Future fusion of VGI and sensor-based information sources

Błażej Ciepłuch and Peter Mooney

Department of Computer Science, National University of Ireland Maynooth,
Maynooth,Co. Kildare. Ireland.
email b.ciepluch@cs.nuim.ie, peter.mooney@nuim.ie
Tel: 353 (1) 2680100, Fax: 353 (1) 2680199

ABSTRACT: VGI is not restricted to spatial data which has been explicitly collected by citizens and contributed to OSM or similar projects. Through the use of sensors, sometimes paired with mobile phones, citizens are empowered to participate in collecting and sharing measurements of their everyday environment that matter to them. In this paper we summarise our proposal for a model for the integration of sensor and non-sensor based information where data from these sources are linked to VGI projects such as OpenStreetMap and GeoNames.

KEYWORDS: OpenStreetMap, Quality, Web GIS, VGI

1. Introduction

Goodchild (2007) presents the vision of the potential of "six billion citizens" sensing their environment. Goodchild's vision does not necessarily mean that all of the worlds citizens will be collection geospatial data specifically for the purposes of contribution to some geospatial database (such as OpenStreetMap). The vision is not restricted to spatial data which has been explicitly collected by citizens and contributed to OSM or similar projects. Through the use of sensors, sometimes paired with mobile phones, citizens are empowered to participate in collecting and sharing measurements of their everyday environment that matter to them. As Diaz et al. (2011) remarks this user-generated content is growing at unprecedented rates. In this paper we present a unified model of VGI (Volunteered Geographic Information) data collection, management, access, and visualisation from fixed and mobile sensors as presented in Figure 1. We have created a high-level organisation of potential sources of VGI from fixed and mobile sensors. We classify sensors into four groups: fixed autonomous sensors, mobile autonomous sensors, fixed user operated sensors, and mobile user operated sensors. Our unified model is restricted to individual sensors rather than large networks of sensors deployed over a large geographical area. At the top of Figure 1 the temporal axis indicates the rate of data capture of these sensors. Capture rates can range from: every *x* seconds (for example ODBII, electricity metering and power consumption), minutes (geocoded photographs, Twitter feeds), hourly (air quality measurement, humidity, etc), or daily (GPS loggers, geocoded photographs, UAV captured aerial imagery). The bottom of Figure 1 shows the means by which other applications and researchers can access the information produced by the sensors. In the next section we will outline examples of each class of sensors.

2. Sensors as a future source of VGI

Goodchild (2007) states that if VGI can attract the attention of citizens than it is very feasible that they will contribute to VGI projects. Elwood (2008) describe how and why citizens contribute to VGI projects like OpenStreetMap. We feel that it is very likely that in near future citizens will voluntarily contribute not only their GPX lines from data loggers and smart-phones or geocoded photographs but VGI in a much broader sense. This data and information will be generated by a broad range of devices with and without our personal involvement. In some cases the human role will only be to sometimes assist (accept or refuse permission, accept security protocols, etc) for sending the sensed data and information to some server on the Internet. In the next four sections we briefly outlined examples from each of the sensor classes in Figure 1.

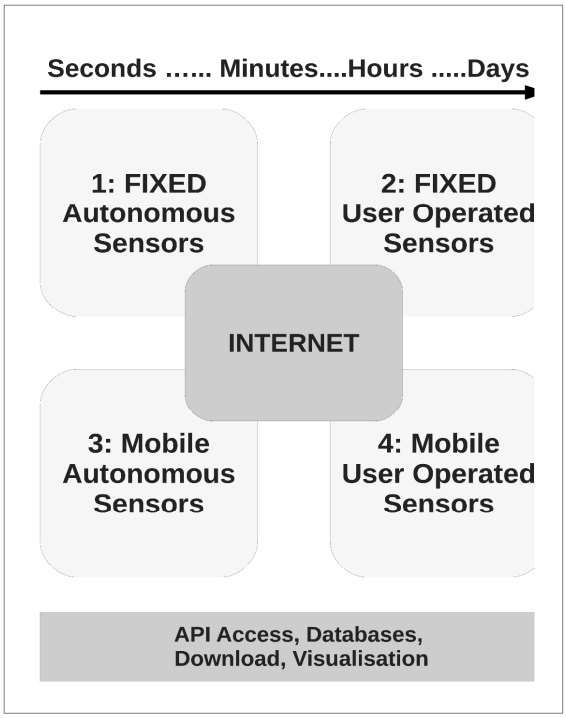

Figure 1: A unified model of VGI data collection, management, access, and visualisation from fixed and mobile sensors

