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Modelling Affective Responses to Space

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1 ABSTRACT

Most geospatial applications rely on objective GIS data to provide services and decision support. These objective GIS data store abstractions of the real world, especially focusing on physical features. However, research on environmental psychology suggests that all stimuli, including large-scale environments, are perceived not only according to physical features, but also in terms of people's affective responses towards them (Russell, 2003). These responses may influence a person's behavior and decision-making in space. For example, some environments might be experienced as stressful with the consequence of avoidance; others might lead to preference and approach (Kaplan & Kaplan, 1989; Nasar, 1984). Although it is well accepted, that people's wellbeing and behavior is influenced by external cues, subjective geo-information has not yet been incorporated in existing geospatial applications, such as in navigation support. Therefore, we propose that in order to provide better services, geospatial applications need to consider people's affective experiences in space. This paper will give an introduction into types of affective responses and methods available to indicate them. We will report on results from our ongoing research project, which aims to model people's affective responses to urban space, and to incorporate this affective data into navigation services for pedestrians.

2 INTRODUCTION

A number of studies in the field of environmental psychology indicate that characteristics of indoor and outdoor environments influence people's wellbeing (Ulrich, 1984; Kaplan, 1993; Hartig & Staats 2006), preference (Nasar, 1984; Kaplan & Kaplan, 1989), satisfaction (Hur et al., 2010), and evoke behavioral changes in space, such as social interactions and intensity of land use (Sullivan et al., 2004), perceived walkability (Leslie et al., 2005; Schmidt et al., 2011), and walking route choices (Zacharias, 2001; Borst et al., 2008).

Data about people's preferences and avoidances of environments may be applicable in various fields of research - one of which is navigation. Borst et al. (2008) studied route choices of elderly people in relation to environmental attributes. Their findings suggest that people do not simply decide for the shortest route, but that decisions in space are influenced by various characteristics of the environment, such as parks, slopes, trees, front gardens, or shops. Consequently, data about people's perception of space can be used to better predict people's route choices, and support spatial behavior in a realistic, user-oriented way (Borst et al., 2009). However, people's perception about environmental characteristics have not yet been incorporated into navigation services. In order to offer services that more adequately support and suit users' needs and preferences, data about people's perception of and feelings in space must be collected. Such subjective data can be assessed through various approaches, such as self reports, physiological recordings, or field observations. Recently, with the ubiquity of smartphones and increasing interests on Web 2.0, researchers start to explore using smartphones as an instrument to collect users' subjective responses about and in space.

In our current project EmoMap, we will use this new approach to gather emotional responses evoked by the environment. Using smartphones enables people to report about their perception of space anytime and anywhere. In our project, we treat affective responses to space as fundamental information approach for geo-spatial applications. We will model affective responses to space by quantifying people's perception of the affective qualities in the environment. For gathering these affective data, we aim to make affective experiences in space easily reportable, and to automatically link these responses to the physical environment. By incorporating the collected data into services for enhancing navigation for pedestrians, we will examine its usefulness in the future.

This paper will report on results from our ongoing research project, which aims to model people's affective responses to urban space, and to incorporate this affective data into navigation services for pedestrians. We

will introduce types of affective (emotional) responses and methods available to indicate them, as well as give an overview about the state of the art of cognitive and emotion mapping, and related work.

3 AFFECTIVE RESPONSES TO SPACE

Stimuli and environments, all are perceived not only according to physical features, but also in terms of a person's affective response towards them. According to Russell (2003) some affective response is always present within a person, either perceived as neutral, moderate or extreme. When affect is in the foreground – due to its intensity or due to situational cues -, it can be consciously experienced as pleasant or unpleasant and form the basis of an emotional experience (Feldman Barrett et al., 2007; Russell, 2003). When affect is milder, it influences conscious experience and behavior in a less direct way. In this case, background affect is experienced as property of the person's environment (Russell, 2003; Feldman Barrett et al., 2007). These two affective states - emotions and affective qualities - are common approaches for investigating affective responses to space. Both affective states have the same common ground, but are experienced differently. Russell (2003) aptly describes this difference as hot experience for emotional reactions, versus cold experience when perceiving affective qualities.

3.1 Emotions

Emotions are complex and multifaceted phenomena. Due to its complexity and connection with other processes, emotions are among the most challenging phenomena in psychology. Until today there is no general agreed-on definition, which can clearly mark off emotions from other affective states. Psychologist offer not one but a variety of definitions, each addressing different components of emotions. However, on its very basis, Feldman Barrett et al. (2007) define emotions as intentional states that are about something, emerging from basic processes.

