Chapter 11
Urban Emotions: Benefits and Risks in Using Human Sensory Assessment for the Extraction of Contextual Emotion Information in Urban Planning

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Abstract This chapter introduces the 'Urban Emotions' approach. It focuses on integrating humans' emotional responses to the urban environment into planning processes. The approach is interdisciplinary and anthropocentric, i.e. citizens and citizens' perceptions are highlighted in this concept. To detect these emotions/perceptions, it combines methods from spatial planning, geoinformatics and computer linguistics to give a better understanding of how people perceive and respond to static and dynamic urban contexts in both time and geographical space. For collecting and analyzing data on the emotional perception to urban space, we use technical and human sensors as well as georeferenced social media posts, and extract contextual emotion information from them. The resulting novel information layer provides an additional, citizen-centric perspective for urban planners. In addition to technical and methodological aspects, data privacy issues and the potential of wearables are discussed in this chapter. Two case studies demonstrate the transferability of the

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approach into planning processes. This approach will potentially reveal new insights for the perception of geographical spaces in spatial planning.

1 Introduction

The question of how people perceive a city and how they feel about it has always been an important issue in urban planning. Typically, citizens/residents as well as visitors classify existing urban situations or new planning projects with the attributes ‘good’ or ‘bad’. “From a nonprofessional perspective, visual quality may be the most important influence on how people experience and respond to urban areas and planning initiatives” (Kaiser et al. 1995, p. 223). For instance, pedestrians or cyclists may emotionally respond differently to the city depending on a variety of context factors including personal mood, environmental conditions like the weather, traffic density or road conditions. Methods for an objective measurement of the quality of architecture and the resulting urban space last boomed in the late 1950s–1970s (Debord 1957; Lynch 1960; Cullen 1961; Franke and Bortz 1972; Krause 1974; Trieb 1974). However, in contrast to landscape design (Bishop and Hull 1991) or especially architectural design, there is still a scientific lack in the discussion of emotional aspects in urban planning. This is relevant because the amenity value or perceived safety are important aspects for making decisions in many urban design proposals. In recent years, the integration of technical and human sensors in combination with a direct feedback from citizens to stakeholders via real-time participatory communication channels (Burke et al. 2006), such as social media, enabled new insights into urban patterns, and dynamic and static contexts like traffic or architecture.

Research fields including computer science, geoinformatics, computational linguistics, sensor technology, citizen science, architecture and spatial planning are overlapping impacts in this interdisciplinary topic, which we call ‘Urban Emotions’. Concisely, the Urban Emotions approach focuses on a new and human-centric perspective onto the city, in which humans as ‘users of a city’ represent the main sensing element. Therefore, we combine and merge objective elements of sensor technology with subjective measurement methods to create a ‘human sensor network’. The long-term goal is to develop a new information layer for planners, in which a visualization of the measured spatial perception is possible. These visualizations allow conclusions about human behavior in an urban environment and enable a new citizen-centered perspective in planning processes.

2 Scientific Background

The research field of human perception of the city originated from the 1970s and deals with the perception of the natural and the built environment (Downs and Meyer 1978). Main components and the chosen cartographic representation are so called 'mental maps' or 'cognitive maps'. These maps reflect the subjective perception of a person in (urban) space segments (Downs and Stea 1974). 'Cognitive Maps and Spatial behavior' (Downs and Stea 1974) or 'Image of the City' (Lynch 1960) describe the concepts of cognitive representation of space. "We are not simply observers of this spectacle, but are ourselves a part of it, on the stage with the other participants. […] Nearly every sense is in operation, and the image is the composite of them all" (Lynch 1960, p. 2).

These days, up-to-date methods like sensing or crowdsourcing offer a valuable supplement in creating these maps and using them in spatial planning. Analog techniques like sketches or descriptions are combined with digital methods like the above mentioned. Emotions and space are linked closely. Each situation creates its own specific atmosphere and triggers an emotional reaction to the respective observer (Mody et al. 2009). The first to combine global positioning systems (GPS) data with biometric human sensor data and investigate the question of collecting cartographically referenced emotional data was Christian Nold in 2004 with his project 'Biomapping'. Therefore, it was possible to visualize user gathered psychophysiological data and share with the community. In his collection of essays entitled 'Emotional Cartography', he presents this concept and other works around the topic of collecting data for a better understanding of people's perception in urban areas (Nold 2009).

