SensorMapRT – a System for Real-Time Acquisition, Visualization and Analysis of Mobile Sensor Data in an Urban Context

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1 ABSTRACT

The use of wearables in citizens' daily life will increase significantly in the coming years. By analyzing these sensor data, it is possible to detect the emotional well-being in urban areas, which is highly relevant for urban planning purposes. Through the combination of several physiological and other sensor data such as GPS, "stress spots" in the urban environment can be recognized and located. A major objective of this project is therefore, to combine and evaluate various research approaches in the field of human as sensorswith wearables. This is the reason why the project group will be an interdisciplinary cooperation between spatial planning, psychophysiology and computer technology.Together with the project partner cities of Neustadt an der Weinstraße and Pirmasens in the German Federal State Rhineland-Palatine, the project group aims to show exemplary the influence of potential stressing factors in the urban area such as traffic and noise and creates scientifically-robust models of stress detection in urban areas. Besides this, a visualization for planning purposes with the tool GeoVisualizer as well as an evaluation of the resilience of such informtion and their potential use for urban planning is aim of the project.

2 INTRODUCTION

The use of sensors for infrastructure technology or to measure environmental stateis widely practised in various research fields. Meanwhile, miniaturized, wearable sensors for gatheringvital data such as heart rate or arterial blood pressure is becoming more and more popular also for non-experts, especially during times of booming wearables. However, there is just a little effort to combine environmental data with personal vital data. In particular, the use in urban and spatial planning for the detection and prevention of critical (stress) zones has not taken place yet. Due to the fact, that human vital data does not allow direct conclusions on the urban environment, a deep medical and psychophysiological interpretation is needed. A major objective of this project is therefore to bring together the various research approaches in the field of human sensory assessmementwith wearable sensors. The project group forms a interdisciplinary cooperation between the field spatial planning, human sensory assessment, psychophysiology and computer technology which in futurewill be indispensable for this research field.

3 THEORETICAL FRAMEWORK

3.1 Sensordata in urban planning

"In the next century, planet earth will don an electronic skin. It will use the Internet as a scaffold to support and transmit its sensations. This skin is already being stitched together" – this quote from fifteen years ago describes a vision of a world interfused with sensors and connected via the Internet (Gross 1999). Thus, sensorsand computers evolve in beingsmaller, cheaper and more powerful. They are ubiquitousin our everyday life and producea flood of sensordata, which allows urban planners a new scientific perspective.This data is produced by conventional sensors (climate sensors for temperatur, humidity e.g. or traffic measurements) as well as from citizens, because they are carrying the sensor devices (mobile phones, tablets, wearables e.g.) with them every day.Through the further development of smartphone technology in recent years starting from "ubiquitous computing", the all-time data connectivity, "pervasive sensing", in which integrated into the smartphone sensors can be used as sensor networks in urban environments (Martino et al. 2010). In this context Goodchild describes the phenomenon "Citizens as sensors" (Goodchild, 2007), where citizens take on "Measuring Tasks" voluntarily in the form of "Voluntered Geographic

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Information" (VGI). Other authors are using the terminology for this phenomenon as "People-Centered Urban Sensing" (Campbell, et al., 2006) or just "urban sensing" (Cuff et al., 2008). All approaches have in common that citizens want to be increasingly integrated into planning processes. With these new approaches targeted data and process support can be produced. The citizens are acting as active sensors in an urban context. Mark Weiser's vision of "ubiquitous computing" becomes reality (Weiser, 1991). This contextual changes, described as "urban sensing", means "a fundamental change to the application, interpretation and motivation of science and engineering in the fields of politics and aesthetics as well" (Cuff et al. 2008).