Emotional reactions can be examined in multiple ways: as subjective feelings, expressive reactions, cognitive performance, motivational changes, behavioral, and physiological reactions. The fact that emotions are a complex construct and cannot be measured directly, but only be indicated through their manifestations, lead to various approaches. In general, methods for indicating a person's emotional response can largely be divided into three most common categories: (1) self reports, (2) physiological methods, and (3) behavioral observations. Feldman Barrett et al. (2007) stress that self reports are the most direct way to gather information about a person's internal state. Self reports, such as verbal descriptions or judgements (e.g. questionnaires or interviews) however are subjective by nature, with its advantages and drawbacks. Physiological recordings through sensors on the other hand, provide an objective measure to affective responses (e.g. electrocardiogram, electromyogram, galvanic skin response), with the advantage that the person does not even have to recognize the physiological changes. Recorded data is used as indicator of emotional reactions, with the drawback that high arousal may or may not be caused by an emotional experience. Behavioral observations have similar advantages and disadvantages as physiological measurements; observed re-actions may or may not be due to a person's affective reactions caused by the environment. Without any interpretation, the data collected from physiological recordings and behavioral observations may be insufficient to precisely discern a person's affective response. However, there is no one agreed-on empirical solution about the components that indicate emotional experiences best.

3.2 Affective quality of the environment

Another way to approach affective responses to space is by handling its affective qualities (cold experience). Affective qualities are experienced as properties of the external world, commonly described with affect-denoting adjectives such as hectic, exciting, or beautiful. These affective qualities are verbally attributed to a place, but have the ability to change a person's affective feeling of pleasure or displeasure (Russell & Pratt, 1980; Russell, 2003). According to Russell (2003), the perception of affective qualities is an ubiquitous process. People evaluate and judge their surroundings routinely, at any time. In contrast, emotional experiences are rather infrequent, triggered by intense or situational cues. Myrtek (2004) reports that among emotional experiences the most often reported one was the experience of no emotion (58% of females, 72% of males).

One approach to quantify affective qualities of environments is by using semantic differential scales (Osgood et al., 1957). A Semantic Differential (SD) provides a list of affect-denoting adjectives on a bipolar rating

scale, designed to measure the connotative meaning (subjective associations) towards a given object, event or concept.

4 FROM COGNITIVE MAPS TO EMOTION MAPPING

In 1948 the concept of cognitive mapping was first introduced by the psychologist Edward C. Tolman. His experiments with rats indicated an ability for memorizing locations and spatial orientation. Tolman (1948) concluded that not only rats, but also humans may be able to develop an inner picture of the external world (a cognitive map), which help guide the individual in space. Researchers from various fields started to explore cognitive processes, such as the cognitive representation of spatial content, which until then were believed to be sealed within the individual (in a black box). In the 1950s this development mounted in the so called Cognitive Revolution.

In 1960 the urban planner Kevin Lynch introduced first ideas on how people perceive and organize spatial information as they navigate through space. According to Lynch's research (1960), key elements of the cognitive representation of space are paths, boundaries, districts, nodes, and landmarks.

About 20 years later Downs and Stea (1982) examined people's mental representation of space and found various distortions of mental maps. Downs and Stea (1982) conclude that cognitive maps do not show realistic images of the external world, but indicate how people believe the world is like. Potential factors which deviate cognitive maps from reality may not only be physical barriers, and semantic unity, but also emotional involvement and attitudes (Carbon & Leder, 2005). These subjective, emotional attitudes towards space were examined by Matei et al. (2001). On the basis of cognitive maps from individuals about the perception of comfort and fear in the city on Los Angeles, one aggregated, cognitive map was generated (Matei et al., 2001). Matei et al. (2001) were not only among the first who added this kind of collective, subjective layer to maps, but they also created one of the first digital map visualizations of feelings. Even though the map reports on the emotional perception (comfort and fear) of Los Angeles, it can only be considered to be a mental or cognitive map, but not an emotion map. Due to the method of retrospective self reports, the data collected may provide more insights into people's perception, in terms of opinions and prejudices, about space than about how people feel in space when they are physically there.

Among the first, the artist Christian Nold (2008) explored emotional responses in space. In his art project BioMapping participants are instructed to re-explore their local area, carrying mobile devices with them. One of the device measures the participant's galvanic skin response (GSR), indicating a person's emotional arousal. Additionally, a GPS device automatically refers the participant's position to a geographical location. As a result, an emotion map visualizes points of high and low arousal experienced in space, and reporting on the contributions of each participant (see Fig.1). However, to generate meaningful maps, the physiological data collected automatically, must be interpreted retrospectively (not every arousal indicated an emotional experience).