Besides the emotion aspects, the perception of humans' urban surroundings and how they were created or triggered is another important point/perspective. Feelings or perceptions are important key facts and not negligible aspects in urban planning, especially for supporting recommendations in design processes and in some infrastructure projects like trespassing of streets, cycle lanes etc. The Urban Emotions concept refers closely to new methods of a 'new understanding of cities', beginning with Baudelaire's 'flaneur', Patrick Geddes' 'outlook tower' from 1892, Walter Benjamin's 'Passagen-Werk' from the late 1920s/40s (Benjamin and Tiedemann 1983), concept of 'dérive' (Debord 1956) and 'guide psychogéographique de Paris' (Debord 1957) up to Lynch's 'mental maps'.

2.1 New Kinds of Participation—Urban Emotions as New Information Layers Within Planning Processes

"Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody" (Jacobs 1961, p. 238). Spatial planning is cross-sectional and interdisciplinary and takes into account all spatial and social structures within the city. In an ideal case, all public and private interests are evaluated to minimize conflicts within planning processes. The quote from Jacobs highlights the need to develop an ideal type of participatory spatial planning approach for a 'good' and citizen-centric planning. This includes theoretical visions as well as human centered implementation strategies.

However, the question is: how can relevant and objective issues be measured and included in the process of planning and evaluation? And why is the use and knowledge about citizens' emotion so interesting for urban designers and planners? Moreover, how can planners recognize which problems citizens are really confronted with in a spatial context?

The use of emotions in urban design is not well-established and far grown. One of the few research efforts is presented by Hoch (2006), yet describing the use of emotional intelligence in communication in planning processes rather than psychophysiological measurements. In landscape design, the discussion of an acceptance of a project is much more integrated in the scientific discourse. Bishop and Hull (1991) discussed 'visual quality' of landscapes as an important emotional issue, even for planners and stakeholders. In the context of 'mental health', they state: "Emotional and mental well-being may be one benefit of a high-quality visual environment. (…) On the negative side, the cluttered visual environment may be distracting and cause stress or emotions which hinder the accomplishment of one's objectives." (Bishop and Hull 1991, p. 298). Good visual quality is, according to the authors, good for residential satisfaction and an overall confidence in land management. These aspects "should be the concern of landscape management and planning because they are socially relevant" (Bishop and Hull 1991, p. 298). These findings will be adopted in Urban Emotions and transferred to other application areas in the domain of urban planning.

The Urban Emotions concept also tries to give the answer by developing a new set of methods for urban planning and spatial planning. Taken into account are the concepts of a network society (Castells 1996), which will join up today's fundamental change of the understanding of planning (Streich 2014). So-called bottom–up processes of participation, a proactive involvement of citizens, are the core elements in this strategy. So, the repertoire of methods in spatial and urban planning has to be extended significantly by using this 'sensor technologies'; traditional deductive planning will be supplemented by inductive planning approaches, like the above mentioned crowdsourcing processes in bottom-up mode (Streich 2014).

2.2 Techniques, Wearable Computing and 'Quantified-Self' Movement

There are several techniques for detecting emotions. One is to combine several technical sensors into a new network. A simple configuration and a communication hub for detecting emotions are enabled by the new generation of smartphones. GPS, microphones and cameras are the basic requirements of participatory sensing (Burke et al. 2006). Smartphones are probably the most efficient standard sensing devices in daily life, because they are mobile, embedded and, thus in situ (Martino et al. 2010). Further, the smartphone's integrated sensors for physical activities will come into vogue more and more. "The mobile phone is the new gateway to people-centric urban sensing, a new sensor-networking paradigm that leverages humans as part of the sensing infrastructure" (Martino et al. 2010, p. 2).

Wearable devices are portable mini computers equipped with various sensors, which are always on and always ready and accessible (Mann 1998) and constitute a supplement for smartphones (Schumacher 2013). They should serve as an "intelligent daily assistant", in which the user's role is passive without any explicit data input (Kotrotsios and Luprano 2011, p. 279). State-of-the-art wearables allow us to measure physiological data like skin conductance, skin temperature or electrocardiography (ECG) and it is possible to derive indicators of negative arousal from these datasets. Hence, wearable technology has an increasingly important role in supporting everyday life and is essential equipment in the Quantified-Self and Life Logging movement.

