Ethical Challenges of participatory sensing for crisis information management

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ABSTRACT

"Participatory Sensing is an approach to data collection and interpretation in which individuals, acting alone or in groups, use their personal mobile devices and web services to systematically explore interesting aspects of their worlds ranging from health to culture."[http://www.mobilizingcs.org/about/participatory-sensing]

Data from the physical world of sensors and the virtual world of social networks and Linked Data can be combined into interesting high-level information. Sensor data can assist in localized information retrieval by giving the search engine direct access to events happening locally in the real world. Participatory sensing enables individuals and communities to collect and share granular, accurate data about a particular area. This paper describes work in progress within the FP7 EU-funded project SMART project to develop a multimedia search engine over content and information streaming from both the physical world and the Internet. We will identify some ethical problems regarding the use and storage of such data.

Keywords

Crisis information management, social search, real-time search, sensor search, ethical problems, open data, participatory sensing

INTRODUCTION

Availability of public access information over the Internet is growing exponentially. This has mobilized public, organizations and governments, which have become increasingly interested to use any available data to solve problems, generate economic activities and intervene during humanitarian crisis. In the last decade, the Internet has grown in the direction of incorporating devices that can monitor the physical world, such as cameras or sensors of various kinds. The availability of these sensors connected to networks offers the opportunity to process data from the real world and get useful information into decision-making processes.

Consider, for example, people adopting smart phones equipped with multiple sensors and connected to the Internet. Those ubiquitous digital tools are increasingly enabling individuals to collect data about the environment they live in. Those billions of ever-connected devices transmit a wealth of data like user locations, images, or motion. As regards crisis information management, in particular when facing life and death situations, the protection of vulnerable population groups and other critical issues, informed decision is preferable to uninformed decision. The SMART Search framework will enable the implementation of search services over large-scale environmental and participatory sensing infrastructures. This will allow users to get information about the environment and provide, in addition, an ambient related synthesis of related contents in real time. This data manipulation will contribute to a better situational picture.

Even though this data availability can significantly contribute to decision making, it also results to professionals facing increasingly complex ethical dilemmas, such as those arising from their multiple, sometimes conflicting, responsibilities and obligations towards states, institutions and the general public.

The rest of this paper is structured as follows: Section 2 introduces related work, section 3 participatory and environmental sensing that stems both from the SMART Project and from related work. Section 4 discusses the representation of information from sensors and social networks within SMART. Section 5 discusses social challenges introduced by the idea of collecting and harvesting data. Section 6 concludes the paper.

RELATED WORK

There are a few approaches to modeling how participatory and environmental sensing can be used in a crisis management context. Tweak the Tweet is a hashtag-based syntax to help direct Twitter communications produce more efficient data extraction for those communicating about disaster events. Use requires modifications of Tweet messages to make use of hashtags to refer to information pieces about #location, #status, #needs, #damage and several other elements of emergency communications. In this way the messages become machine-readable. VGI (Volunteered Geographic Information) Sensing is an emergent research field, which aims at designing a set of standards and techniques to streamline geo-referenced contents published online by citizens as a valuable and timely source of spatio-temporal information (Goodchild, 2007). Indeed such techniques are necessary to harness the potential of billions of sensors to monitor the state of the environment, contribute to situation awareness for crisis, validate global models with local knowledge, and provide information that only humans can capture (Elwood, 2008, Schade, Luraschi, De Longueville, Cox and Diaz 2010).

PARTICIPATORY AND ENVIRONMENTAL SENSING

Participatory sensing is the process whereby individuals and communities use evermore-capable mobile phones and cloud services to collect and analyze systematic data for use in discovery. The SMART search framework will enable the implementation of search services over large scale community environmental and participatory sensing infrastructures, which have recently attracted the interest of cities, communities and individuals. In particular, participatory sensing describes the use of individuals and communities to gather information about their environment. It usually leverages the ubiquity of smart phones as sensing devices, of cloud based services for big data analysis, resource discovery and application delivery, while anticipating the trend towards more powerful sensing and processing capabilities of mobile devices and social networking sites.

HARVESTING DATA FROM SENSORS AND SOCIAL NETWORKS

SMART aims to combine information stemming from both sensor and social networks, in order to answer sensor based queries in a more social, useful and accurate way. Indeed, information from social networks can be used to enhance the end-users' context and overall understand the context of the query in a much better way. Social networks information can be used to adapt a query for environment generated context to the end-user's daily life. The concept is quite new, but there is a mutual benefit from the convergence of both sensor networks and social networks (John Soldatos, Moez Draief, Craig Macdonald, Iadh Ounis and the SMART consortium (2012)). Social networks can benefit from the fact that human activity and intent can be directly derived from sensors, which obviates the needs for explicit use input. On the other hand, sensor societies could start their collaboration in a social way (i.e. based on information derived from social networks). However, even though the potential of integrating social networks with sensor networks has been identified, only a few applications exist thus far.

The SMART framework aims to provide an infrastructure where multimedia sensing devices in the physical world can be easily used to provide information about the status of their environments and make it available in real-time for search in combination with information from social networks.

In Figure 1 below, the architecture of the SMART framework is illustrated and four SMART layers are identified. At the top reside the sensors, either physical sensing the physical world, or virtual sensing the internet and the social networks. All these sensors retrieve data into SMART. The Data Harvesting and Correlation layer is made of edge nodes. An edge node processes local raw sensor data to produce metadata about the local environment. Those metadata are fused together via a reasoning engine and are made available through the knowledge base. The search layer collects the streams from the various edge nodes and indexes them in real-time using an efficient distributed index structure. Finally, the application layer provides a set of APIs to build custom SMART-based applications. In the next sub-sections, the Edge Node, Search and Application layers are described.