3.2 Mapping Emotions in an urban context

In the combined field of human sensory and spatial planning methods, following approaches in basic research are already known: We start with "mental maps" by Kevin Lynch (1960), where the test subjects had to draw a map of the city that was under investigation only from their memory.The approached method was criticized, because the participants must have very good drawing skills. With the use of GPS technologies for reconstructing the traveled distance by the subjects in the city these limitations could be minimized. The localization of stress points or areas of anxiety within a city in a virtual context was first conducted by Sorin Matei (2001). These were the first virtual "emotional maps". The first example of the creation of "emotional maps" using data from psychophysiological monitoring (skin conductance) and GPS data to do the positioning of the measurement results in urban areas yielded Christian Nold with the art project"Biomapping" (2009). Other examples of the collection of "human collected sensor data" can be found in the approaches of the MIT SENSEable City Lab (Martino et al. 2010, Resch et al. 2011). The measurement of human emotions in spatial planning is based on the approach to take advantage of people as sensors and at the same time producers of environmentally induced emotionaldata in real time (Exner et al. 2012). For the measurement of human emotions the so-called BMS Smartband can be used to determine physiological changes of the body related to its environment. This so-called approach of psychophysiological monitoring enablesto read emotional states due physiological data (eg. Skin temperature changes) (Kreibig, 2010).

The project aims to address this shortcoming by providing a new approach for extracting planning relevant data from wearable sensor data.Potential areas of use are in the domain of urban planning for decision support and the evaluation of ongoing planning processes.Working with methods of psycho-physiological monitoring to identify georeferenced stress reactions in towns has been carried out by the Department of CPE in an experimental form (Zeile, et al. 2009; Exner, et al. 2012;. Zeile, et al. 2013). Considering the thesis of Kreibig (2010) the resultingemotional reactions could be visualized by physiological parameters such as skin temperature. This was for example used in various projects perceptioning the city of Alexandria (Taha et al.2012), or in the area of barrier-free planning (Bergner &Zeile 2012). In all of these experiments the data had to be post-processed manually which was time-consuming. A future task, therefore, must be to automate the operation process to obtain truly representative statements and to enable a real-time analysis and interpretation of data. In addition, the quantitative and qualitative evaluation methods in the field of human sensors must be reconsidered and validated again with the help of physiologists.

3.3 Visualizations of sensor data

In order to achieve a target-oriented and tailor-made visualization in the third dimension, a specific tool is needed. The 3D-visualization of data is a common feature of modern geographic information systems (GIS). In the past many "stand-alone" applications and plug-ins have been developed to do so. The use of current visualization concepts and methods from the field of computer graphics (for example, information visualization) remained, however, often reserved for experts. Basis for this project is a preliminary project between the partners CPE, urban sociology and Augmented Vision from University of Kaiserslautern, which shows the potential of the prototypical platform GeoVisualizer.At this point theduring research developed software GeoVisualizer by Professor Didier Stricker builds on, which can also be used by non-visualization experts to create a meaningful representation and get a quick impression of underlying geo-referenced data (Steffen et al., 2013; Michel et al., 2013). The application GeoVisualizer is based on the NASA World Wind SDK. The open source SDK provides a 3D Virtual Globe API. In addition, the GeoVisualizer application was developed based on the Java Web Start technology.