2.1 Mobile User Operated Sensors

The rapid growth in mobile sensor devices today will continute as we expect the cost of these devices to drop in the future (Lin et al., 2011).

Example: Quadrocopter

A good example of a mobile sensor operated by users is the Quadrocopter based on the Paparazzi project (Paparazzi, 2011). Equipping this remote controlled helicopter with a digital camera aerial surveying of locations can be performed. Quadropter can hover on a preprogrammed path. From safety reasons it is still required to maintain radio control connection in case of an emergency situation. The landing and starting procedure need attention from the user side, even if they are executed autonomously. The price of these devices is a barrier (around 1000 Euro). As these types of devices become cheaper citizens will be able to perform surveying (subject to security and privacy conditions) and then use this data for tracing features and visualisation of temporal changes to an environment. The OSM community could benefit greatly from these sensors but will have to provide easy methods for users to upload, store and then access to the imagery.

2.2 Autonomous Mobile Sensors

Autonomous mobile sensors do not require very intense interactions from the users. In some cases they can operate without user interaction with the exception of start-up and shut-down.

Example: On-board Diagnostics

Is there potential for using data captured by On-board Diagnostics ODBII in cars as a VGI source? All the cars manufactured after 1996 in USA and 2001 in Europe are equipped in interface called ODBII which is standard for all manufacturers. This create a common way to access provided by car on-board computer. This interface is commonly used by technicians during car systems inspection. With use of this connector is possible to gather a data about the vehicle's real time parameters (engine speed, fuel consumption, environmental parameters, etc.). At the end of the journey the stored data in the ODBII system could then be contributed to a VGI project. If close to real-time contribution over the Internet was possible then ODBII could provide very useful information about a fast changing environment. Information about engine speed could provide input for analysis of real-time traffic information (Cohen et al., 2008; Li and Ouyang, 2011). Lin et al. (2009) uses ODBII for real-time monitoring of a fleet of vehicles. Data about position from GPS together with ODBII data such as speed, RPM, voltage, and temperature of engine are send to a central fleet management server. Checkoway et al. (2011)

considers the ODBII interface with in-vehicle entertainment systems with USB ports, iPods connectors, bluetooth , remote key less entry, etc. Barry and Stockton (2011) speculates that the cars of the near future will feature more additional features in terms of software rather than hardware. Authors such as Koscher et al. (2010) warn of security and privacy implications of these approaches. Storage and visualisation is the key challenge here. As Checkoway et al. (2011) speculates in the near future vehicles will be equipped with more sensors and possibility to upload our own software applications to the ODBII operating system.

2.3 Fixed Autonomous Sensors

Fixed autonomous sensors are “installed” into a fixed position and usually run completely independent of user input. These include: electricity consumption meters, humidity and temperature measurements, water flow measurements, data about the status of home appliances (water consumption, heating appliances)

Example: Power meter consumption monitoring

Electricity power meter measurements is a potentially very popular application for citizens as it has a direct connection to making financial savings. Potential benefits from storing such data in VGI systems was already noted by Godbole and Gurney (2011). An example device is manufactured by Current Cost Ltd. Their device has output ports in RS-232 allowing transmission to an Arduino device with a network card. The power consumption data can then be transmitted and stored in a database. Arduino (Arduino, 2011) is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It is intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Pachube (2011) provide an implementation of this concept with a MySQL database and different visualisations components are available for users with mapping output to Google Maps. We have implemented a demonstration of these power meters for measurement of power consumptions in the Undergraduate computing laboratories in our department. Sensed data is sent over the network to a database and then displayed on a map of the building. Power consumption, on a large scale of thousands of citizens, will require a storage environment capable of storing millions of records every day. Visualisation will have to aggregate this information into temporal clusters (morning, rush-hour, midday, etc.). Power consumption for an area could then be visualised on VGI mapping such as OSM.

