Incorporating Land Use in a Spatiotemporal Trigger for Ecological Momentary Assessments

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Short paper

Abstract

Mental health and well-being can be related to both individual as well as environmental factors. In order to address the latter relationship we use an Ecological Momentary Assessment (EMA) approach to capture the mood of 10 persons in real-time and real-life via questionnaires sent to their smartphones. This paper focuses on the timing of the questionnaire trigger. In order to avoid the questionnaires being triggered simply at fixed time intervals, we add a spatial component incorporating the land use associated with the participant's location. The results show that the introduced trigger, which can send out an electronic questionnaire when a person moves to an area with a different land use, results in more unique trigger positions and displays an increase of triggers at less frequently visited land uses. This helps obtain a spatial spreading of the questionnaires.

1 Introduction

Ecological Momentary Assessment (EMA, STONE & SHIFFMAN 1994) is a technique where data are collected in real-time and real-life (SHIFFMAN et al. 2008). The method is often used in psychological research to obtain personalized data outside a lab environment. With the EMA technique, in-situ data, e.g., obtained from electronic diaries, can be captured using a technical device (SHIFFMAN et al. 2008). For example, the daily mood variation of a person can be assessed by using an electronic questionnaire, which also records the time stamp. By including movement information, mood variations can be linked to other parameters like physical activity (EBNER-PRIEMER et al. 2012; TRULL & EBNER-PRIEMER 2009). Furthermore, it is possible to include a spatial component in the studies. Depending on the technical device, locations can be captured in order to address the relationship between the natural environment and health. For instance, BOGERS et al. (2013) use an EMA approach to compare the actual exposure to radiofrequency electromagnetic fields in relation to the perceived exposure in real-life and real-time.

As a joint effort of the Central Institute of Mental Health (ZI), the Psychiatric-Epidemiological Centrum (PEZ; Mannheim), the Karlsruhe Institute of Technology (KIT) and the GIScience Research Group at the Heidelberg University an ongoing longitudinal study is investigating the influence of environmentally driven stress on epigenetics. The Psychiatric-Epidemiological Centrum (PEZ) project addresses the interaction between individual-

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related factors, environmental factors as well as the well-being and mental health. The study is conducted in the Rhine-Neckar region in southern Germany. In the study, participants report their mood and well-being using a smartphone app which also obtains the time and location (coordinates) of the participant. Subsequently, the EMA results will be correlated with socio-economic and environmental data such as population density and land use. This paper focuses on the trigger of the EMA questionnaire, i.e., when and where the participants will be asked to fill in a questionnaire. A previously applied time trigger, which triggers at fixed time intervals, is compared to a spatiotemporal trigger incorporating the location of the participants. The aim is to investigate if the timing of the trigger could be improved by considering environmental factors associated with the participant's current location. The idea is to increase the spatial distribution of triggers, i.e., to increase the amount of unique trigger positions and obtain information regarding mood and well-being from places that are visited less regularly.

2 Land Use Data

For this analysis, we used the ATKIS DLM (Digital Landscape Model) land use data provided by the *Landesamt für Geoinformation und Landentwicklung Baden-Württemberg (LGL)* and *Landesamt für Vermessung und Geobasisinformationen Rheinland-Pfalz*. The datasets have a scale of 1:25,000 and contain 46 land use classes as polygon features. For our study region we considered the following classes: Farmland (covering 39.2% of the area), forest (32.8%), industry (5.6%), scrub (2.5%), recreation (2.5%), river (1%), railway (0.3%), cemetery (0.3%), urban (4.3%), residential (9.2%) as well as areas classified as unknown (1.5%) land use. After considering the locations, that the participants actually visited, the amount of classes was further reduced.

3 Methods for Data Collection and EMA Trigger

3.1 Participant location data

In this study we analyzed the movement patterns of ten participants in the Rhine-Neckar region, located in southern Germany. The position data were obtained during one week in 2014 using a smartphone app named movisensXS (Movisens GmbH). The app collected the participants' positions either with the smartphone's GPS unit (accuracy ± 10 m), Wi-Fi (± 40 m) or via GSM (± 200–3,000m). Once determined, the positon data were processed in a geographic information system (GIS) in order to derive the land use associated with each location. Since people in urban areas tend to move on streets and sidewalks a buffer with a radius of 10 meters was added to each point. Afterwards, the land use within the buffer could be determined with a spatial join.

3.2 EMA trigger

This study is based on non-real-time simulated triggers. By simulating the triggers it was possible to compare two trigger methods using the very same movement data. The trigger criteria were based on EBNER-PRIEMER et al. (2012) and set as the following:

- **Method 1: Time trigger -** A questionnaire is triggered every hour between 8:00 am and 9:00 pm whether the participant moves to another land use or not (Fig. 1).