Kevin Kelly and Gary Wolf initiated the Quantified-Self movement in 2007. "Self-knowledge through self-observation" is the slogan of the movement. People measure their bio data digitally and want to learn from these data, to live better, or at least to be able to understand certain physical and psychological processes better (Klausnitzer 2013, p. 29).

3 Methodology—The Urban Emotions Concept

The Urban Emotions concept proposes a new human-centered approach in order to extract contextual emotion information from human and technical sensor data. As illustrated in Fig. 1, the methodology comprises four main components: first, detecting emotions using wristband sensors to measure the human's bio-feedback in the urban context; second, 'ground-truthing' these measurements (assigning a

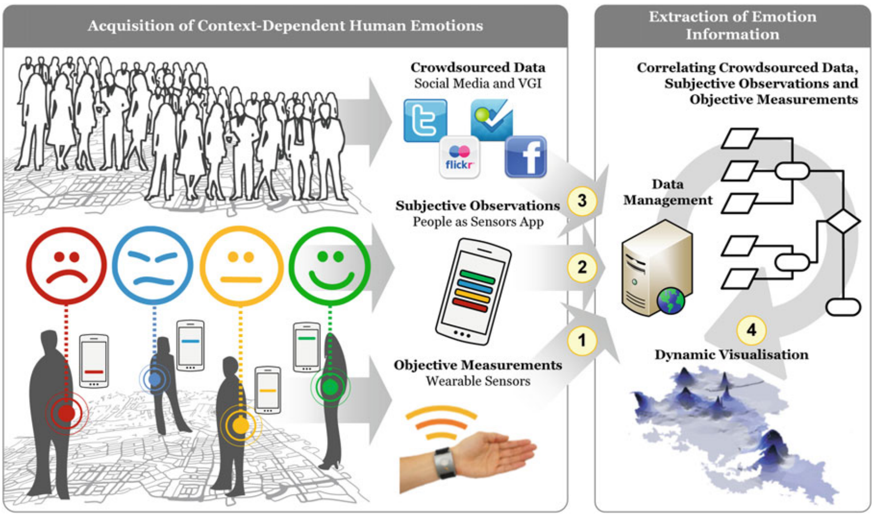

Fig. 1 Urban emotions concept (Zeile et al. 2014; Resch et al. 2015a)

formal emotion category to each measurement) using a 'people as sensors' location-aware mobile application; third, extracting emotion information from crowdsourced data and geo-social media like Twitter; and fourth, correlating the measured and extracted emotions in order to provide urban planners with additional insights into the complex human-city relationships. However, the Urban Emotions concept's major innovation is its trans-disciplinary nature as it consolidates the know-how and perspectives of at least four additional scientific disciplines, namely GIScience, computational linguistics, sociology and computer science. Hence, the contextual emotion information extracted can serve as the citizens' direct feedback for urban planning and decision support for ongoing planning and design processes.

The most important factor in this approach is that Urban Emotions is not conceived as a general tool of solving all planning tasks, but it can help to create another view and better understanding of 'the body of the city'. A big success would be, if this new knowledge can be integrated as a fact or indicator system in weighting in official planning processes. Urban Emotions can provide valuable information not in every case, but in special tasks like the above mentioned design processes or in the discussion of personal perceived safety.

3.1 Modes of Measuring Emotions

There are several modes to measure the emotions of people within physical spaces. These range from simple online questionnaires to a basic localization 'tagging' of the attributes 'good' or 'bad' using a smartphone app, over automated text-extraction from social media channels up to psychophysiological measurements. These different modes are considered in the Urban Emotions concepts and explained in detail below.

