POSSIBILITIES OF USING RADIO FREQUENCY IDENTIFICATION (RFID) FOR DISASTER MANGEMENT

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SUMMARY

The purpose of this paper is to investigate the use of contemporary geosensors such as RFID for disaster management. First of all, a classification and description of the nature of disasters is given following by a brief discussion of the basics and operational principle of RFID. Finally, it is identified that RFID in stand-alone mode or in conjunction with other sensors is a suitable technology.

Key words: natural and man-made disasters, contemporary sensors, geosensors, RFID, GIS, Web-GIS.

NATURE AND CLASSIFICATION OF DISASTERS

Following Doukas and Retscher (2011) there are several definitions of the terms disaster, hazard, risk, emergency, and crisis with a certain degree of synonymity among them. The United Nations defines a disaster as:

> *A disaster is a serious disruption of the functioning of a community or a society causing widespread human, material, economic and environmental losses which exceed the ability of the affected community/society to cope using its own resources.*

Disaster is a term which has its direct roots from an ancient Greek word which has a clearly astrological base, originally meant an unlucky constellation (or combination of positions) of the stars. The term disaster implied that a bad event or severe misfortune was going to happen when specific stars, due their temporal position, form a malevolent constellation (also referred to as malefic constellation; an expression that was used by old

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generations of astrologers). Nowadays, a disaster is termed as the impact of natural or man-made (or a combination of both) hazards that negatively affect society or environment. Disasters may be classified into two main general categories which are (a) man-made (e.g. hazardous materials, social-sociological, technological, transportation) and (b) natural (e.g. astronomical-cosmic, biological, geological, meteorological-weather) (see Doukas and Retscher, 2011). The two main categories can have up to eight sub-categories where a good number of them belong to more than one category understandably. A flood or a sea-level change, for instance, plausibly belong both to geological and meteorological categories. Furthermore, a mine fire could have either technological or geological causes and so on. For any kind of disaster, there is a lifecycle consisting of five phases, i.e., response, recovery, mitigation, prevention, and preparedness. This lifecycle is called Emergency Management and Disaster (Crisis) Risk Management Cycle (DRMC). A fundamentally substantial tool to cover and support the DRMC is GIS, especially Web-GIS. Disasters will always happen, this is an axiom. Hence, a double target exists, namely the minimization of (a) human losses and (b) consequences to the natural and built environment (Grigoriadis, 2008).

A comprehensive literature review and discussion of the classification of disasters can be found in Doukas and Retscher (2011). In their paper the have mainly concentrated on the pertinence of earthquakes and their consequences. After a description of the basics and operation principle of the RFID technology the possibilities of the use of this technology in disaster management and monitoring is briefly discussed in the following sections.

FUNDAMENTALS OF THE RFID TECHNOLOGY

The RFID technique was originally designed as a contactless and low energy consumption device for automatic identification of objects. The application of this technique has been predominantly in logistic industries for transferring object identification to monitoring sensors. The major applications also reflect the extension of the use of RFID from a stand-alone identification system to tracking and positioning. The advantages of using RFID in indoor/outdoor personal positioning include the simplicity of the system, low-cost of the device, high portability, ease of maintenance, long effective range, and the use of radio frequency signals which have the capability of penetrating obstacles. Active and passive tags can be distinguished where the second one have practical reading ranges of up to several meters depending on the radio frequency used whereas long-range active tags can have reading ranges up to several hundreds of meters. In general, two specific positioning strategies are possible. The first scenario is that RFID readers are installed at specific locations or waypoints in the area of interest. The person or object to be positioned is equipped with an RFID tag and can be located in a certain section between two different waypoints. The second scenario is a reverse approach. Here tags are mounted at certain known locations of interest (so-called active landmarks) and the mobile user is equipped with a reader. The tag's ID and additional information (e.g. the 3-D coordinates of the tag) can be retrieved in the given read range if the user passes by. Note, the second scenario usually is less expensive than the first as a low-cost tags are installed at known locations instead of more expensive readers. The location of the user can then be determined using different methods such as cell-based or lateration and fingerprinting. For a detailed discussion of these localization techniques the interested reader is referred to Retscher et al. (2012).

