Trends in the Applications of GeoICT in Disaster Management

Rifaat Abdalla

Department of Hydrographic Surveying, Faculty of Maritime Studies, King Abdulaziz University, Jeddah, rmbdalla@kau.edu.sa

Abstract

Substantial work has been done by Geospatial Information and Communications Technology (GeoICT) and Disaster Management communities to evaluate and develop tools and applications that integrate the complex inter-relationships that are required for adequate preparedness, planning, mitigation, response, and recovery from extreme situations. GeoICT technologies have contributed and are contributing to saving life and property throughout the globe. Over the past decade, extensive research has resulted in more advanced GeoICT technologies. This has helped to maximize the demand for these tools, with a noticeable pattern of adoption and expanding user community. This paper will provide an overview of selected rising stars in GeoICT technology and their applications in Disaster Management. This discussion will evaluate the trends in technology development, with emphasis on data collection, processing, and visualization.

Keywords:
GeoICT, Disaster Management, Scenario Development, Stakeholders, Decision-making.

1- Introduction

The concept of GeoICT attempts to utilize telecommunications technologies to link between various geospatial technologies including GIS, Remote Sensing, GPS, Photogrammetry, Computing, the Internet, Databases and Visualization Systems. As the name stands, it integrates various domains of knowledge that require specific skills and abilities to synthesize and integrate. Over the past decades, extensive research on utilizing GIS has resulted in many new technologies. The developing use and request of these technologies have vigorously endorsed the way that GIS and other integrating spatial technologies attempt to find ways and means to determine incongruence and heterogeneity of information from numerous sources, specifically for disaster management. In this way, the integration of different geospatial technologies, supported by advanced ICT infrastructure is one of a kind technology-based approach for securing straightforward and useful information access over various platforms, specifically for disaster management applications. This has made GeoICT integration and to some extent, its
interoperability, as a focal innovative work activity. This convenience of interoperaing GIS-based spatial technologies remains exceedingly requested with the end goal for us to have a viable framework which will inevitably rely on upon how well we are set up to handle different circumstances (Longley, Goodchild et al. 2005).

Natural Disasters are among humanity's most costly, deadliest and dreaded occasions (Blaikie and et.al. 1994). Jie, Jian-hua et al. (2001) have characterized Natural Disasters as an occasion that has an enormous effect on the general public. Despite what might be expected, there is no solid definition for Natural Disasters, as the recognition and elucidation differ with the perspective between the audiences. For example disaster or emergency, perception varies between social scientists; natural scientists and information technologists, each of them have a particular field of interest and a special recognition to disasters. Despite that, the standard issue to all catastrophes scenarios is that: disasters leave behind many killed, many injured and significant economic loss.

Disaster Management is an applied science which attempts to use systematic observation (Cutter 2003), monitoring and analysis of environmental parameters to reduce or eliminate the loss that might occur. However, monitoring and analysis of environmental parameters for the purpose of disaster management are not easy to be documented in a flow chart, since disasters are nonlinear processes (Abdalla, Tao et al. 2007). At any rate, the disagreement situation about the definition of tragedy has certainly reflected no agreement in the ways that disasters are managed. What are agreed upon are the phases of disasters management cycle, which are: mitigation, preparedness, recovery and response as shown in Figure “1”.

![Figure 1 Showing disaster management cycle](image)

Goodchild, (2006) indicated that Geospatial Technologies support a cost-effective means for spatial data acquisition, processing, and presentation, for the application of emergency...
management. Nevertheless, planning a Geospatial Information application requires an in-depth, detailed information and analysis of the constituents of the event, be it disaster management or emergency situation, under each of the mentioned stages.

Methodology

The method for conducting this work involved three major phases. The first phase focused on reviewing the state-of-the-art in the development of GeoICT systems. This has been investigated from acquisition systems perspective, processing systems perspective and presentation and visualization systems perspective. The second phase of the study involved reviewing the recent literature in disaster management policies and procedures, with a focus on issues related to stakeholders’ involvement and decision-support through geospatial technologies in general and GeoICT specifically. The last phase of the methodology focused on the analysis of application scenarios, where geospatial technologies were effective in addressing issues related to saving life and property when an emergency strike. Figure 2 is showing the research methodology adopted in this paper.