3.1.1 Tagging

An easy method is to 'tag' annotations with the help of a digital place mark within the urban space. This is for example possible by using the smartphone RADAR SENSING app, with which users can locate explicitly GPS-based positive or negative impressions within urban areas (Zeile et al. 2012). The RADAR infrastructure (Memmel and Groß 2011) can generate 'on the fly heat maps' or 'density maps' out of the attributed dataset. The RADAR SENSING app runs on AndroidOS devices and saves all the information such as user data and user contributions in an appropriate database in RADAR SENSING back-end. Simply a registration and the installation of the RADAR SENSING app are required. Then users can give both negative and positive ratings, with the help of predefined categories, all relevant to planning issues. If there is a missing category, it is also possible to define a free text for a new classification. In order to ensure easy and fast handling, the app locates the user's position directly with the help of several sensors

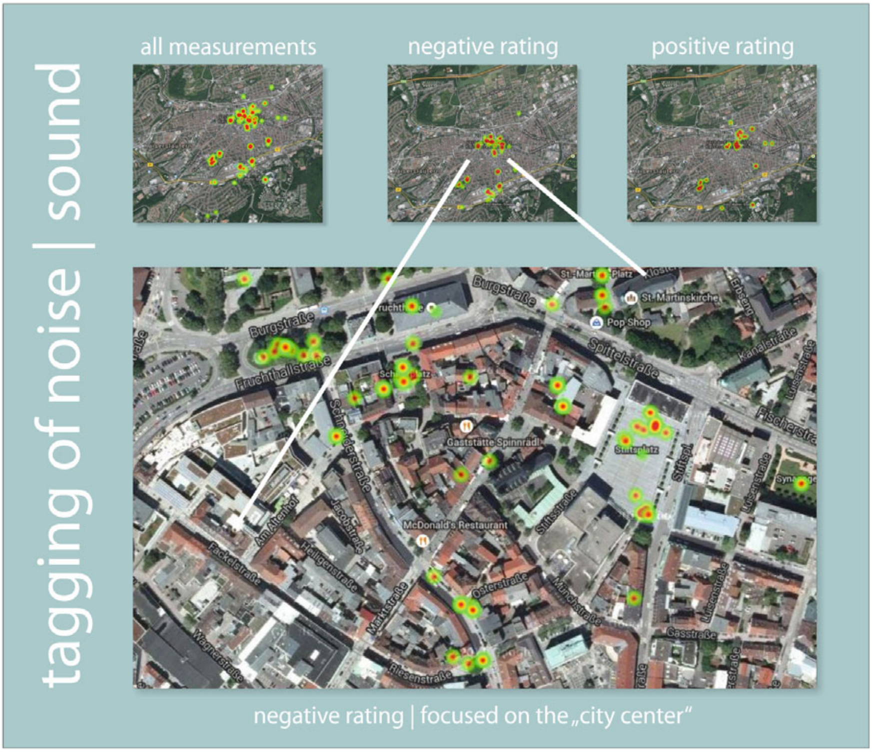

Fig. 2 Tagged classification of negative or positive rating concerning ‘sound’ into the city of Kaiserslautern (Zeile et al. 2012)

(GPS and WiFi) and displays them on a map. If the position is not accurate enough, it can be manually edited. The aforementioned interactive heat map of the marked points is interesting for spatial planning (Fig. 2). In addition, it is also possible to display only a certain period of time or the real time to allow the generation of the heat map (Zeile et al. 2013).

The above-mentioned technology is easy to use and useful for a quick examination and first overview for planning facts, but it is not to collect ‘emotional data’. Therefore, the following modes were developed.

3.1.2 Extraction of Emotion Information from User-Generated Data

Previous methods for extracting information from crowdsourced data have relied on methods from a single discipline; for instance, geographers tried to detect hot spots in geographic space, whereas computational linguists analyzed crowdsourced data with respect to their semantic content. The Urban Emotions approach extracts information by means of a trans-disciplinary algorithm, in this case, integrating methods from computational linguistics, GIScience and urban planning.

Figure 3 shows the workflow for the extraction of information from unstructured datasets like Twitter tweets. Generally speaking, the algorithm assigns an emotional quality (joy, anger, fear, sadness, surprise and disgust) to each tweet. In practice, this means that we produce a set of labelled tweets from initially unlabeled tweets in four steps. *First*, the tweet text is pre-processed by applying basic text processing algorithms (part-of-speech [POS] tagging to detect emoticons, negations, etc.) and by comparing their content to the Affective Norms for English Words (ANEW) word list. *Second*, the similarity between all tweets is computed according to three dimensions: linguistic and semantic content, temporal distance, and geo-spatial distance. *Third*, a tweet graph is constructed, where "thicker" edges between tweets indicate higher similarity scores. *Fourth*, a graph-based label propagation algorithm is applied to the graph, resulting in a probability distribution over all labels for each previously unlabeled node. The methodological details of the approach are described in Resch et al. (2015a).

