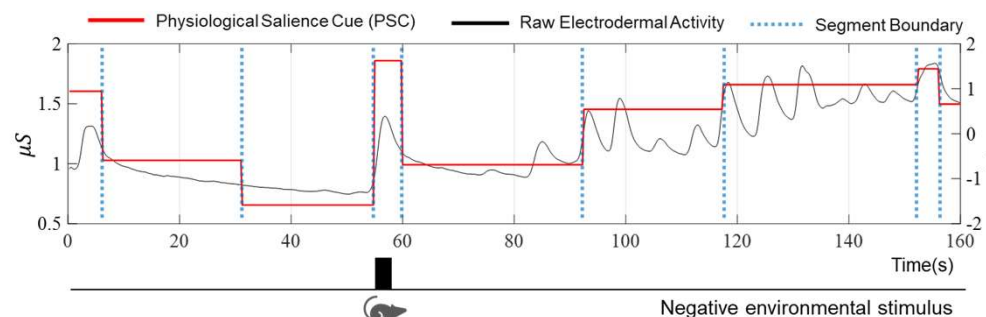
The saliency detection approach portrays prominent local patterns in bio-signals generated from negative environmental stimuli

## Case Study in a Multiple-stimulus Setting

Broken house   A gas container   Dead leaves   No sidewalk   Sidewalk defections
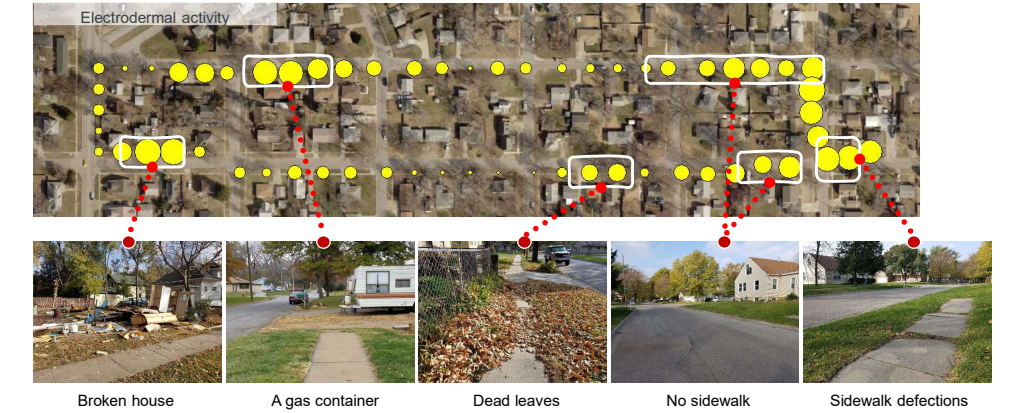
PSC values from the saliency detection method possess the power to identify the effects of negative environmental stimuli ($p < 0.05$ in all bio-signals).

The Interplay of Multimodal Data

Physiological distress detection
- Physiological features

Visual distress detection
- Contextual information
  ✓ Built environment information
- Perceptual distress
  ✓ Pairwise comparison

[Prediction accuracy to environmental stimuli]
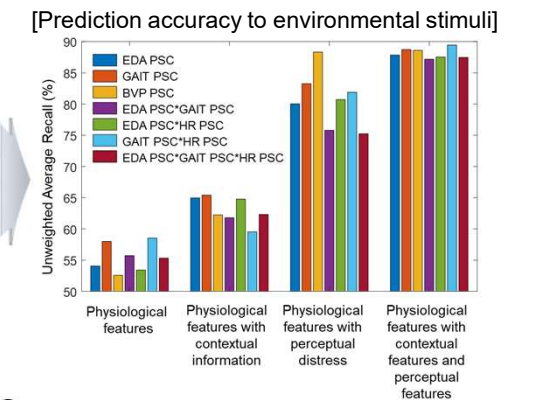
Results and Discussions

- Significant correlations have been found between bio-signals and experiencing the presence of negative environmental stimuli.
- Classification experiment using multimodal data has resulted in ~87% accuracy in data from Downtown Bryan
- Further exploration can enable us to implement this method in real-life scenarios.
- We expect that these approaches and results will provide an opportunity for advancing built environment assessment and infrastructure management.

Acknowledgments

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