Web-Based Near Real-Time Geo-Analyses of Environmental Sensor Measurements

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Abstract. This paper demonstrates two web-based applications for near real-time geo-analysis. Environmental sensor measurements are directly integrated in a fully service oriented workflow. Emphasis is put on rapid web-based dissemination of in-situ data (points) and their interpolation results (lines, polygons, or surface) for web clients such as Google Earth or common web-browsers. One aim of such applications is to enhance time-critical spatial decision support in crisis management.

Keywords. web-based geo-processing, standardised environmental monitoring

Introduction

Nowadays, near real-time analyses of a vast amount of sensor information is crucial for decision-support systems utilized for crisis management. Geographically oriented perspectives on such sensor data might enhance spatial temporal awareness of decision makers.

Today's technology is already capable of generating measurements of environmental phenomena that can be (pre-)filtered and quality assured. Additionally, standardized web-services are able to deliver this information in real-time by means of smart in-situ sensors [1, 2]. Distributed geo-sensor networks in combination with Geographic Information Systems (GIS) can be deployed "intelligently" to automatically generate multidimensional information beyond point measurements through web-based geo-processing routines [3, 4]. Such information could e.g. inform the general public with "live weather data" or enhance crisis management with near real-time localisation of harmful substances such as toxic gases or radioactive radiation.

In order to demonstrate how such technology can be used to assist time-critical decision support, we developed two web applications for near real-time geo-analyses of environmental sensor measurements. In contrast to previous research, we integrate these measurements directly into GIS. We show "live" interpolation results of temperature and gamma radiation dose rate measurements. The utilization of standardized services enables the seamless integration of these measurements and their analysis results into a variety of other systems including widely accepted visualization clients such as Google Earth.

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1. **Methodology**

Environmental measurements are usually available in a variety of well-established but mostly heterogeneous, and thus incompatible, systems. Recent standardization efforts tackle this problem and enhance data accessibility and integration. We, therefore, follow the 'live geography' approach [1] which fulfils the needs for environmental monitoring almost perfectly in terms of interoperability. Up-to-date environmental in-situ sensor measurements are requested from accurately calibrated weather stations and highly mobile intelligent sensor pods (see [5] for a detailed description) using Open Geospatial Consortium (OGC) Sensor Observation Service (SOS). In order to integrate these measurements in real-time into GIS, we developed a SOS plug-in for ESRI ArcGIS which we utilize as a geo-processing engine. As a result, spatio-temporal data (e.g. temperature) provided via SOS are directly integrated into the (geo-)processing workflow. In-situ sensor measurements and their geo-processed results, i.e. interpolation, are then published as standardized web-services. Client-side usability includes easily interpretable visualization of interpolation results. Thus, emphasis has been put on simple user interface design and the use of widely accepted visualization clients (e.g. Google Earth).

2. **Results**

Figure 1 illustrates 'live' Kriging interpolation results – elevation corrected – of temperature measurements from fixed weather stations within a mountainous region. Two selected clients are shown herein, ArcGIS Explorer (left) and Google Earth (right).

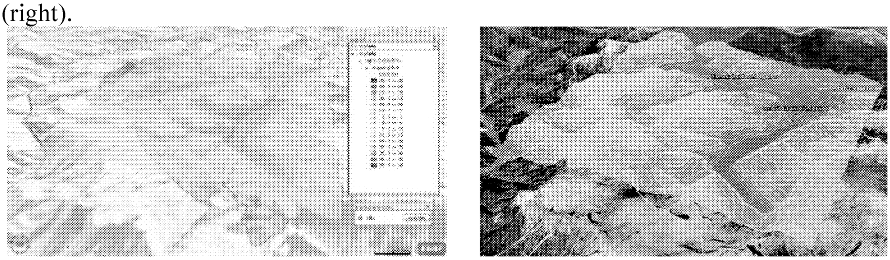

Figure 1**:** web-based 'live' Kriging interpolation of temperature measurements (elevation corrected)

Figure 2 shows Inverse Distance Weighting (left) and Kriging (right) interpolation results of gamma radiation dose rate measurements obtained from 'intelligent' sensor pods mentioned above. During a radiation safety exercise, two scenarios have been conducted: placement of one (Figure 2 left), and two radiation sources (Figure 2 right).