3.1.3 "People as Sensors" for Ground-Truthing Emotion Measurements

Current emotion sensors are able to detect spikes in different biometric parameters like additional heart rate, skin conductance or body temperature, but they are not capable of identifying the emotional quality, as mentioned above. To address this shortcoming, a 'people as sensors' smartphone app was developed, with which persons can manually enter the emotional category and the according context in the case of an emotional spike (Resch 2013). So, the app's inputs are twofold, namely objective sensor measurements, and subjective observations—both are send to the back-end (refer to Fig. 1). In the design of the app, the main challenge was to account for technological requirements for web development and at the same time integrate psychological theories for interaction design and emotion detection. More information about the design can be found in Resch et al. (2015a). The technical design considerations including the standardized communication with the back-end will be presented in Resch et al. (2015b).

3.1.4 Psychophysiological Monitoring

The so-called psychophysiological monitoring is the technology to measure the arousal of a person. In principle, the measurement occurs in nearly real time and provides data about the change in body reactions (body physiology) of a participant. There is a variety of assessment methods to identify emotions (Schumacher 2014). Using 'emotional stimuli' with IAPS (International Affective Picture System), in which a collection of pictures is shown representing the range of human experience and the users rate them with the attributes 'positive', 'negative' or 'neutral' (Bradley and Lang 2007). Another method is to measure the 'startle reflex', a peripheral physiological parameter. Thereby, negative stimuli can be measured over

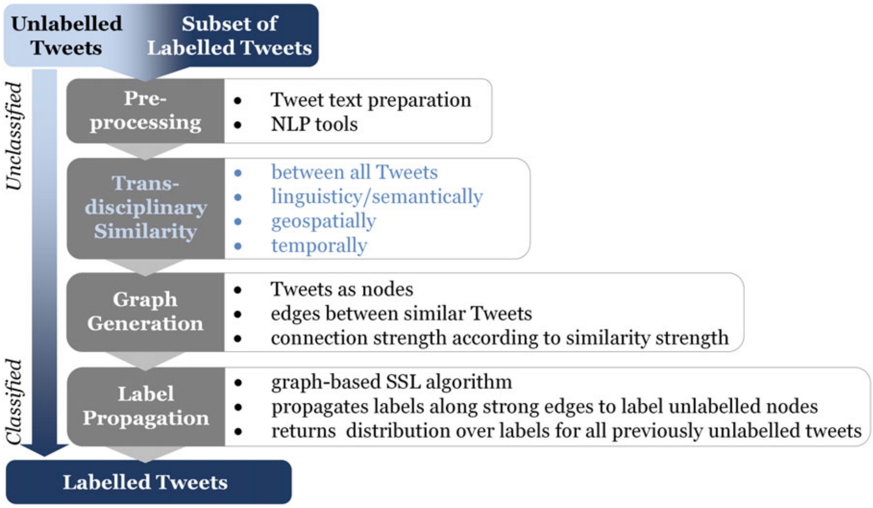

Fig. 3 Labelling tweets in a semi-supervised learning approach

a reflex of the neck or the eye (eyeblink). With the help of two electrodes, placed under the eye, minimal muscle tension can be recorded and is an indicator of negative stimuli (Geyer and Swerdlow 1998). For a mobile use in field research in urban environment, only the following two methods are suitable: A combination of body temperature and skin conductance (Stern et al. 2001; Boucsein 2012) or by using the additional heart rate (Fahrenberg and Myrtek 2001; Myrtek et al. 2005; Schächinger 2003).

Currently, only negative emotions are clearly identifiable based on these physiological parameters. In a popular scientific manner, this negative emotion can also be classified as 'stress'. "According to emotion researchers, when a negative experience occurs, the skin conductivity increases and the measured skin temperature decreases" (da Silva et al. 2014, p. 97). For instance, a test person has the experience of anger or fear—a negative emotion—skin conductance (the difference between sweat production and absorption of the skin) increases and skin temperature in the extremities decreases. A well-known example in extreme mental stress situations is known as 'cold sweat' (Bergner and Zeile 2012). These identified and georeferenced points can then be visualized as exemplarily shown in Fig. 4.