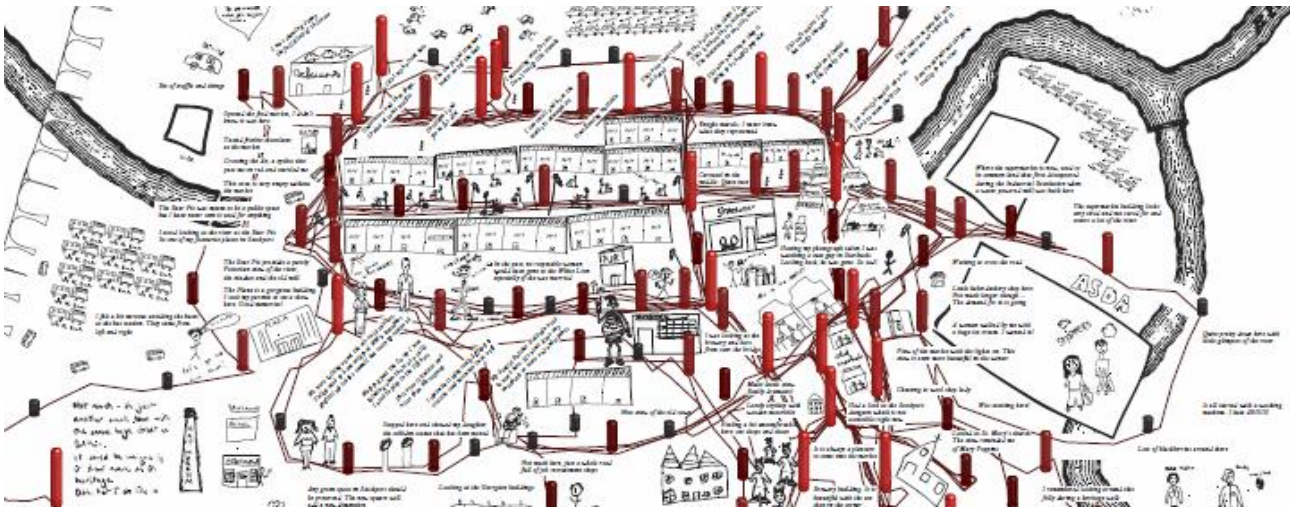

Fig. 1: Stockport emotion map by Christian Nold (2008). The higher the bars the higher arousal was measured. Textual descriptions and drawings were added retrospectively by the participants.

Recently, with the ubiquity of smartphones and increasing interests on Web 2.0, researchers start to explore using smartphones to capture users' self-reported affective responses. With smartphones the contributions can be easily linked to a person's geographic location. Current services, which ask for the user's feelings by using smartphones, as well as safe information about a persons location (by asking the user about the location or by storing the geographic information automatically), are:

- The service "Mappiness" developed by MacKerron and Mourato (http://www.mappiness.org.uk) is part of a research project, asking its users via smartphones to rate how happy, relaxed, and awake they are (on an eleven-point Likert scale). Some additional questions are asked (e.g. for current company and activities). The user's current position is stored automatically. The collected data are based on self reports. However, the benefit of using smartphones for gathering affective data, seems to be a quite promising one. Until today 48274 participants are reported on their website, indicating that a large number of contributions may be gathered easily.
- The smartphone application "Glow" (http://glowapp.com) asks the users to rate how they feel on one to five stars. The user's location is stored automatically. Personal results as well as the aggregated data of all users are displayed as heat maps with a color range from blue (awesome) to red (not so awesome).
- "Track Your Happiness" (https://www.trackyourhappiness.org/) is a research project by Killingsworth from Harvard University that aims to investigate causes and correlates of happiness. This research aims to understand what factors affect people's happiness in their daily lives. Information is gathered (on a webpage via smartphone) about a person's current happiness, and related to current activities, location, company, time of day, etc.
- "CaptureEmo" (http://www.capturemo.com/) is an instrument, which aims to assess people's emotional experiences about environments. A picture, sound recordings or a video of environments can be labelled emotionally (such as happy, interested, disgusted, etc.). However, the instrument is not a location based service. The only reference of the location is the picture or recording itself.

Present location based services for collecting emotional experiences in space tend to focus on various affective states of the users, but not necessarily on a momentary affective experience caused by the spatial surroundings. It can certainly be the case that the feelings reported by these services are influenced by a person's current environment, but not inevitably. To get clearer data it may therefore be necessary to address this issue by asking the user more specifically, such as "How does the environment make you feel?" instead of "How are you?", or as Russell (2003) suggests to have people evaluate an environment's affective qualities.

