Geosensors are extending our senses and can be defined as any device receiving and measuring environmental stimuli that can be geographically referenced.

As such they include satellite-based sensors providing multi-spectral information about the Earth’s surface (imagery, land cover, vegetation indices and so on), air-borne sensors for detailed imagery but also for laser scans of physical or man-made structures (LiDAR), and sensors near, on, or under the Earth’s surface measuring anything from physical characteristics (pressure, temperature, humidity) and phenomena (wind, rain, earthquakes), to the tracking of animals, vehicles, and people.

Geometry modeling (coordinates and topology) is equally important and included in the definition (GNSS receivers, Total Stations, High Definition Scanners). Large-scale networks of sensors have been in existence for several decades.

What is novel is the web-enablement of these sensors (having their own IP6 address) and their networks so that individual sensors can be discovered, tasked, and accessed through web standards (sensor web), and that the networks can exchange information through interoperability arrangements.

The new generation digital earth will then be boosted by the “Internet of Things” where spatial objects will be accessible by anyone through RFID, QR code or new digital tags and communicate but also where spatial objects will exchange each others and have their own social networks.

In that vision, surveyors will not only survey but also tag our environment and make spatial objects alive by connecting them to their web. Linking the virtual representation of the earth with its reality through the spatial objects or “things” will bring people to break free of any matrix.

**Key words:** geosensors, geosensing, digital earth, the Internet of Things, RFID, QR code, surveyors, GIS, Spatial objects, Spatial Data Infrastructure

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Senses and Geosensing

“I think one of the things that really separate us from the high primates is that we are tool builders. I read a study that measured the efficiency of locomotion for various species on the planet. The condor used the least energy to move a kilometre. And, humans came in with a rather unimpressive showing, about a third of the way down the list. It was not too proud a showing for the crown of creation. So, that didn’t look so good. But, then somebody at Scientific American had the insight to test the efficiency of locomotion for a man on a bicycle. And, a man on a bicycle, a human on a bicycle, blew the condor away, completely off the top of the charts. And that’s what a computer is to me. What a computer is to me is it’s the most remarkable tool that we’ve ever come up with, and it’s the equivalent of a bicycle for our minds.” Steve Jobs.

Extending our senses has been the scope of many outstanding developments at the last century. Vision has been extended by telescopes, scanner, camera, airborne sensors etc, ... Automatic target recognition has replaced the best operator's eyes and level instruments "reading" code bar made any levelling of the first order without any much effort for the operator. Sound has been used for measuring ranges (echo sounding). Stars have been replaced by artificial satellites for remote sensing and positioning. GNSS is actually taken for granted without any question about its vulnerability. But even more if satellites and signals can be obstructed or jammed, ground positioning system such Locata are already available. The list of innovation is pretty long and even if we would like to become exhaustive, there will be new sensors tomorrow based on physics that we are still ignoring today.

All these geosensors are contributing to map and survey faster and faster bringing another issue on how to handle these mega databases efficiently to recover the information and produce synthetic reports. When installed permanently, geosensors have been the building blocks of automatic acquisition systems and the basis of modern deformation monitoring systems. Permanent GNSS Reference Stations have been used to measure the plate tectonics behaviours, to forecast the weather, to model or mitigate the effect of the ionosphere and to deliver corrected observations for Network RTK rovers.

We can define such geosensors as any device receiving and measuring environmental stimuli that can be geographically referenced. As such they include satellite-based sensors providing multi-spectral information about the Earth’s surface (imagery, land cover, vegetation indices and so on), air-borne sensors for detailed imagery but also for laser scans of physical or man-made structures (LiDAR), and sensors near, on, or under the Earth’s surface measuring anything from physical characteristics (pressure, temperature, humidity) and phenomena (wind, rain, earthquakes), to the tracking of animals, vehicles, and people. Geometry (coordinates and topology) is equally important and must not be ignored in the definition (GNSS receivers, Total Stations, High Definition Scanners). Large-scale networks of sensors have been in existence for several decades.

Who is benefitting the Spatial Data Infrastructures?