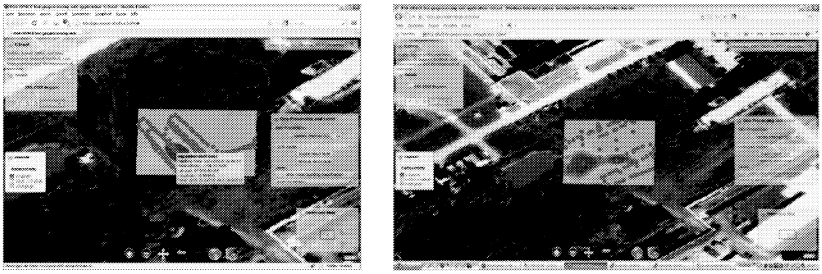

Figure 2: tailored web-application: 'live' spatial interpolation of radiation dose rate measurements (points)

3. Discussion and Conclusion

This paper illustrates web-based geo-analysis of sensor measurements in near real-time. Two selected applications served as examples to highlight the added value of using web-based geo-processing routines, in particular spatial interpolation methods.

Temperature measurements and their interpolation results shown in Figure underline the flexibility of visualisation on different clients. It also demonstrates the use of rather complex underlying models which integrate also legacy geodata, for example Digital Elevation Models for elevation correction of temperature measurements.

Geo-analyses results shown in Figure 2 have been captured in the course of the G2real project[2] exercise 'shining garden', which is described in detail in [6]. In the first case, as shown in Figure 2 left, the radiation source is clearly identifiable based on the spatial interpolation result. In the second case, two radiation sources were placed and subsequently precisely localised as shown in Figure 2 right. The results have been evaluated by domain experts and show that this near real-time approach can enhance time-critical decision making.

We conclude that standardized services enable an easy and direct integration of sensor measurements and their interpolation results into a variety of internet-based clients, in particular for visualisation purposes. The rapid web-based dissemination of geo-processing and geo-analyses results improve, depending of the application specific context, spatial awareness for the environmental phenomenon of interest. Monitoring the current state of the environment is an important component for various applications and domains, for example public information platforms and time-critical spatial decision support.

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[2] http://www.g2real.eu

References

[1] B. Resch, M. Mittlboeck, F. Girardin, R. Britter, and C. Ratti, Live Geography – Embedded Sensing for Standardised Urban Environmental Monitoring, *International Journal on Advances in Systems and Measurements,* **2** (2009), pp. 156-167.

[2] J. K. Hart and K. Martinez, Environmental Sensor Networks: A revolution in the earth system science?, *Earth-Science Reviews,* **78** (2006), pp. 177-191.

[3] A. Friis-Christensen, R. Lucchi, M. Lutz, and N. Ostländer, Service chaining architectures for applications implementing distributed geographic information processing, *International Journal of Geographical Information Science,* **23** (2009), pp. 561 - 580.

[4] S. Ninsawat, V. Raghavan, and S. Masumoto, Integration of Web Processing Service and Sensor Observation Service for distributed geoprocessing using real-time data, *Geoinformatics,* **13** (2008).

[5] B. Resch, M. Mittlboeck, and M. Lippautz, Pervasive Monitoring—An Intelligent Sensor Pod Approach for Standardised Measurement Infrastructures, *Sensors,* **10** (2010), pp. 11440-11467.

[6] G. Sagl, M. Lippautz, B. Resch, and M. Mittlboeck, Near Real-Time Geo-Analyses for Emergency Support: An Radiation Safety Exercise, in *14th AGILE International Conference on Geographic Information Science*, Utrecht, The Netherlands, in press, p. pending.