4 Results

The research in this topic is ongoing; the following first results show the potential of the new approach.

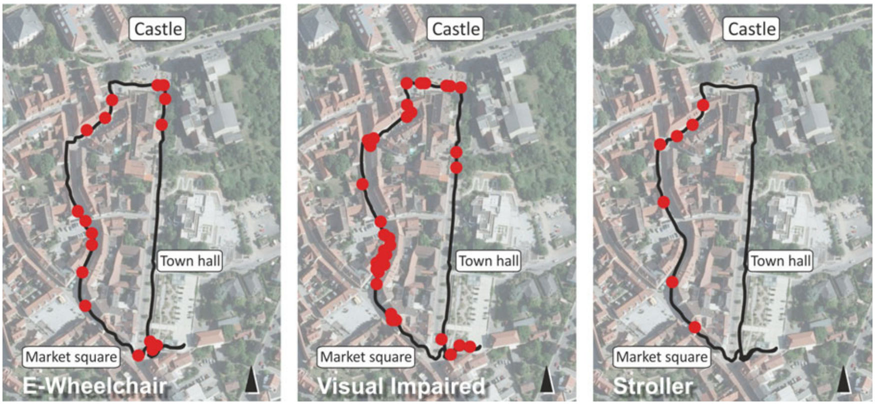

Fig. 4 Identified stress points of the test persons within the city of Kirchheimbolanden (Bergner and Zeile 2012)

4.1 Barrier-Free Planning

The topic of accessibility plays an increasingly important role in urban planning processes. Due to demographic changes and high expectations and demands on mobility, especially in old ages, the accessibility of infrastructures in new planning projects is now more and more important. A requirement for accessibility is that people can use objects, media and infrastructure fully independently, regardless of possibly having a disability or mobility limitation. Especially in the design of public space, various problems can thereby arise concerning accessibility.

At the core of Urban Emotions, georeferenced and time stamped psychophysiological measurements from the combination of human and technical sensors enrich traditional planning methods with a new layer of contextual emotion information. This is a new and objective method of rating the accessibility of infrastructures. Besides the known experiments (da Silva et al. 2014), the example shows the potential benefits of using this technology in planning processes. This study is set-up in the small village of Kirchheimbolanden, which is characterized by having a high age structure and a correspondingly high number of senior residences. The four participants included a woman with an electric wheelchair, a visual impaired woman, a mother with a stroller and a non-handicapped reference person (Bergner and Zeile 2012).

In Kirchheimbolanden, an urban renewal project to renovate old infrastructure like pavements, streets, stairs and crossing sections was planned. The announcement of the project included a part to implement 'barrier free planning'. After termination, the accessibility towards special industry standards like DIN 18024 (surface indicators in public space) and DIN 32984 (barrier-free construction) was checked again. This served as a reference to compare these results to the psychophysiological monitoring, where the participants delivered data to identify 'stress points' within the urban area.

As shown in Fig. 4, a number of individual stress points were identified, which were compared with the DIN survey on-site. With the help of the DIN survey, recorded movies of the walk and the stress points, it was possible to interpret if there really is a planning deficiency, a temporal barrier or only a personal negative impression. For example, it was noticeable in this study, that in the pedestrian zone, located in the southwest, different cobblestones and temporary barriers of the retailers had a considerable impact on the handicapped participants, especially to the blind person. The results were presented to the public, stakeholder participants and the representative of people with disabilities. The subsequent debate discussed a limitation of mobile billboards within the pedestrian zone and if it was possible to remove the identified deficiencies.

4.2 Emocycling

The topic of cycling in urban areas emerged as another application field in the Urban Emotions approach. The possibility to detect urban development problems for bicycle traffic can give hints for better planning and a resulting acceptance of using cycles, especially against the background of the need to conserve energy and the search for alternatives in modal choice. 'Emocycling' examines negative arousals of a cyclist while riding a bike in the city (Höffken et al. 2014). Again, participants were equipped with a variety of 'wearables' to measure psychophysiological data. A GoPro-camera and a GPS-tracker to geolocate the measurement made it possible to detect areas of negative arousal in the city. Because of the analysis, we identified hotspots of 'stress' in the city, where an increased change of vital data was detected. Even nonprofessionals can clearly identify potential danger spots with this technology. Consequently, this kind of survey helps in public discussions of traffic safety to communicate between all parties concerned.