A mass of observation and data have been compiled for years now into big sever databases. The GIS has evolved in spatial data infrastructures with an enormous benefit for organisations in charge of managing infrastructures and the consequence of natural induced disasters on the population. There is no question about that... Car navigation systems are now so popular that drivers consider them more important that the sound system as we are touching the fundamentals. However today we may still question ourselves about to whom a city GIS is benefitting? The technical staffs that need such tool to support their daily routines in managing assets and activities are the primary beneficiaries but not directly the street people. One of many reasons is that most GIS have been designed by technicians for technicians, not directly for the citizens.
The effective and efficient use of geospatial data to deliver services requires that the data is available when needed, wherever needed. Too often, geospatial data that can benefit the public goes unused because effective distribution policies or mechanisms are not in place. At times, cost or licensing restrictions limit data use. While restricted access to geospatial data may be appropriate in some instances – privacy or public safety are two notable cases – the public benefit will be greatest if geospatial data becomes available through a well-integrated data distribution infrastructure, supported by clear policies and well-defined organizational relationships.

When we are looking for the effective benefit to the population, the experts are often gazing as even a simple cost/benefit analysis are missing most of the times to justify the investment. Many promises about developing new applications and business cases have been made while in the reality the return of the investment is rarely for the people who are contributing by paying taxes. We are raising the question because we do believe that there is a gap to bridge and actually the Internet of Things will be the vehicle for that positive change.

A gap between the model and the reality

Street people are "goggling" now from their mobile phone and it seems that most of the GIS functions are available for anyone who is searching for a restaurant or even to find friends around. The car navigation systems and the ease to find a location using a smart phone are just showing up that there is a gap between the geo-specialists and the street people who are looking for more applications than speculations. Land management systems and cadastres are not developed necessarily to act as a platform to plug new applications. The future must be found on day today activities with a high focus on how to make any people a better life. And that is the reason why today there is a gap that will be filled by the Internet of Things.

The Internet of Things

The Internet of Things (IoT), which Wikipedia says, “refers to uniquely identifiable objects and their virtual representations in an internet like structure,” could be transformative for surveying and mapping and any intelligence activity that involves things whose location matters. The internet connection is critical, because the IoT depends on the ability of systems to:

- Communicate information about things and their locations
- Communicate information from things, including information about their locations
- Communicate instructions to things – to control sensors and machines

The small, fast, limited functionality information systems embedded in things may communicate with each other, as happens when tiny UAV's fly in formation, and the information systems may at the same time be communicating with powerful data, processing and communication resources in the cloud. The IoT is very much a “system of systems.”

‘Activity-based’ and ‘Event-based’ intelligence are terms that appear more and more frequently in intelligence discussions. These categories of intelligence invariably involve people and things whose locations matter. These people and things often need to be communicating location and location-related properties such as proximity and adjacency, area and volume, path and trajectory, spatial probability, signal strength, and line of sight, all of which also have a temporal dimension — speed, rate of change, history, etc.

The IoT has the potential to transform surveying activities too, but the surveyor's community needs to participate in IoT development if the community is to acquire the system of systems that matches community needs.
A system of systems depends on standards. Internet provides a channel for communication, but location communication requires standards — software interface and data encoding standards, and best practices — that meet requirements like those outlined above. Those requirements are only partially satisfied by current standards. Building the IoT is an international project, and progress is being made in the Open Geospatial Consortium and its many partner standards development organisations. A few in the information technology world, however, fully realise how important and cost-effective participation in these organisations can be, or how beneficial such participation is for participants.

The IoT’s rapid growth is enabled by the rapidly falling size, cost and power requirements of sensors and wireless internet connections. The growth is driven by applications. Makers of things, seeing the cheap wireless sensors, naturally begin to think in terms of embedded devices which interact with apps that connect to mobile devices via cloud computing services.

When people think of location aware devices, they immediately think of GPS devices (which are sensors), but there are other ways of sensing location. Some mobile device location systems determine location by calculating distance between a phone and nearby cell towers (using precise timing of signal latencies) or by sensing proximity to WiFi points of known location. Cell phone cameras can read QR codes affixed to buildings, buses, products or posters. Applications in logistics use RFID chips and other near field communication (NFC) approaches. Also, technology exists to match patterns in smart phones’ images of streetscapes or building interiors. As big databases of such images become available, provided by millions of users, this is likely to become a common way of determining location.