![Figure 2: Research Methodology](image)

2- Discussion of Technology Trends

Current geospatial technologies have significantly evolved to provide geodata and geoprocessing such as routing and geocoding. With the emergence of advanced, sophisticated technologies such as sensor webs, Internet of Things (IoT) and advanced web mapping protocols that are being used every day, such as Google Maps. As a result, many new platforms are integrated using advanced telecommunications protocols and infrastructure. As such, a significant number of applications have been rapidly developed. This section will discuss these developments from
GeoICT integration perspective, for the purpose of data acquisition, processing, and presentation. It will specifically address the user interest in these technologies and what are the capabilities provided by each of the researched themes.

**a. Data Acquisition Systems**

Geospatial information coordination is the procedure that includes gathering information from various sources at different accumulation modes and bringing these data together in a sizeable database to give a bound together environment to preparing, displaying and perception.

**i. Lidar**

LIDAR is a surveying technique that measures the distance of an object known as a target, by sending laser pulses to hit the target and return to the transmitter. The name LIDAR, some of the time considered an acronym for Light Detection And Ranging. Sometimes Light Imaging, Detection, And Ranging), was initially a blend of light and radar. Lidar is prevalently used to make high-determination maps, with applications. Lidar here and there is called laser filtering and 3D checking; with earthbound, airborne, and portable applications the airborne LIDAR Bathymetric technological framework includes the estimation of time of flight of a flag from a source to its arrival to the sensor (Goodwin, Coops et al. 2009). According to Lin, Hyyppa et al. (2011) UAVs are currently being utilized with laser scanners, and also other remote sensors, as a more conservative strategy to filter littler territories.

**ii. UAVs/AUVs**

UAVs are additionally generally known as "drones" are a little to medium size flying machines are automatically fly, without human pilots’ association. The majority of UAVs are remotely guided (Samad, Kamarulzaman et al. 2013). They are checked and worked from ground stations that give full insights about the UAV flying data, including flying way, height, information accumulation and time stamping different information items got from the UAV, which is recorded installed and additionally transmitted to the ground control station. In any case, there is another kind of UAV which is known as self-governing UAV (Guoqing and Deyan 2007). This type is entirely programmed framework, and it is limitedly utilized as a part of non-military personnel applications, because of security concern connected with permitting such sort of frameworks Figure 3 demonstrate a specimen mission is arranging programming inscription.
Autonomous Underwater Vehicles (AUVs) are automated frameworks that are equipped for performing particular undertakings submerged, utilizing their outline and their application (Wernli 2002). AUVs are the improvement of the long referred to marine information gathering innovation known as Remotely Operated Vehicles (ROVs), where is non-independent control over the ROV and it is associated with a link to the base station locally available a vessels, where it sends information and get directions over wired correspondence conventions. In particular, they can plunge, float or skim in shallow or deep water, completely autonomous of any human steering or control. Carreño, Wilson et al. (2010) Indicated that AUVs advancements have reformed the path in which hydrographic looking over is directed and the methods for delivering hydrographic information items, for example, profundity soundings and sweep symbolisms of the ocean depths. They are utilized as a part of complex applications for observing, upkeep, and the establishment of submerged framework, for example, media transmission links and also submerged oil and gas pipelines, the typical citizen area. Figure 4 is showing an image for AUV system.

Figure 3 different UAV Systems

Figure 4, AUV platform, image courtesy to (http://www.mbari.org/)
iii. Sensor-Webs

The expression "sensor-web" has risen as of late as a system of sensors for natural checking is constructed associating distinctive ecological administration hubs. Delin and Jackson (2001) Described it as a detecting framework that uses the Internet to speak with exceptionally little sensors in the field and send estimations over the system to committed servers that take into account information administration, handling, and investigation. The key normal for sensor web is that the system of sensors are connected and cooperate, and a brought together the framework. Every hub in the system speaks to the spatial element and discuss remote premise with the server and with each other hub in the system. Whiteside (2005) Discussed the OGC standard for SensorWeb Enablement, where every hub is spoken to by a sensor equipment that gives single estimation and can be connected to the sensor web over the system (Teillet 2010). Figure 5 is showing the concept of Sensor Web application in emergency management operations.