- **Method 2: Spatiotemporal trigger –** This method considers both space and time. A questionnaire is triggered by the participant moving to a land use differing from the land use at the last trigger location (Fig. 1). Furthermore, the amount of time since the last trigger must be at least 40 minutes. Additionally, after 100 minutes it is triggered even if the participant has not moved to another land use. As in method 1 it is only triggered between 8:00 am and 9:00 pm.

4 Results and Discussion

The EMA triggers were simulated using two different methods. Table 1 depicts the total number of triggers, the number of unique trigger positions, the percentage of unique trigger position as well as the percentage of triggers at the same position as the last trigger. The results are shown for both trigger methods and for each of the ten participants. Examining the results reveals a lower total amount of triggers by the spatiotemporal trigger, yet a higher amount of unique trigger positions in comparison to the time trigger. Furthermore, the percentage of triggers at the same location as the previous trigger is strongly reduced for every single participant when applying the spatiotemporal method.

Figure 2 shows the distribution of the triggers within the land use classes. It illustrates that a majority of the questionnaires are triggered in residential (time trigger 54.8%; spatiotemporal trigger 51.7%) and urban areas (31.1%; 28.4%). For these two land use classes, the time-based method triggers more often than the spatiotemporal approach (in percentage terms). The third most visited land use is railway; here both methods perform the same (8.0%; 8.0%). For all other less visited land uses (with exception for cemetery), it becomes evident that the time-based method triggers less frequent than the spatiotemporally based trigger. That is the case for the land uses recreation (3.7%; 5.7%), industry (1.1%; 2.4%) and farmland (0.8%; 2.3%), among others. Altogether the results show that a higher spatial spreading is obtained with the spatiotemporal trigger in comparison to the time based trigger.

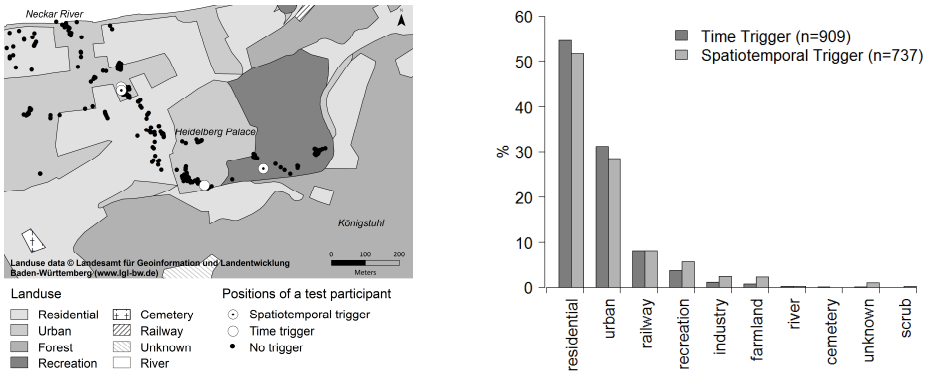

Fig. 1-2: An example of a person's movement pattern and the associated locations for the time-based and spatiotemporal-based triggers (left). The percentage of triggers at different land uses for both trigger methods (right).

Table 1: Statistics from a simulated time trigger and a simulated spatiotemporal trigger.

	Time Trigger				Spatiotemporal Trigger			
Participant	Total number of triggers	Unique trigger positions	% unique trigger positions	% same position as last trigger	Total number of triggers	Unique trigger positions	% unique trigger positions	% same position as last trigger
1	84	20	23.81	58.33	70	33	47.14	35.71
2	95	36	37.89	47.37	76	35	46.05	36.84
3	99	24	24.24	66.67	74	28	37.84	45.95
4	87	19	21.84	68.97	63	23	36.51	44.44
5	82	40	48.78	40.24	70	43	61.43	30.00
6	87	45	51.72	40.23	86	53	61.63	25.58
7	89	39	43.82	47.19	68	36	52.94	32.35
8	91	22	24.18	58.24	79	31	39.24	36.71
9	104	14	13.46	72.12	75	21	28.00	54.67
10	91	23	25.27	58.24	76	34	44.74	34.21
Total	909	282	31.02	56.22	737	337	45.72	37.44

5 Conclusion and Outlook

The objective of this study was to increase the spatial distribution of EMA triggers in order to assess the relationship between mood and less visited land use classes. The results show that the spatiotemporal trigger method reduces the amount of triggers and increases the percentage of unique trigger positions and the share of triggers in less frequently visited land uses. In future studies the sample size of currently 10 participants should be increased. A study incorporating other datasets, e.g. socio-economic variables, may also increase the spatial spreading of the triggers. Finally, it should be noted that a person's mood is affected by various factors and might be related to personal issues more than to the environment. Nevertheless, the proposed approach seems beneficial when investigating the potential relationship between environmental factors and self-reports on mood.

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