The Internet of Things is bridging the gap between the models generated by the GIS and Spatial Data Infrastructure and the geospatial objects. We will be back fast to the reality we left several decades ago by being fascinated by virtual 3D modelling and other graphical fantasy.

**Bridging the gap and paradigm shift: the animated survey**

In the past a surveyor was the expert to measure precisely the coordinates of a pool with reflector handled by his assistant that was pin pointing objects and their geometry relationship (topology).

With Automatic and Robotic Total Station, the surveyor is nowadays handling himself the survey pool to do the job himself leaving the instrument alone. The bottle neck of handling all the information has been overcome with the use of tablet computers on the field with onboard graphical and processing software to avoid miss-modelling and achieve the level of completeness requested.

Generally nothing has much change and since centuries, the surveyors are leaving no marks on the field except the case of boundaries delimitation and survey marks.

The paradigm shift suggested is that the surveyors will tag the objects surveyed and will leave the identification linked up with a hyper link to a GIS system. And of course at the first approach some tags (control survey tags) will be used to retrieve the coordinates on the field and provide support for precise location.

RFID tag has been the first device we were thinking to use in our research. Distance can be a limitation that can also be overcome by the use of active RFID tags.

QR code can be read by any smart phone to get access to the static information or to a hyperlink. We may argue that actually we have to be pretty closed to the QR code to get the image scanned properly but that is exactly here the telescope of an imaging type total station can to nicely the job. And by no way there has been a restriction to the size of the QR code. We can well imagine that the surface of such QR code can be retro-reflective to support electronic distance measurement.
precisely and even that the automatic target recognition system will be able to detect the centre of the QR code pattern to align automatically the telescope precisely. QR code can also be read by UAV camera and be used during the processing as fiducially marks. The geotags will make the geospatial objects beating and will be the way to bridge the gap created by too much virtual representation and the reality.

**Use cases**

**Positioning Infrastructure:** The first use case is a direct application for surveyors. In urban environment where GNSS will hardly supply the signals for a precise location due to the lack of decent geometry (GDOP), we may well think back to setup a dense control survey network consisting of geotags placed on the facade of the buildings for instance that will be used to assist location of the Total Station (free stationing). These tags will extend the Positioning Infrastructure that has been defined first to give a generic name to the various types of GNSS Network (Active Geodetic Network). Because of the Internet of Things, the coordinates and other related information (accuracy, reliability, update and version) will be updated directly when needed.

**Blind people:** they are people who cannot see the world as we can as they are blind. However they have outstanding developed senses and we know extra-ordinary musicians to cite an example. However they can hardly move alone and they are using white stick to prevent obstacle in their journey. We can imagine to place RFID tags along the roads or in high risk areas for them and have their white stick with RFID reader transmitting location position by digital voice or pulses.

**Using radio frequency identification (RFID) tags is a new way of giving location information to users. Due to its passive communication circuit, RFID tags can be embedded almost anywhere without an energy source. The tags stores location information and give it to any reader that is within a proximity range which can be up to 10-15 meters for UHF RFID systems. We propose an RFID-based system for navigation in a building for blind people or visually impaired. The system relies on the location information on the tag, a user destination, and a routing server where the shortest route from the user current location to the destination. The navigation device communicates with the routing server using GPRS networks. (A blind navigation system using RFID for indoor environments in IEEE by Chumkamon, S.; Dept. of Electr. Eng., King Mongkut's Univ. of Technol. North Bangkok, Bangkok ; Tuvaphanthaphiphat, P. ; Keerattiwintakorn, P.)

The European Union has supported SESAMONET a similar project … Now we can extrapolate the concept for non blind people and get the RFID reader even in the shoes like NIKE did for an other purpose. Fashion company WeSC has come up with a concept that could see social interactions powered by an RFID tag embedded in your shoe. The result is somewhere between Foursquare and Nike Plus. WeSC's KarmaTech concept, designed by students at digital media school Hyper Island, sees RFID used for linking the real world with social media. By placing an RFID tag into each WeSC shoe (or any shoe for that matter), you can create a network of people that could have access to their social networking services, as well as special location-based deals and services.