5 EMOMAP PROJECT

Research in one of our previous projects suggests environmental factors, such as safety, convenience, and attractiveness, to be relevant for the perceived route quality in pedestrian navigation (Schmidt et al., 2011). Although these factors are not emotions itself, they are affective evaluations caused by the environment.

In our current project EmoMap, we aim to gather emotional responses evoked by the environment. These emotional responses to space will be therefore modelled as a person's evaluation of affective qualities. We will ask users to evaluate the environment by ratings instead of asking them for their emotions directly. By doing so, we will direct a person's attention to the environment. We expect the collected data to be – at least to some extent - "cleaned" from non-spatial feelings of the person. According to Russell (2003) affective qualities are routinely evaluated anytime. We therefore expect to collect data, which is easily reportable by anyone, and present at any time (contrariwise to emotions, which occur rather infrequent, and which are evoked by intense external and internal cues).

For gathering this affective information, we will use a crowd sourcing approach to get a high volume of data. Self reports are the most promising method, since people can simply and freely contribute via their own mobile application any time and anywhere. People's perception of affective quality will be measured by implementing a Semantic Differential (SD), invented by Osgood et al. (1957), into a mobile application. This approach provides a list of affect-denoting adjectives on a seven-point rating scale. Using SD for our research, integrated into smartphones, brings several advantages:

- Subjective data: SD bases on self-reports and therefore no additional retrospective interpretation of data is needed.
- Simple integration: The instrument can be easily integrated in mobile phone devices. Anyone with a smartphone can contribute.
- Geo-referenced data: Contribution will automatically be stored geo-referenced. with a coordinate, obtained from GPS, and according to time of the day.
- Equipment: A smartphone is the only device needed. It can easily be carried, and is not an additional burden or creates an "unnatural" test setting for the user.
- Time-efficiency: SD provides a quick measurement for evaluating affective quality in space.
- Comparability: Different environments, as well as one place at different times can be compared.

By gathering affective responses in space with mobile devices, we expect an efficient, real-time collection of data, evoked by realistic scenarios, and therefore leading to results with high ecological validity. Within this project, this data will be used to create an emotional city layer, which will depict people's perception of space. This affective data will be the basis of a navigation service, which aims to better suit and predict people's behavior in space.

5.1 Inventory of affective qualities

In order to measure people's affective experiences in space, we first had to collect and specify affective parameters relevant to space. By using a multistage method, we obtained affective experiences related to space through several iterations:

5.1.1 Focus group

In a first step, a set of 39 affective qualities was compiled from affect-denoting terms found in literature. A focus group of non-experts (N=9; 5 females, 4 males) selected all relevant terms from the sets, as well as amended missing or inaccurate ones, resulting in a new sample of 67 affective qualities related to space (34 positive and 33 negative terms).

5.1.2 Online questionnaires

In a next step, online questionnaires were carried out, with the aim to reduce the affective parameters complied in the focus group to the most important ones. Participants were invited by social media and mailing lists. In the online questionnaire, participants were asked to select all of the parameters experienced in the urban environment of Vienna.

Among the 102 subjects (MeanAge= 34.4, SD=12) who completed the online questionnaires, exactly half of them were females, respectively males (n=51). Chi-square analyses showed a highly significant difference in the selection of positive affective qualities (χ^2= 309.007; df= 33). The standardized squared residuals indicate seven parameters, which were selected significantly more often: divers, lively, interesting, safe, upkeep, atmospheric, and beautiful. For negative affective qualities, chi-square analyses indicate a highly significance of the five parameters busy, noisy, hectic, stressful, and dirty (χ^2= 550.578; df = 32; $p < 0.001$).

5.1.3 Data aggregation

To reduce redundancies, the 12 parameters selected in the online questionnaire were further aggregated according to their synonyms, resulting in six environmental attributes (traffic, people, noise, attractiveness, diversity, safety). We added one more factor to our model, even though it has not shown to be significant. We added the attribute "smell" to our preliminary emotion model to find out whether smell was an important environmental aspect, which may had not been selected due to the fact that the questionnaires were conducted indoors. The resulting 7 aggregated parameters form the elements in our hierarchical preliminary emotion model, which is the basis for the geo-referenced collection of affective responses in space.

5.1.4 Preliminary emotion model

The hierarchical structure of the model considers people's emotional granularity, which are interindividual differences in the ability of characterizing affective experiences as broad affective or discrete terms

(Feldman Barrett et al., 2007). On two levels, the model serves as the basis for the geo-referenced collection of affective responses in space:

(1) Level of broad affect. On the first level, people can rate how pleasant or unpleasant the environment is experienced. This broad affect is considered to be reportable by any individual, independent of culture and age (Feldman Barrett et al., 2007; Wierzbicka, 1999; Russell, 2003).

