Integrating Human Observations and Sensor Observations - the Example of a Noise Mapping Community

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Abstract. Human observations have the potential to significantly improve the actuality and completeness of data about phenomena such as noise distribution in urban environments. The Human Sensor Web aims at providing approaches for creating and sharing human observations as well as sensor observations on the Web. One challenge is the integration of these observations for further analysis. The aspects presented in this paper are examined by the example of a noise mapping community.

1 Introduction

Noise maps are currently generated out of a sparse measurement basis using complex processing steps including simulations. Thus, the information provided for a specific point of interest is a rough estimation based on this sparse measurement basis. Human observations have the potential to significantly improve the measurement basis, which supports the EC directive on the assessment and management of environmental noise [1]. The effort of integrating human observations as well as sensor observations is subject of the Human Sensor Web, which aims at providing a full spatio-temporal data coverage on specific phenomena by incorporating different types of observations. In this context we distinguish between *human observations* which are collected by humans directly (such as a textual description) and *human sensor observations* which are collected by sensors carried by or attached to humans (e.g. continuous measurements by carried smart phones).

The Human Sensor Web adopts technology from the Sensor Web, with a strong focus on the concepts of VGI [2] and the Digital Earth [3]. The challenge attached to the Human Sensor Web regarding the integration of human observations and sensor observations has not been described yet. In this paper we will analyse this challenge based on the example of establishing a noise mapping community.

Section 2 will describe in detail the envisioned noise mapping community and will show the difference with the established quake catcher network. The challenges for the Human Sensor Web are described in Section 3. The paper ends with a conclusion.

2 Noise Mapping Community

The integration of sensor observations and human observations is exemplified by establishing a noise mapping community. Mapping noise in urban environments is motivated by an according EC directive [1]. In this community, which is currently in preparation at our lab we envisage that noise data is collected and shared by users through smart phones. In particular, the smart phones are configured to continuously send current noise measures to the community. These measures include the volume of noise, its main characteristics (e.g. frequency distribution) and the location, at which this noise has been measured. By integrating such data, collected by different users, it is possible to analyze the noise level and to calculate a full coverage of noise distribution regarding time and space. In this case the person carrying the mobile phone does not act as a human sensor but rather as a human sensor platform.

These technical measurements can be supported by human observations that are sent via smart phones or any other kind of web browser. These human observations may describe the noise intensity and the source producing the noise. By sending such observations, these users become sensors themselves. This makes it possible to better interpret the noise map based on the noise measurements (taken by mobile phones). An overview of the noise mapping community is depicted in Figure 1. This figure shows that the different types of observations are integrated into the Human Sensor Web to create and share noise measurements, which can be visualized as a full coverage map. In the given map example, the noise intensity is visualized from green (low noise level) to red (high noise level).

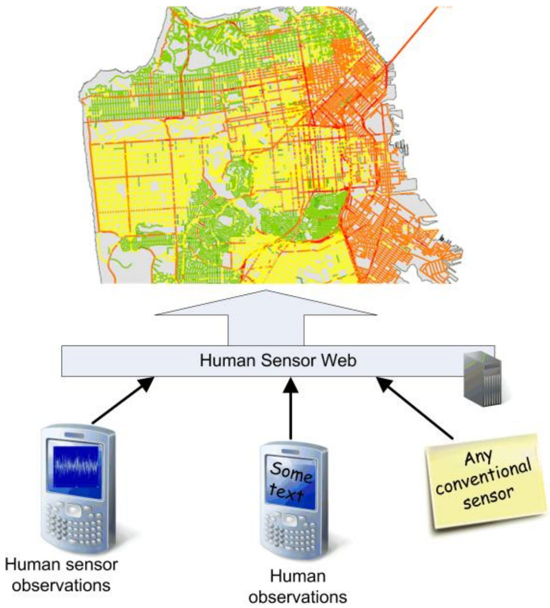

Fig. 1. Overview of the architecture of the noise mapping community.