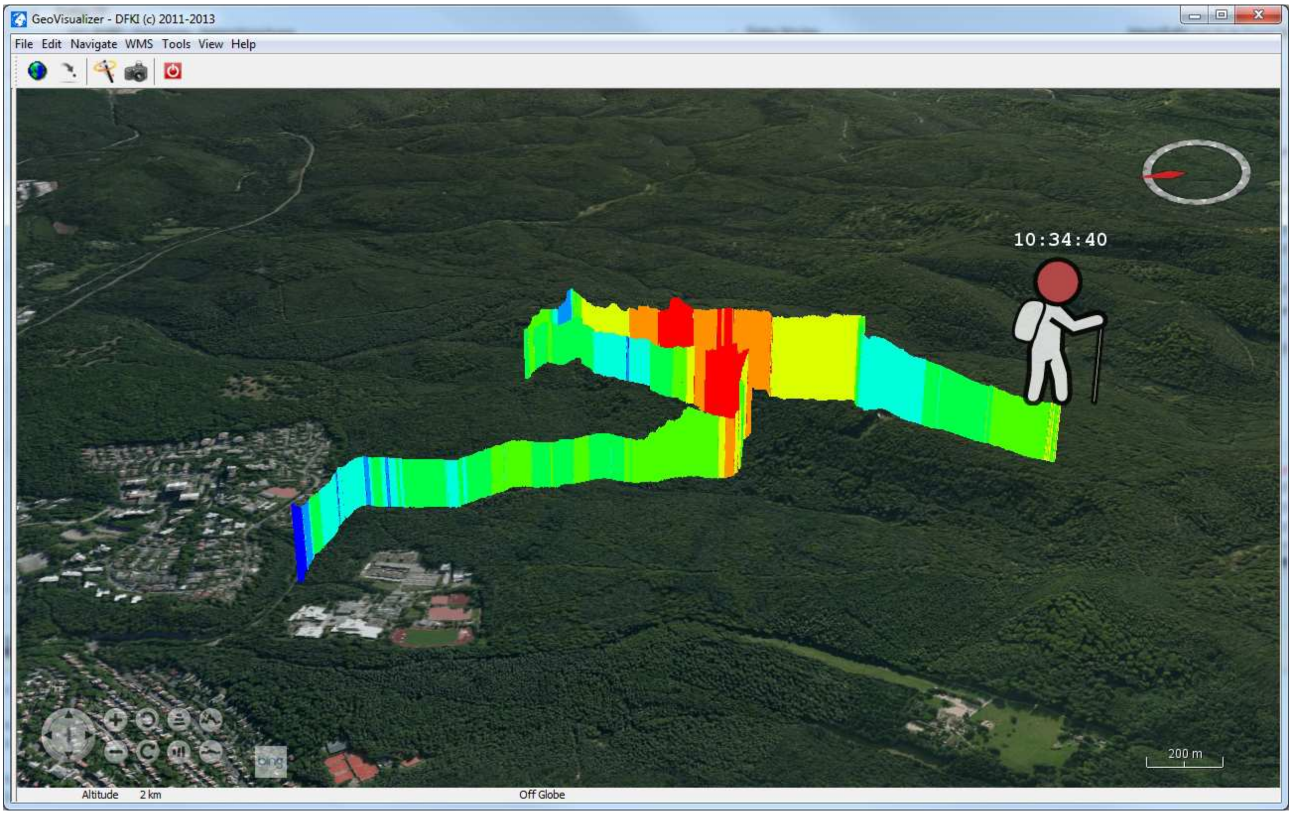

Figure 1: Visualizaiton of human sensory data with GeoVizualizer(DFKI 2013)

Further aims of GeoVisualizer are on a simple operating concept and a flexible and extensible application architecture for the representation of geo-referenced 3D and 4D data. In this case the fourth dimension is obtained by adding the time factor to the geo-referenced data, which allows the animation and the interactive explorationon the one hand and the analysis of the data on the other hand (Steffen et al., 2013; Michel, et al. 2013).In this research area developing the software in terms of its near real-time data-processing as well as an open interface for direct implementation of human sensory data is an important step.

4 IMPLENTATION AND STUDY CASES

4.1 Preliminary studies

The focus in preliminary studies was on the calibration of the used wearable devices under laboratory conditions from Professor Hartmut Schächinger at University of Trier.His department has embracing experience in non-invasive collection and interpretation of cardio-respirative indicators (Schächinger et al., 2001). To measure the native heart rate of the test persons the BioHarness3 by Zephyr was used. To calibrate BioHarness3 the test persons went through different situations wearing the heart rate monitor. While the heart rate changes individually and of course in different situations like sitting, walking, e.g. these situations had to be simulated first. After detecting the individual baseline of the native heart rate the test persons had to lay down, sit and walk around to simulate the different positions of their body to the accelerometer they were wearing as well as the heart rate monitor. In the next situation the test persons had to sit again while reading out loud from a book. The following PASAT-test was also a mind-demanding task where the test persons were sitting as well. After that the test persons were challenged in physical-demanding tasks, going downstairs, walking, going upstairs and riding a stationary bicycle. The left part of the following figure shows the native heart rate measurement of one of the test persons.