(2) Level of distinct affective environmental qualities. This level asks for ratings about the current environment, regarding the categories of traffic, noise, smell, people, safety, attractiveness and diversity (on a seven-point scale, ranging from -3 to +3). This level of distinct environmental qualities provides more detailed information about characteristics of the environment.

5.2 Location model

In order to link people's affective responses to space, a location model was needed. For providing a suitable location model, we analyzed different check-in applications, such as Foursquare and Facebook Places. They link users' check-ins to place labels, each of which basically has a latitude/longitude pair (i.e. a point) and a name. However some places are hard to be named. In our current location model we link reported experiences as points to a location, which will be automatically obtained from GPS devices. In the future, we may also allow users to link their emotions to points, lines (along street network), and polygons. For each object, only the geometry is stored.

6 WORK IN PROGRESS AND CONCLUSION

After implementing the preliminary emotion model into a prototypical mobile application, the usability, as well as the emotion and location model is currently examined by using the application in the study area of Vienna. First results from people's affective responses to space are visualized in Figure 2. The colored points represent the geo-coded affective responses from eight participants (4 females, 4 males), bright red indicating places where people feel uncomfortable, dots in dark green indicating comfort. Depending an the zoom level, the data will be displayed as aggregated content with numbers of contributions provided, or as individual contributions.

Preliminary results from user's responses and correlations between the parameters suggest to aggregate, and further reduce the number of parameters. Due to the relatively small screen of smartphones, the information being displayed is limited. Consequently, a further aggregation of the parameters to their core will not only allow an even faster and non-redundant contribution, but will avoid the information overload.

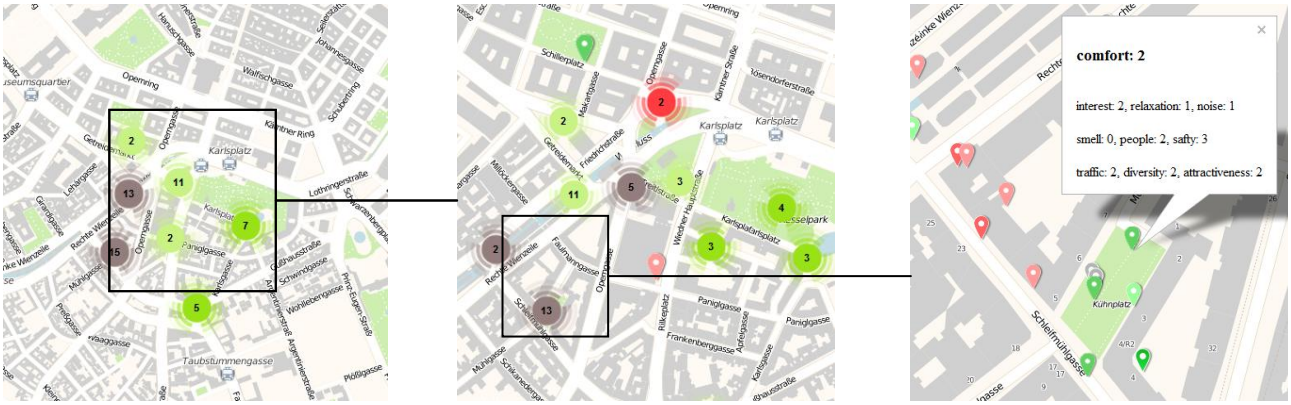

Fig. 2: Emotion maps of Vienna. Depending an the zoom level, the data is displayed as aggregated content (with numbers of contributions provided) (left and center) or as individual contributions (right). Red dots indicate discomfort, dark green dots represent comfort. Map source: cc-by-sa OpenStreetMap - contributors, 20.02.2012.

In the future, we will use the option of volunteered geographic information to collect affective responses to space. In order to illustrate the importance of affective experiences in space, the data collected in the current project will be aggregated, resulting in a collective affective map-layer, and further be used for enhancing navigation systems for pedestrians. Route suggestions based on subjective information about space will be provided, and its usefulness as well as users' satisfaction evaluated.

However, applications will not be restricted to navigation services only. The data will be stored in an open online database (OpenEmotionMap.org), which will be open for other usages and disciplines. We expect the

inclusion of this affective layer will bring benefits to different disciplines, not only in Information and Communication Technology, but also Urban Planning, Architecture, and Policy Making.

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