Another example of such a community is the quake catcher network[1] [4], which measures earth quakes through acceleration sensors as built-in in current laptops. The essential difference of the quake catcher network over the noise mapping community is that it does not incorporate human observations. This difference is also the challenge faced by the noise mapping community and is described in Section 3.

3 Challenge

When establishing a Human Sensor Web such as the noise mapping community one challenge which appears to be essential is the integration of human observations and sensor observations. This integration is important to provide full coverage data but it is challenging due to their different nature. While sensor observations usually are well calibrated and errors can be automatically detected (for instance [5]), human observations are not quality assured and might be error-prone. Therefore, mechanisms to automatically detect errors in the data are required. One possibility is to validate human observations by these sensor observations. For example, noise sensors can be used to detect erroneous noise observations. Additionally, mechanisms to assign trust levels to human observers depending on the quality of their previous observations need to be elaborated [6]. This requires developing validation algorithms that take into account observations from conventional technical sensor networks but also trust and metrics for determining whether observations are suitable for the validation process.

In a second step, established sensor network architectures on the Web such as OGC's Sensor Web Enablement framework [7] need to be investigated for further usage. This especially applies to the scalability of such frameworks. Scalability will become an important factor, as the amount of noise data might become critical, if the community becomes intensively used. In this regard, cloud computing can be one solution to increase scalability of such architectures. Besides that, reducing the amount of transferred data by the means of aggregation might be a further promising approach to increase scalability and performance.

When tackling the described challenge of the Human Sensor Web further challenges need to be addressed, such as (in prioritized order):

- Enabling semantics of human observations
- Designing ergonomic user interfaces
- Investigating and stimulate incentives of people to participate in such a community
- Handling of human cognition and resulting uncertainties
- Ensuring security and privacy aspects
- Handling of unstructured information provided by human observers.

[1] Quake Catcher Network website: http://qcn.stanford.edu/

4 Conclusions & Outlook

In this paper we introduce the Human Sensor Web for building a noise mapping community. By integrating sensor observations measured by carried smart phones and by taking into account (fuzzy) human observations the noise mapping capabilities of conventional sensor networks can be significantly enhanced.

We identify a series of challenges that will need to be solved before such a noise mapping system can become functional. Currently, we focus on the flexible combination of the Human Sensor Web with conventional sources of sensor measurements as well as geospatial data.

Regarding the challenges described within this paper, we will continue our work with the design and implementation of the noise mapping community. We expect to make use of the OGC Sensor Web Enablement concepts to integrate the different kinds of (sensor) data sources. Based on this initial implementation, further research topics like incentives for increasing the participation of users, the analysis of data quality/reliability, security and the handling of unstructured information can be addressed. Future research will also investigate the benefits of this Human Sensor Web approach to noise mapping over conventional approaches.

References

1. European Parliament: Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, (2002).
2. Goodchild, M.: Citizens as Sensors: the World of Volunteered Geography. GeoJournal. 69, 211-221 (2007).
3. Craglia, M., Goodchild, M., Annoni, A., Camara, G., Gould, M., Kuhn, W., Mark, D.M., Maguire, D., Liang, S., Parsons, E.: Next-generation Digital Earth. International Journal of Spatial Data Infrastructure Research. 3, 146-167 (2008).
4. Cochran, E.S., Lawrence, J.F., Christensen, C., Jakka, R.S.: The Quake-Catcher Network: Citizen Science Expanding Seismic Horizons. Seismological Research Letters. 80, 26-30 (2009).
5. Everding, T., Jürrens, E., Andrae, S.: In-stream Validation of Measurements with OGC SWE Web Services. Second International Conference on Advanced Geographic Information Systems, Applications, and Services. pp. 93-98IEEE Computer Society (2010).
6. Bishr, M., Mantelas, L.: A trust and reputation model for filtering and classifying knowledge about urban growth. GeoJournal. 229-237 (2008).
7. Botts, M., Percivall, G., Reed, C., Davidson, J.: OGC Sensor Web Enablement: Overview And High Level Architecture. OGC, Wayland, MA, USA (2007).