Figure 5 Sensor-network Scenario in Emergency Operations Center (EOC) image courtesy of Sensors Online Magazine (http://www.mbari.org/)

b. Data Processing Systems

i. Online Processing and Web-Services

Web-Services provide a standard method for interoperating between various programming applications, running on an assortment of stages as well as systems(Peishing, Genong et al. 2007). It gives access to GIS Data or usefulness over the standardized web way. It is not a web
mapping application, however, a service can be considered as a web application (Andrei, Berre et al. 2008). It can be regarded as an Interface, by which application gets access to data and functionality. According to Andrei, Berre et al. (2008) Web Services are Web Map Service (WMS), Web Feature Service (WFS), Web Coverage Service (WCS) and Web Processing Service (WPS).

ii. Big Data Processing

Manyika, Chui et al., (2011) have described Big Data as the name has given to the expanding capacity to gather more information from a large number of sources, and break it down for specific knowledge utilizing advanced computing functions. Patterns and people can't give a superior comprehension of the circumstances and answers for issues, as highlighted by Big Data. Disasters are enormous, muddled and uproarious situations and precisely the kind of conditions in which Big Data can comprehend the disarray. The large measures of information that we are creating with cell phones, satellites, and online networking can all have influence in giving pieces of information to an ideal approach to react to a circumstance. Figure 6 the concept of Internet of Things (IoT), as comprehensive approach for linking various sensors in one place.

Figure 6, The concept of IoT

Through Big Data Analytics, disasters managers and experts can; enormous information is a more convoluted world because the scale is much bigger (McAfee, Brynjolfsson et al. 2012). The data is spread out over various servers, and the work of ordering the information must be composed among them. Previously, the work was to a high extent designated to the database programming, which would utilize its particular composition and programming.
iii. Crowdsourcing Data Processing

The expression "crowdsourcing" was instituted in 2005 by Jeff Howe and Mark Robinson, editors at Wired, to depict how organizations were utilizing the Internet to "outsource work to the group." McAfee, Brynjolfsson et al. (2012) have described crowdsourcing as providing a particular sourcing model in which people or associations utilize commitments from Internet clients to get required information or ideas through different means. Crowdsourcing is recognized from outsourcing in that the work can originate from an indistinct open (rather than being appointed from a particular group) and in that crowdsourcing incorporates a blend of base up and beat down procedures (Elwood, Goodchild et al. 2012). Focal points of utilizing crowdsourcing may include enhanced costs, speed, quality, adaptability, versatility, or differences. Crowdsourcing as thought rivalries or development challenges gives an approach to associations to realize past what their "base of brains" of representatives provides. Crowdsourcing has additionally been utilized for non-commercial work and to create primary products (Bengtsson, Lu et al. 2011).

c. Data Presentation Systems
   i. Perspective Multidimensional Visualization

Geovisualization alludes to an arrangement of tools and techniques supporting the investigation of geospatial information using intuitive perception (Elwood 2008). GIS and visualization take into consideration more intuitive maps; including the capacity to investigate distinctive layers of the guide, to zoom in or out, and to change the visual appearance of the handbook, usually on a computer display (Andrienko, Andrienko et al. 2003). Cadavid, (2013) discussed geovisualization as an arrangement of cartographic advances and practices that exploit the capacity of current microchips to render changes to a guide continuously, permitting clients to confirm the mapped information on the fly. According to Erskine, Gregg et al. (2013), geovisualization gives various user communities the capacity to settle on adjusted informed decisions by considering "the complex cooperating components that ought to be considered when contemplating natural changes." Geovisualization clients can utilize a georeferenced model to investigate an intricate arrangement of environmental information, examining various situations or strategy choices to decide the best fit.

Disaster Managers can consider scenarios of situations and build a model 'imagine a scenario where' cases are given spatial-transient information Tomaszewski, (2011) have described geovisualization in the other fields to be partitioned into two separate areas—the private space. That is where experts can utilize Geovisualization to investigate information and create theories, and the general population area, in which these experts show their "visual considering" to the overall population—arranging depends on more intensely than numerous different fields of cooperation between the overall population and specialists.
i. Virtual Reality and Augmented Reality

The utilization of computer software to generate animated scenes comprise of a series multimedia components in the form of pictures, sounds and different effects that reproduce the real world and recreate the simulated environment of the users’ virtual environment (Burdea and Coiffet 2003). Virtual Reality empowers the association with this space and any articles portrayed in that utilizing particular show screens or projectors and different gadgets. According to Fisher and Unwin, (2003) virtual Reality is formally characterized as “an accurate and immersive simulation of a 3D environment, made utilizing automatic programming and equipment, over the computer.