2.4 Fixed Sensors operated by user

Fixed user operated autonomous sensors include sensors which are sensors installed in a fixed location but require a user to “switch-on”. The “switch on” can be performed over to web using a simple web interface or using some physical switch on a micro-controller. Data logger sensors without permanent connection to the Internet must store their captured data on-board until the user connects them to the Internet to upload their captured data.

Example: Home Entertainment System monitoring

Even your TV together with MCE PC can contribute some data to systems such like OpenStreetMap. Example for that may be a TV adapted version of Linux called Linux MCE (2011) this version of entertain system has build in function to follow a user trough rooms when he switch the place where he view his favourite TV program. TV receivers are connected to thin client terminals which are driven by server. If presence of user will be detected in another room system my simple redirect video stream to different destination. This type of functionality may be also used to generate map of area where our curious person will be able to see in real time which channels are most popular in his part of the town and also which places are use for viewing living room or kitchens. Of course data will must be anonymous in some way that we can see most popular TV programs in our estates but not in specific home that will be to big intrusion into privacy. The option to contribute or not data to VGI and also what contribute should be a part of settings in our entertain system to easy switch off if we change our mind about. Similar functionality may be implemented in washing machines that we will be able observe options in washing programs or how much water we consume in our house during washing and if we decide that we do like to reveal something we should be able. This choices maybe use by VGI systems to create a maps which will show real time but also past choices in washing programmes in our estate - town - country. Or in the same way reveal on maps how looks habits in our town related with watching TV when we look what we prefers and where we prefers to watch.

3 Conclusions and Outlook

A current realisation of our concept is Pachube (2011) which is a software platform that “connects people to devices, applications, and the Internet of Things”. As a web-based service built to manage the world’s real-time data, Pachube gives people the power to share, collaborate, and make use of information generated from the

world around them. Future VGI contributors will be very different to the current sources of information: gpx tracks, photographs, messaging, etc. We personally believe that this type of data may create totally new types of maps and mashups which will be able to visualise and answer on very basic questions like how many sinks of water is used in may town daily. This data are already captured and stored by various company's and governmental agencies but probably none has full prospect from macro-scale to micro-scale. Some of this type data are already collected by company's lets mention for example sending by some software some statistical data to manufacturer. Unfortunately they can be also gather in stealthy way lets mention Iphone location scam recently. We just think that the best way will be show in devices all the variables gathered during operation and allow him to decide what he do like to do with them store , delete or contribute to VGI. We also think that will be necessary to create some unified schematics which will allow different brands products send the data in unified form to OpenStreetMap

References

[Arduino 2011] arduino Arduino 2011. Wikipedia definition of arduino, Wikipedia Page: http://en.wikipedia.org/wiki/Arduino.

[Barry and Stockton 2011] Barry, K. Stockton, F. 2011. The future of In-Car technology - your dashboard may soon become as versatile as your laptop., *Car and Driver* (August 2011).

[Checkoway et al.]Checkoway, McCoy, Kantor, Anderson, Shacham, Savage, Koscher, Czeskis, Roesner Kohno2011Checkoway2011 Checkoway, S., McCoy, D., Kantor, B., Anderson, D., Shacham, H., Savage, S., Koscher, K., Czeskis, A., Roesner, F. Kohno, T. 2011. Comprehensive experimental analyses of automotive attack surfaces. http://www.autosec.org/pubs/cars-usenixsec2011.pdf

[Cohen et al.]Cohen, Avrahami-Bakish, Last, Kandel Kipersztok2008Cohen2008344 Cohen, L., Avrahami-Bakish, G., Last, M., Kandel, A. Kipersztok, O. 2008. Real-time data mining of non-stationary data streams from sensor networks, *Information Fusion* **9**(3): 344 – 353.