In addition to cycling, this study also compared whether or not there are differences in the subjective feeling of safety by using a traditional bicycle or a 'pedelec' (pedal electric cycle), especially if the drivers ride on tracks with exhausting topography like ramps or streets with more than 6 % gradient. All the records were aggregated to identify stress hotspots, and the trigger points were extracted and condensed into a heat map, as shown in Fig. 5. Subsequently, particular areas of increased stress reactions can be viewed by video material and deliver hints for optimization in traffic planning. A lower stress density is noticeable when riding up the hill during the test with a pedelec. One reason for this is the reduced physical effort of the drivers. They are not deflected and thereby attentive in detecting obstacles. The subjective feeling of security is increased (Höffken et al. 2014). The simultaneously recorded movie material proves this assumption, the traffic conditions and obstacles didn't change in comparison to the test rides with normal bicycles.

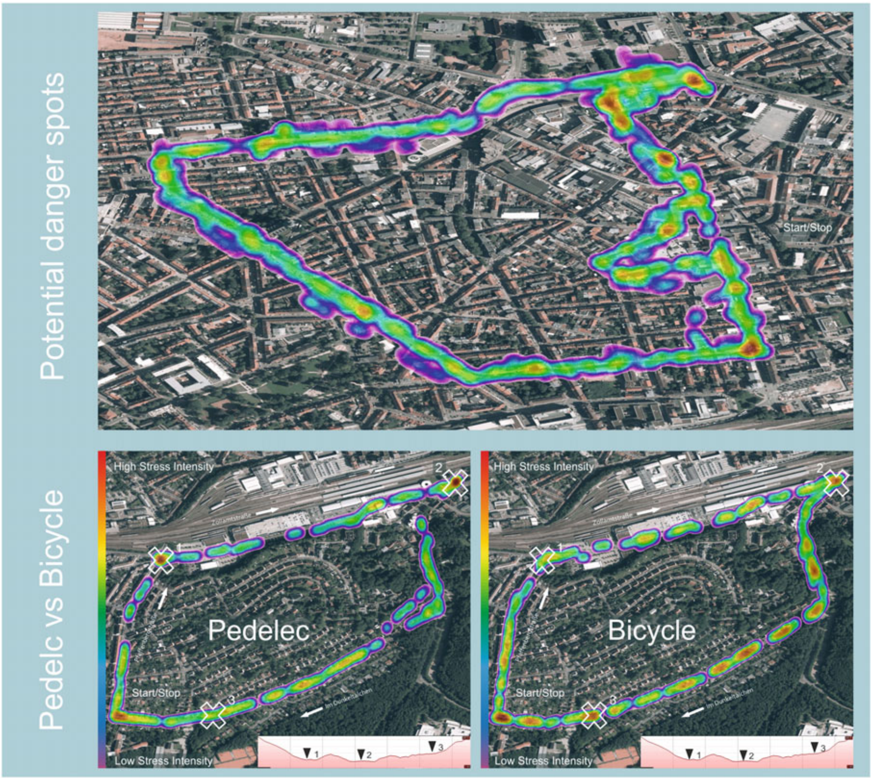

Fig. 5 Potential danger spots for cyclists, identified by psychophysiological monitoring (*top*) and different stress points by using a pedelec (*bottom left*) or a bike (*bottom right*) (Höffken et al. 2014)

5 Risks and Limits of Using Physiological Data

As elaborated above, the results of the various studies show that the use of technical and human sensor data brings an enormous potential for a variety of applications, specifically in urban areas. However, an issue like data privacy has to be borne in mind, because people as mobile users produce the most sensitive data. If there are additional parameters involved, such as private messages or the physical sense, the demands for data protection are even higher. Hence, the smartphone itself is in focus of various privacy concerns […] "Could mobile phones become the most wide spread surveillance tools embedded in history" (Shilton 2009, p. 48).