TOOLS AND TECHNIQUES FOR DISASTER MANAGEMENT

For GIS dedicated to disaster management systems, permanent and mobile monitoring units are essential in order to acquire data. Regarding their collection, management, processing, analysis, assessment and delivery current technological achievements vitally affect everything that relates to real-time geospatial data. A suitable tool are distributed geosensor networks which are responsible for an extremely powerful boost to the GIS status and its traditional philosophy of being static and centralized (Nittel et al., 2008). Geosensors can be defined as any device receiving and measuring environmental parameters that can be geographically referenced. Geosensors can be categorized in:

1. satellite-based sensors providing multi-spectral information about the Earth's surface;
2. air-borne sensors for detailed imagery but also for laser scans (LiDAR) of physical or man-made structures; and
3. near, on, or under the Earth's surface sensors measuring anything from physical characteristics (e.g. pressure, temperature, humidity, sound, pollutants) and phenomena (i.e., wind, rain, earthquakes) to the tracking of living beings, vehicles, etc. (Craglia et al., 2008).

From another relative point of view, geosensors could also be wearable, ambient and remote. Generally speaking, a geosensor network is a sensor network that monitors phenomena in geographic space where the collection of both temporally and spatially high-resolution, up-to-date data is supported, even for broad geographic areas. Such sensors could be mobile or static and furthermore they are able to passively collect information about the environment or, eventually, to actively influence it (see Doukas and Retscher, 2011). Geographic space can range in scale from the confined environment of a room to the highly complex dynamics of an ecosystem region. Nodes in the network are static or mobile, or attached to mobile objects (e.g. on cars, tracks, buses) or used by humans (e.g. smartphones or other mobile device). A Wireless Sensor Network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions. Such networks cooperatively pass their data through the network to a main location. Modern networks are usually bi-directional enabling also to control the activity of the sensors (see Roemer and Mattern, 2004). Nowadays, such networks are used in a wide variety of industrial, engineering and consumer applications, to name a few for instance, in monitoring industrial processes, machine health, environment and habitat, ocean and coastal regions, as well as precision agriculture and fisheries, health-care applications, surveillance and battlefield situations, home automation and traffic control (Doukas and Retscher, 2011).

Where GNSS signals are blocked, indoor positioning system technology can be used to more precisely track locations. After an earthquake strikes the built environment, for instance, it is vital that residents help to retrieve location information for efficient search and rescue operations. This location information should include the information about the neighbourhood (e.g. transportation plan of the area, usage type of buildings), buildings within the neighbourhood (e.g. layout plans, contents of buildings and number of residents) and their residents (e.g. personal and health information) (Avdan et al., 2010). Contemporary disciplines, technologies, services and IT tools are required in this wide field concerning applications to disaster management. This field includes signals such as radio, ultrasound and infrared, RTLS, LBS, RFID, cloud computing, networks (wireless, sensor), sensor-Web, Micro-Electro-Mechanical-Systems (MEMS), Micro-Opto-Electro-Mechanical Systems (MOEMS), Nano-Electro-Mechanical Systems (NEMS), etc. The default need and demand is that all these sensors must be plugged-in into a Web environment considering the knowledge of each sensor's capabilities and precision. Their connection to the Web challenges specific needs for them, such as metadata registration, capability for reporting position, remotely readability, controllability of systems, observations, processes as well as and accessibility of all parameters. Doukas and Retscher (2011) have discussed these aspects in more detail.

DISCUSSION OF THE USEABILITY OF RFID

In the opinion of the authors the RFID technology is predistinated to serve as a location system in a disaster. In this context most suitable is the second localization strategy described above. In an emergency situation passive RFID tags may be placed at certain locations in the affected area serving as active landmarks. Imagine, in the case of a fire in a building the firefigther could place RFID tags at certain crossings in the building which can help then to guide him away from the affected site. In addition, the tags can serve as identification marks. In this case, for instance, tags are placed at doors of rooms which have already been checked by the firefighter and where no people to be rescued are anymore. Hence, RFID is a multi-purpose technology and its application fields are nearly unlimited in disaster management and other emergency situations. This technique can serve as a guidance and localization system as introduced and discussed in this contribution. RFID can also be employed together with other techniques which complement and support each other.

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