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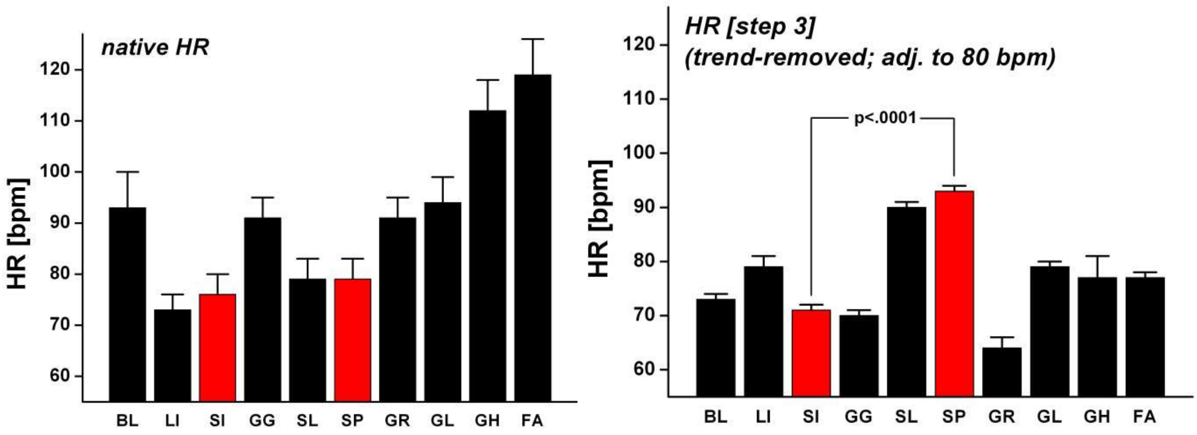

Figure 2: Native heart rate of one test persons (left); heart rate with removed motion trend (right) (Schächinger 2015)

If you look at the native heart rate (HR) you can see that the heart rate is always higher in situation wherethe test persons were demanded physically. As you can see in the right part of the picture the HR changes to the contrary if you remove the motion-trend. Situations where the mind ofthe test persons is demanded are showing the hightest heart rate now. This means that you can detect an actual emotion related heart rate response after removing the trend of the motion.

4.2 Studycases

The project was set up in cooperation with two cities in the German Federal State of Rhineland-Palatine. The validation of the platform and the results occurs in cooperation with the city of Neustadt an der Weinstraße and the city of Pirmasens based on different scenarios. Both areas are close to the city center and where chosen due to the possibility to create a varying test walk for the test persons with their devices. One of the goals of the project was to show the external impacts of the urban environment to the human body and so the test person's walks were designed, to embrace a variety of urban situation like traffic noise, traffic crossings and in alternation to it also quiet areas.

Figure 3: Study testbed Neustadtwith path (Google Inc. 2015)

The area in Neustadt is located close tothe trainstation. Start ofthe path is on the western side and close to B39 with its heavy traffic. Passing this street, there will be a first crossing of B39 which will lead the person to the trainstation square which will bring them in a more silent situation. After this section, the path leads towards north, with an additional crossing of B39 and the following walk towards the pedestrian area.

Figure 4: Study testbed Pirmasens with path(Google Inc. 2015)

Start of the path in Pirmasens is a business district towards direction south. The next section will be a bridge crossing of the B10 with its heavy traffic which will expose the test persons to traffic noise and probably also blowing winds. After this crossing, the persons follow the L482 towards west where they will experience the noise impacts fromtraffic passing by. After this, their routes leads them in a more quiet residential area from which they head towards north to pass B10 over a bridge again.

5 SUMMARY

The aim of this project is to develop a modular platform for high-performance detection and near real-time, intuitive discussion and analysis of results obtained from mobile sensors. First results of some field tests indicate a correlation of the measured data and the envirmonmental circumstances especially in terms of external influences for the test persons like noise from crossroad traffic e.g..Further the study intends to develope an easy to use tool set with good visualizations which can be used by planners on one side, but also which is scientifically correct in physiological ways. Extensive tests will prove the suitability for daily use and a real-time vizualization is also on the roadmap. Issues like data privacy and protection are of course important in the light of measured human sensory data, though they are not in the focus of this reserch project and have to be discussed in complementary research projects.

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