Augmented Reality (AR) is characterized by an innovation that superimposes a digital picture on a client's perspective of this present reality, in this way giving a composite view (Ghadirian and Bishop 2008). It is a live immediate or backhanded perspective of a physical, actual environment whose components are expanded (or supplemented) by computer-built information. For example, sound, video, graphics or GPS data. In Augmented Reality, the innovation capacities by improving one's present view of reality (Van Krevelen and Poelman 2010).

Tsai, Lee et al. (2012) have discussed the application of augmented reality and how it helps in envisioning the delayed consequences of those catastrophes well before giving the opportunity to the specialists for making the substitute arrangements. At the point when every one of the provisions is made accessible before any disaster, the alleviation work should be possible promptly amid such debacles.

ii. Location-based Services (LBS)

“LBS have been available as one of the most important developed technological concepts that are intended for mobile devices users. It can answer the spatial question of where would be the nearby incident investigation site? Where would be the nearby clinic, restaurant? Tracking, traffic monitoring and directions, telematics, real-time shuttle location information and what is now known as vehicle tracking for courier delivery and other businesses. The actual determination of location in the form of geographic coordinates is not very helpful in itself. However, when it is combined this with service and linked with different spatial data and its attributes provides an added value for accessing the service through LBS for Mobile users”. (Abdalla 2016).

In 2020, the location-based service market is a $1.3 trillion industry (Location Based Services 2016). In the same year, use of geo-location data, including GPS, generates $500 billion in consumer value (MacLeod Consulting 2014).
3- Findings and Discussion

A major characteristic of the evolving new GeoICT systems is their ability to expand and collapse, based on the scope, purpose, and application. This scalability provides added value advantage to the user community. This is supported by the flexibility of the advanced system regarding hardware integration and software processing capabilities, backed by cloud-based data storage or a level of data distribution over a specific data management protocols. Advanced GeoICTs are also robust. This strengthens the process of data collection, processing, and manipulation.

The expected major trends for the near future is the expansion of adopting more UAV and AUV systems and integrating data sharing from these platforms with real-time image processing systems. The original features of-of integrated data systems regarding sophisticated on-the-fly quality assurance modules, processing, and transmission of data are growing. The quality of sensor data, infrared data collection and on the fly decision-support is increasing. It is expected that real-time processing and QC modules as well as automated data flow will further shorten the production cycle, minimize the human interaction, and will consequently enable a smooth transfer of integrated data systems to many platforms.

The need for adopting advanced GeoICT is supported by the growing user community with diverse applications requirements. In the field of disaster management, GeoICTs are getting a broader user community, because of the less technical expertise required and the expanded public participation in disaster management. Between voluntary or crowdsourcing data products, to substantial involvement in the response operations to disaster and emergency management, all this is supported by the trend in ubiquitous, robust and affordable computing.

The indicators of efficient use of technology in both public and private domains, in the field disaster and emergency management support are justified by the availability of systems and the practical use of these systems, as well as by the ability of upgrading technology infrastructure, as the case with various emergency management authorities. Data and procedures standardization and mature policies are among the essential factors for advancing the role of GeoICT in emergency management. ICT infrastructure and open, transparent systems are primary factors in developing advanced procurement policies and in fostering interoperability, between disaster management sectors. However, the challenges related to the system security and interoperability, remain. However, they do not significantly impact the use of the technology.

4- Conclusions

Disaster and Emergency Management operations today, rely heavily on leading GeoICT Technologies. These technologies have maximized the planning and response operations and contributed to saving life and property in many situations, including but not limited to (coastal zone tsunamis and earthquakes.). The fast pace of the development in advanced computing have significantly contributed to disaster management by providing more robust telecommunications, and through growing utilization of the technology, based on a broader standardized user-base, and less required technical expertise. The rapid growth in GeoICT has helped disaster management community by expanding public participation along with first responders advanced capabilities of responding to extreme situations.
5- References

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