SensorWebBike: a participatory urban sensing for air quality monitoring

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Introduction

Sustainable development and effective environmental policies are key to ensuring public safety and health. People feel safer in their cities when national and local government are clearly committed to a better environmental governance, building public trust and transparency. Urban environmental monitoring is a driving force to set up continuous information services and applications to improve the day-to-day lives of individuals and communities.

Atmospheric pollutant concentration assessment based on emission and dispersion models, weather and traffic conditions, requires integration of observed data at different spatiotemporal scales to better respond to the growing demand for finer-grained information on the urban environment.

ICT (Information Communication Technology) innovations are extending the data sources available, allowing local and national spatial data infrastructures to be positively integrated by a participatory involvement of different stakeholders, including citizens.

Furthermore the web 2.0 revolution and the new paradigm for accomplishing large-scale sensing, known in the literature as *participatory sensing*[1], is transforming information production, distribution and consumption models, with citizens/individuals being key players generating content and data.

In the last few years, from being a distributed problem-solving model[2], and regardless of any cliché in global talks and chattering, crowdsourcing has become a new "practice" involving both every-day life and science.

Citizens contributions are an opportunity[3] that the scientific community is becoming aware of, and the challenge is now to integrate the user-generated content within a wider framework of validation and reliability[4].

Objectives

This paper presents the SensorWebBike, a Geospatial Information Infrastructure designed to support a participative sensing approach for urban environmental monitoring. Bikers become voluntary citizen-sensors who measure environmental parameters, by means of a small sensor box - an innovative low-cost mobile device - mounted on their bikes.

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The main goal of this research is to investigate the technical methods with which a research centre's Open Geospatial Information Infrastructure can integrate and process data from voluntary bikers in real-time to provide reliable data, information and knowledge on urban pollution.
The overall aim is to share participatory monitoring tools and services that could improve the scientific understanding of monitored spatial phenomena, which cannot be fully detected by static air quality and meteorological stations; real-time participatory sensing could also represent an alternative to data inferred from models.

SensorWebBike architecture
SensorWebBike architecture and functions have been designed to create a participatory environmental monitoring system where the data collected with innovative low-cost and open source mobile sensor devices are processed and published using OGC (Open Geospatial Consortium) services and geospatial data standards.
The components are organized in typical client-server architecture and interact from the sensing process to the representation of the results to the end-users.
The SensorBikes, equipped with Arduino electronics platform and low-cost sensors, can collect environmental data (CO_2, atmospheric pollutants, noise, humidity and temperature) and relay them to the data server through GPRS connection.
A specific ETL (Extract Transform Load) procedure has been developed using Java programming language. It works as web service callback and reads all participatory sensing data, performs a data quality check on Arduino devices and stores them in the urban GeoDB.
Using PostGIS functions, the geographic information is transformed from NMEA RMC standard into point elements for PostgreSQL. UML (Unified Modeling Language) as formal language adopted in the ISO TC/211 (http://www.isotc211.org) context for geomatic data description has been used for formal data model definition.
The Web Application named "Urban Climate" views all data stored in Urban GeoDB in real-time. The "Urban Climate" interface and functions have been developed using J2EE technology with Java Server Faces and PrimeFaces library for GUI (Graphic User Interface) customization.
Through common web or mobile browsers all the collected data are visualized in table or chart format, or tracks and spot values on a Google mashup. Interface functions allow to export data and visualize metadata. Advanced user-friendly data analysis tools are under development to better fit individual or community-scale information needs on urban pollutant concentrations.

Results and conclusions
The prototype has been tested in the city of Florence, and is online at [http://149.139.16.20:8080/bikeclimate/]; the geotagged measurements, bike tracks and user-generated meta-data are visualized on a city map, contributing to build a comprehensive and constantly updated spatial representation of air quality in the whole urban area. Furthermore the web application becomes an open data platform to share and reuse spatial data for different applications and community benefits.
SensorWebBike opens urban monitoring systems and data to the public, "augmenting" urban social interactions to increase citizens' awareness on air quality issues, and helping to create city "intelligence data spots".