A Case Study for Urban Stress Level Monitoring

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Introduction

With the emergence of cities as the predominant living & working environment it is important to further understand how people feel in such urban metropolises. However, perception and experienced stress levels are challenging metrics to measure and are even more difficult to correlate with an underlying causal-effectual relationship in such stimulus abundant environments. We can start analyzing this dynamic with the emergence of mobile sensing equipment and data science techniques. Therefore the aim of this study is to develop a quantitative methodology to indicate the predominant features that influence inhabitant's perception in the urban context through the use of mobile sensing devices.

Research Question and Hypothesis

The goal of this study is to find an effective method to analyze heterogeneous data sources from select mobile sensing devices (Table 1 of the Appendix) to better understand the predominant factors, which influence perceptual qualities of inhabitants in the urban environment. Based previous behavioral studies utilizing biofeedback wearable devices, it is hypothesized that the change of state conditions such as light to dark, quiet to noisy, and/or low occupancy to high occupancy will have the greatest impact on stress levels. The research questions can be outlined in stages:

1. Do environmental factors such as temperature, noise, dust, illuminance and occupant density actually influence the stress levels of urban inhabitants?
2. Do responses only occur at expected change of state stimuli or are there other un-measured features that contribute to stress levels?
3. Do all (or most) urban dwellers respond similarly to the above stimuli?
4. Which of these externalities have the greatest contribution to measured stress levels?

Approach and Method

The hypothesis and research questions will be addressed by collecting and analysing data from an experimental set up where 25-40 participants will take the mobile sensing equipment along the same path (Figure 1). The path was chosen in such a way to show a variation in sound, occupancy density, light levels, traffic, etc. We will collect the data during a 2-week period during mid April. For the study, all study participants will make an initial calibration to establish a baseline for the biofeedback wristband by reading a 3-minute bedtime story to obtain their personal low stress level frequency. Next, participants will walk along the given path still wearing the biofeedback wristband, carrying the mobile sensors (all arranged in a "sensor-rucksack"). The given path is approximately 20 minutes and the participants will also be given a cue to respond to a mobile app if they find each section pleasant, unpleasant or neutral. This is important to understand the association with the biofeedback measurements since it only provides arousal levels and cannot be used to determine if it is positive, negative, or neutral.

Given the above experimental set up, the focus of this research project will be to develop an efficient workflow and appropriate data analysis techniques to answer our above research questions. Therefore the first step is to perform a pre-study to collect a sample data set, of which we will need to pre-process the data to reduce the noise of the environmental sensors and to align the heterogeneous sensor data to a common frequency. The biofeedback wristband data has the highest sampling frequency and will therefore be used as the reference for matching change of state events from the other sensors. We will also use this sample set to test different data analysis techniques to find correlations between the biofeedback data and the sensor measurements. The final stage will be to analyze the full set of data with the full experimental data set.

Contribution and expected outcomes

The findings of this project are not only important to understand the perceptual qualities of cities experienced by it's inhabitants, but also to further utilize what is becoming ubiquitous mobile sensing devices. This experiment enables us to develop a workflow that others could use and further elaborate upon in future projects and potentially for the use of other citizen science projects.

Appendix

Device	***Measurement frequency***	***Sensor/ Measurement***	***units***	***Measurement range***	***Accuracy***	***Response time***
WaspCity	0.4 Hz	Sound Pressure	dB	50-100 dB	±2.5 dB	Not Given
	0.4 Hz	Luminosity	%	0-100% (400- 700 nm)	Resistive sensor 20MOhm (Darkness) 5-20 kOhm(Light)	Not Given
	0.4 Hz	Dust	mg/m3	Typical 0.5V/(0.1mg/m3)	Operating supply voltage 5±0.5V	10±1ms
WaspGas	0.25 Hz	Temperature	C	-40 ~ 125 C	±2 C(0-70 C), ±4 C(<0 C, >70C)	1.65 seconds
	0.25 Hz	Atmospheric Pressure	kPa	15 - 115 kPa	<±1.5% V	20 ms
	0.25 Hz	Humidity	%RH	0-100% RH	<±4% RH (a 25C, range 30-80%), ±6 %RH(range 0-100)	<15 seconds
	0.25 Hz	O3/VOC	V - kohm	0.01 ppm		
	0.25 Hz	CO2	V	350-1000 ppm	44-72 mV variation between voltage at 350ppm and 3500ppm	90 seconds
	0.25 Hz	NO2	V - kohm	0.05 - 5 ppm	6-100 (typically 55, ratio between the resistance at 0.25ppm and in air)	30 seconds
GPS	1 Hz	GPS	Lat/Long	outdoor only		
Mobile Device	variable	GPS	Lat/Long	indoor/outdoor		
Meshlium Scanner AP	push values @ 0.016 Hz	Wifi Scanner	MAC address	Wifi Scanner (50-200m) Bluetooth Scanner (20-30m)	Measurement range depends on he antenna and line of sight to the device	60 seconds
	push values @ 0.016 Hz	Wifi Scanner	AP			
	push values @ 0.016 Hz	Wifi Scanner	RSSI (Received Signal Strenght Indicator)	-40 dBm (nearest node) to -90 dBm (marthes nodes)	distance of 10m ~=(50dBm), 50m ~=(75dBm)	
Biofeedback Wristband	64 Hz	PPG (Photoplethysmography)	Sensor output: Blood Volume Pulse (BPV)		0.9 nW/Digit	
	4 Hz	EDA (Electrodermal Activity)		0.01 mSiements -100 mSiemens		
	4 Hz	Skin Temperature Infrared thermopile	C	-40-115 C	±0.2 C within 36-39 C	
	32 Hz	3 Axis accelerometer	x, y, z			