Edge Node Layer

The edge node is the local interface of SMART with the physical and virtual worlds. Each edge node can cover sensors from a single geographic area, e.g. a city block or a public square in the city. At the edge node, the signal streams, either from physical sensors (e.g. audio/visual or environmental measurements), or from social networks, are processed to extract events of interest. Edge nodes are built upon the idea of creating distributed

architectures where groups of sensors can be associated to create geographically distributed sensor networks.

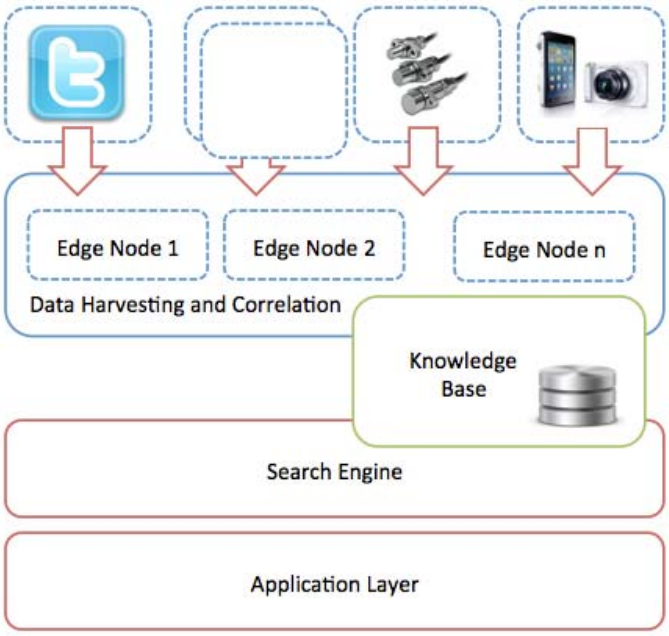

Figure 1: SMART Architecture

Search Engine Layer

The SMART search layer indexes in real-time streams of updates from the edge nodes. The search engine abstracts away the complexity of the edge node network. It is built using the Terrier open source search engine (Ounis, Amati, Plachouras, Macdonald and Lioma, 2006) with enhanced real-time indexing and a scalable distributed architecture to handle the large amount of streams. The SMART search layer offers an interface to services and end users to retrieve 'interesting' events and associated relevant posts in the social networks for a given query. While an interesting event is a subjective notion that likely depends on the application, the search layer can make inferences on interestingness, based on how unusual an event is, and learning from training examples of interesting events.

Application Layer

The last layer of the SMART platform (see Figure 1) contains the software applications that can deliver the real benefits of the framework to end users. The application layer mainly supports developers who want to create Web 2.0 services or smart phone applications that exploit the SMART framework capabilities.

POTENTIAL APPLICATIONS IN CRM

The SMART framework has many potential applications in Crisis Response and Management (CRM). As already discussed in (Jiang & McGill, 2010), knowledge generated from data coming from traditional sensing, combined with data from social network and resident participatory sensing allow for creating local and regional sensor networks that detect or prevent risks. Such kind of networks could be used to risk detection and prevention, Emergency Planning Support (EMS), during- and Post-blast Analysis.

SOCIAL CHALLENGES AND ETHICAL ISSUES IN PARTICIPATORY SENSING

There are many social issues relating to the collection and use of data from 'participatory sensing. Collecting data is a major potential source of innovation and knowledge generation, but can be invasive. The use of 'Participatory sensing' in situations of crisis management becomes an interesting case study wanting to find the boundary between decision support system and control or surveillance.

We have identified three main ethical issues concerning the collection and processing of data: privacy, consent and equity. Privacy is traditionally conceived of as*"the right to be left alone" (Warren and Brandeis 1890)*, more recently recognized as a contextual practice of negotiating boundaries (Palen & Dourish 2003). Consent is the informed permission to participate to the data collection, while equity focuses on the fairness and justice in how individuals are treated.

Privacy: SMART may gather data on locations and habits of people, but not only. Harvested data could be correlated with data coming from sensors from the real world (the environment where people live in). As a result the knowledge base could contain pervasive information revealing individuals' habits, routines, or decisions (Christin, Reinhardt, Kanhere & Hollick, 2011; Clarke, 2008; Krumm, 2007).

Equity: Accumulating and manipulating information is a form of power in a global information economy (Castells, 1999; Lievrouw & Farb 2003). Institutions can control data collections and knowledge bases. How do SMART stakeholders, clients and users decide in whose hands this power will reside?

Social forgetting: The collection of sensitive data involves, first of all, a series of problems relating to 'whether and how' the data collected should persist over time. The ability to record and correlate data from the real world and then save them indefinitely, provides a way to persist information that would otherwise be lost because of the fallibility of the human mind. This can be an intriguing source of power. The more data is collected and stored, the more we have to consider the social consequences. For example the US Law has established a set of social structures that act to help to 'forget the social', by activating a tabula rasa on issues such as: bankruptcy, credit reports, records of juvenile delinquency (Blanchette & Johnson, 2002). However, the implications of creating a persistent record of people's movements, habits, and routines are largely unexplored (Byrne & Alexander,2006, Bannon 2006).

CONCLUSIONS AND FUTURE WORK

There are many unanswered questions in the field of 'participatory sensing' and its use in crisis response and management that require a continuous exchange between development of technology and ethics. Studies should be conducted to understand how users perceive the problems of privacy, and how they use the options available to them to protect it. The SMART system harvests and correlates data from diverse sources. It would be helpful to understand whether and how the correlation of data sources can affect privacy issues. By shaping how pervasive data harvesting and correlation can be, how such systems impact on social behavior in an information society and on decision making processes in crisis situations, ethicists and engineers should be capable of taking aspects resulting from privacy into account the when designing future SMART-based networks.

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