Apple's privacy policy in terms of location-based services reveals, for instance, that the company and its partners use and share precise location data in real time. Also, installed apps can access a variety of relevant data from the GPS sensor, calendar, browser history, etc. (Kersten and Klett 2012). There are no reliable facts, but it is assumed that about one third of all free apps access the location of its mobile device. Furthermore, about 50 % of free Android apps have a so-called Third Party Code and "support the sending and showing of mobile advertising and the analysis and tracking of user behavior" (Kersten and Klett 2012, p. 88). This can bring users into permanent conflict between participative motivation and concerns for their own privacy. The postulated freedom in the internet is equally compromised by commercial companies, which use the data for their own purposes (Caesar 2012). This dilemma can also be seen in the Internet, because "lack of clarity, commercialization and information overload must be monitored continuously. Nevertheless, it can be stated that the advantages of using social media in terms of strengthened legitimacy, transparency and democracy prevail through citizens' participation" (Caesar 2012, p. 84).

Some approaches which consider four geographic locations as sufficient to reveal a person's identity through the analysis of movement patterns (Montjoye et al. 2013), although the requirements for an effective anonymization have to be discussed continuously in the light of the technological development because the possibility of geographical traceability will increase. Zang and Bolot explored in their study for example, that the location of call via call details records (CDR) together with publicly available data will make it possible to re-identify users despite anonymized data records (Zang and Bolot 2011). The concerns about data protection and privacy have to be dealt with wisely in the context of the ongoing development. Hence, the problems are less about technical hurdles, but are rather to raise awareness of the multi-dimensional connections. A biased attitude against the use of sensor data for planning purposes is not beneficial in this case. As Shilton (2009, p. 53) explains: "participant engagement in privacy decision making must therefore be fortified by supporting social structures". Thus, it should be noted, that as well as technical protection mechanisms, people's awareness for transparency, openness and especially control over the data are all important. For instance, every new or edited 'End User License Agreements' (EULA) of Facebook opens a public debate. Following campaigns, public debates and blogs can contribute to social acceptance as well as clear and easy to understand EULAs (Shilton 2009). Or, if the usage of personal data is not well documented, people quit the service or won't take part of a survey.

6 Conclusion

Urban Emotions is an interdisciplinary approach at the interface between the research domains of geoinformatics/GIScience and spatial planning, between language processing, sensor technology, citizen science and architecture. It can be seen as a novel anthropocentric approach for understanding the complex spatio-temporal dynamics and interactions in the human-space framework. Thus, the approach focuses on the human being with their perceptions and sensations in the urban context.

The objective and subjective measurements of human feelings and perceptions in terms of urban circumstances like architecture or traffic represent the basis for the extraction of contextual emotion information in a fine-grained spatial and temporal resolution. The extracted information can be used and implemented in planning processes and provide innovative opportunities for citizen-centered urban and spatial planning. Moreover, such contextual information as emotion data enables new forms of validation to make planning more sustainable; for example—do the newly designed traffic management systems reveal the desired effect, or how is the newly created city park perceived at different times of the day by citizens?

Technological advances in sensor technology, smart-phones and networks as well as the evolution of web 2.0 and social media enable new opportunities for networking and the collaboration of different research domains—these possibilities are not limited to geoinformatics and spatial planning. It is rather a question of joining the paradigms of engineering, applied science, natural sciences, social sciences and humanities to identify synergies and potential benefits.

Measuring emotions in a complex microstructure what we know as a city is a core element in the Urban Emotions approach. The methods of detecting emotions are manifold, ranging from a simple localization of opinions ('good' or 'bad') up to psychophysiological measurements. By using such sensitive data, a prognosis of the acceptance of the above-mentioned approach is difficult to estimate. Accessibility or emocycling are only a two examples of a range of relevant issues in spatial planning, in which emotions and human beings are increasingly being focused on in the shift towards human-centric planning.

Privacy issues have to be discussed in an open and transparent way to inform and clarify the methods. However, a tendency in sharing personal information through online platforms, even sensitive physiological data or personal emotions can be observed in the above mentioned 'Quantified-self' movement. How these datasets can influence or be used in urban planning processes remains to be determined. It is positive to note that 'life loggers', with their personal motivation and initiative, can play an important factor in the collection of emotion data. Spatial planning should recognize this potential and use them to enhance participation processes.

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