**Intelligent doors:** that use case has been given by a Chinese mother who was carrying about their home security. When his kid is coming from the school it would be possible that the door recognise him and let him enter, while for unidentified people the door will even issue an alarm signal. On the other side, the door will compile the entire friend visit and will be able to welcome them. Intelligent doors will need location too. Already many hotel rooms door are equipped with RFID reader but the idea here is to extent the system for private housing and to relay much more information. Doors within a building can also be part of a social doors network and have adaptive behaviours based on a knowledge database!
Friend with tree: Can a tree become your friend? That's a true story based in a test case in Brussels where a tree has been equipped with various sensors connected to a server that is synthesizing all the signals into simple talks. The tree has a Facebook profile and you can request to become its friend. In Putuo Shan Island there are many beautiful trees and most of them are maintained by benevolent people who got their name attached to the tree. Everyone who wants to join them to become friend with the tree can call the mobile number indicated. The Internet of Things is just the way to go smoothly at an upper level of intimacy with the tree. In Australia, a company developed tree motion sensor system using tilt meter, GPS for location and an electronic compass to give directional information. We can add biological sensors to get a health status of the tree. Brussels city has inventoried more than 900 remarkable trees. Trees will have their own social network and will start to share information to each other and may be experiences and health status.

Self Mapping: In an area where lot of geotags are available and located precisely, a user can trig the geotags to get immediately all the coordinates into an application that will rebuild the digital map around him.

We can easily see through these use cases that positioning sensors and geosensors will become the main business in the coming years and the surveyors will have to consider that markets as well or they will seriously be impacted by other people who will take over their traditional missions. Another learning is that small tags such RFID and QR Code will become soon the new survey marks and will constitute an enhanced positioning infrastructure (ePositioning Infrastructure)

Prospective

The surveyors will have to look for gaining a new role and a new mission: to place, survey and feed geotags with geo-information to allow street people and specialists to update the information related to the geospatial objects while real time GIS will take advantage of the updates and will manage the distribution and knowledge to others.

Who else than surveyors would be the ideal professional category to handle that task? Is that a revolution for the surveyors? Not really if we remember that prior any survey, these professionals are asking around local people for information to get a full picture of the survey context. Most at the time, people are bringing souvenirs, stories and eventually past conflicts that have been the reason of a change in the boundaries etc... The paradigm shift is that all the professional practices will be boosted back to the state of art of surveying with the Internet of Things.

The huge benefit of that approach is that progressively the society addicted to social networks and virtual relationships will get back on the reality and even more closed to their environment. At that stage of our investigation, words are missing to describe the fundamental change and the benefit to the society but every one can feel how much impact it will be on creating new jobs, new industry and new business.

Conclusion

Geosensing the world is going to be an every one task motivated by the new kind of relationship between people, between people and objects and between objects.

Of course there will still need development and especially concerning the security in the transactions with the objects and how objects can have a reliable exchange of information. Standards and other conceptual refinements will be need for sure but the exciting situation is that the implementation can start overnight adopting an iterative and heuristic progress.

More deeply, giving every spatial object a "soul" and to get them animated is also the better way to build a harmonious society where people will be more keen to respect their environment. Last not
least, even lost in the middle of a big city or in a shopping mall, nobody will stay alone anymore longer than today.

We do hope that our reflexion will be relayed by the professional organisations such the FIG to take over that initiative and be on the driver seat. The Internet of Things and of geospatial objects is a fantastic new opportunity to re-think the role and the mission of the surveyors. Geotagging will be the new act and the industry will have to consider new type of devices and improvement in the total station technology. At least again we will see some new functionality than only improvement on performances and accessories.

We would like to conclude by citing Abbas Rajabifard from the University of Melbourne, Australia “The ability of society to meet sustainable development objectives is a complex and temporal process involving multiple stakeholders. This can be facilitated through the development of a spatially enabled society, where location and spatial information are regarded as common goods made available to citizens and businesses to encourage creativity and product development. This requires data and services to be accessible and accurate, well-maintained and sufficiently reliable for use by the majority of society which is not spatially aware.”

References


[2] Spatial Data Infrastructure (SDI) - A Symbol of Confidence and Trust. Tuesday, October 5th 2010 By John Moeller


[4] The Internet of Things by Wikkipedia.org


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