[Diaz et al.]Diaz, Granell, Gould Huerta2011Diaz2011304 Diaz, L., Granell, C., Gould, M. Huerta, J. 2011. Managing user-generated information in geospatial cyberinfrastructures, *Future Generation Computer Systems* **27**(3): 304 – 314.

[Elwood 2008] 2008 Elwood, S. 2008. Volunteered geographic information: key questions, concepts and methods to guide emerging research and practice, *GeoJournal* **72**(3-4): 133–135. From the issue entitled "Volunteered geographic information: key questions, concepts and methods to guide emerging research and practice". http://www.springerlink.com/content/a6700l9w463013g8/fulltext.pdf

[Gurney 2011 and Godbole 2011] Godbole, A. V. Gurney, K. R. 2011. The role of vgi in modeling future energy demand, *Role of Volunteered Geographic Information in Advancing Science*, Vol. 1, Department of Earth and Atmospheric Sciences, 550 Stadium Mall Drive, Purdue University, West Lafayette, IN 47906, USA. http://www.ornl.gov/sci/gist/workshops/papers/advaitgodbole.pdf

[Goodchild 2007] springerlink:10.1007—s10708-007-9111-y Goodchild, M. 2007. Citizens as sensors: the world of volunteered geography, *GeoJournal* **69**: 211–221. 10.1007/s10708-007-9111-y.

[Koscher et al.]Koscher, Czeskis, Roesner, Patel, Kohno, Checkoway, McCoy, Kantor, Anderson, Shacham Savage2010 Koscher2010 Koscher, K., Czeskis, A., Roesner, F., Patel, S., Kohno, T., Checkoway, S., McCoy, D., Kantor, B., Anderson, D., Shacham, H. Savage, S. 2010. Experimental security analysis of a modern automobile, *Proceedings of IEEE Symposium on Security and Privacy*, IEEE, Oakland. http://www.autosec.org/pubs/cars-oakland2010.pdf

[Li Ouyang 2011] Li, X. Ouyang, Y. 2011. Reliable sensor deployment for network traffic surveillance, *Transportation Research Part B: Methodological* **45**(1): 218 – 231.

[Lin et al.]Lin, Chen, Shih Chen2009Lin2009 Lin, J., Chen, S., Shih, Y. Chen, S. 2009. A study on remote On-Line diagnostic system for vehicles by integrating the technology of OBD, GPS, and 3G, **56**(56): 435. http://www.waset.org/journals/waset/v56/v56-81.pdf

[Lin et al.]Lin, Saluja Megerian2011Lin2011713 Lin, Y.-T., Saluja, K. K. Megerian, S. 2011. Adaptive cost efficient deployment strategy for homogeneous wireless camera sensors, *Ad Hoc Networks* **9**(5): 713 – 726.

[Linux MCE 2011] Linux MCE 2011. Linux MCE a open source multimedia home entertainment system with functionality of home automation, Home Page: `http://linuxmce.com/`.

[Pachube 2011] Pachube 2011. Pachube: Connecting people to devices, applications, and the internet of things, Online: `https://pachube.com/about_us`.

[Paparazzi 2011] quadrocopter Paparazzi 2011. A free and open-source hardware and software project intended to create an exceptionally powerful and versatile autopilot system for fixed-wing aircraft's, Online: `http://paparazzi.enac.fr/wiki/Main_Page`.

4 Biography

Blazej Ciepluch is a PhD student at the Department of Computer Science NUI Maynooth. His PhD is focused on the integration of sensor and non-sensor based information in an extended model of Volunteered Geographic Information (VGI) which includes OpenStreetMap as a core component. Dr. Peter Mooney is a research fellow at the Department of Computer Science NUI Maynooth. Both Blazej and Peter are funded by the Irish Environmental Protection Agency STRIVE programme (grant 2008-FS-DM-14-S4).