Table 1: Mobile Sensor Equipment Specifications

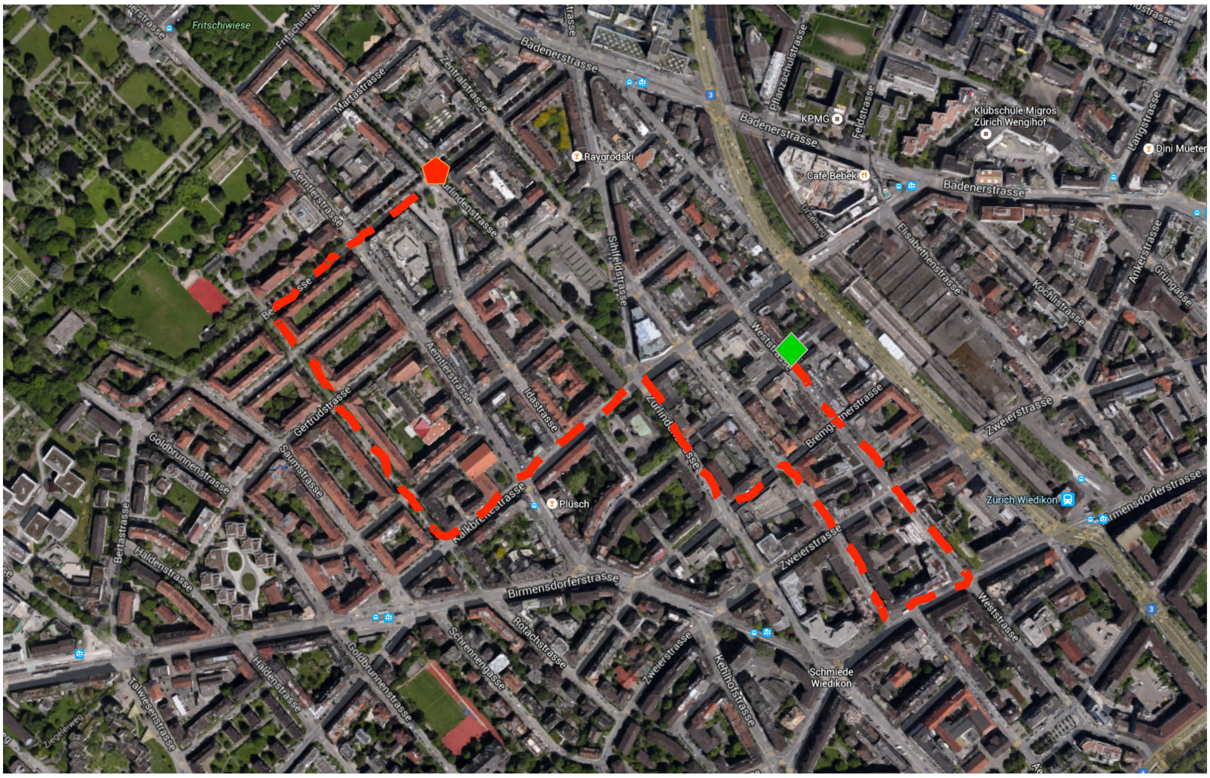

Figure 1: Urban area for participant study