A NEW WEB-BASED GEO-INFORMATION SERVICE APPROACH WITH DIGITAL MEASURABLE IMAGE TOWARD DIRECT VIRTUAL REALITY

HU Qingwu[a], * Wang Haiyin[b]

[a]School of Remote Sensing and Information Engineering, Wuhan University, Luoyu Road 129#, Wuhan, Hubei, P.R. China,430079
[a]Qingdao Geotechnical Investigation & Surveying Research Institute, Baiquan Road 95#, Qingdao, Shandong, P.R. China,266032

Commission IV, WG IV/5

ABSTRACT:

A new web-based geo-information service approach with digital measurable image (DMI) from direct dereference system is proposed to construct the geo information infrastructures for the web service on web 2.0 ear. Firstly, the requirements of geo-spatial information are described facing to the next generation of internet and Web 2.0. The geo information service technique architecture and its requirement is designed for the new web service mode which different to the traditional web GIS architecture. Ajax, SVG, GML and grid technique together with web service development is proposed to make the geo information visible, measurable and minable via internet. And the requirements of geo information data are summarized with the measurable geo-referenced images from land based mobile mapping system. A new concept of digital measurable images is proposed for the geo information service. Secondly, the related technique for data acquisition, organization and management for DMI is proposed. Land based mobile mapping system with over than 8 cameras and DGPS/IMU integrated sensors is designed to collect the DMI for the geo information service. Data collection procedure and related quality control methods are designed to obtain high quality DMI. A unique geo coding algorithm is proposed to handle huge volume DMI images via internet with a query response within 0.2 second. The unified database integrated DMI with existing 4D products (DEM/DOM/DLG/DRG) are described. Based on these techniques a new geo-spatial information service system-DMI based location based service is set up to improve the quality of geo information service. The geo information service with DMI can obtain a direct and fast visualization with the geo spatial data which is different to the traditional 3D model construction to realize visualization toward a direct virtual reality. Finally, the appliatability of DMI based geo-information service system is briefly discussed for business to business and business to customs service. A prototype is developed to verify the new approach on the web 2.0.

1. INTRODUCTION

Why people need internet is not for the internet technique because the internet is not represent information. People can access all kinds of information from internet for the website provides a plat roof to share, search and release information. People visit website to access information thus information play core role on the internet ear. With the development of the internet and wireless internet technique, communication, spatial grid and web 2.0, the Google Earth and Virtual Earth provide a new research plat roof for the spatial information service either for government, enterprisement and personal user (Chen Ai-Jun,2002; Goodchild, M.F., 2007;). The web based geography information service provides a new experience for the user to easy utility the spatial data and work in the virtual spatial domain to find their interested information. And all these services are free. The web based spatial information service will push the development of geography information together with the internet technique. The share of global spatial information service cause many business modes and play a great role in economic increase macroscopically (Scharl, A,2007; Chao Li, 2006; Jae-Kwan Yun,2006). Like the internet technique, users visit geo-information service website is not for the technique of web geography information system but the spatial information

from the website. The spatial data is the key of the spatial information service on the website. Currently, the spatial information service applications such as Google Earth, Virtual Earth use the digital map and satellite images (Bin Jiang,2006; Scharl, A,2007). It can obtain direct virtual reality experience from the view of global observation and it catches the eyes of the personal user at the first peer. With the development of the web technique such as web 2.0, user needs more information from the spatial information service website to obtain better experience and friendly interactivity (Skiba, Diane J, 2006). Thus the spatial data should tend to visible with high resolution and fast update frequency. The traditional 4D(DEM/DOM/DLG/DRG) product used in spatial information system take a long time to processing and it can not provide more detail POIs (point of interesting) information as the photo, address, telephone number while it very important for the user. And the internality, exactness and up-to-date of geo-spatial data play critical role for the quality and effectiveness of geo-spatial information services.

In this paper, a new web-based geo-information service approach with digital measurable image (DMI) from direct dereference system of land based mobile mapping system is proposed to construct the geo information infrastructures for the

*   qwhu@263.net 0086-13407142833

web service on web 2.0 ear. In order to release large volume data of DMI on the website, DMI data collection, arrangement and query technique are discussed. Comparing to the street view of Virtual Earth and Google map, a prototype Image City is designed and released to realize spatial information service with real reality of the city. Visiting data of the release Image City of Wuhan show this web based shows the DMI based geo-information service can attract and retain user. And it can provide a new geo-information service approach toward directly reality.

2. GEO-INFORMATION SERVICE REQUIREMENTS

2.1 Geo-information data requirement

Most website provide the virtual reality through satellite images which just have a view from sky side and it is difficult to identify detail object and its attribute while the user want to experience with a street view. Although sensing provides a massive and constant flow of Earth imagery, many other types of geographic information are not visible from above (Nakayama Masaya, 2006). They include the names humans attach to features, otherwise known as geo names or gazetteer entries, environmental information, including measures of air quality; cultural information, including information on the use of land and buildings; and population information, including population density and socioeconomic measures. Most information comes from the street view and it just has one scale while the street view warrant to different scale both close view and far view. The geo-information data for geo-portals should be a set of all kinds of images from the multiple sensor integration system. As the requirements of web 2.0, the geo-information should support a service mode which can be designed to acquire, assemble, and publish geographic information both the data and its service. It means the data should provide both the content and service. And it can make all users as a sensor for the geo information database. In this paper, a digital measurable image (DMI) is promoted to meet the geo-information requirements of web 2.0. DMI carries such data as external orientation elements and attitude elements. Cooperated with accurate time parameters, these data constitute the basis of surveying on multiple levels and seamless merging of database. Generally, the height and area information of a building is difficult to measure and the usual method is to get through querying attribute database which save these information by traditional surveying in advance. That is to say, if the information we interested are not stored in database beforehand, they cannot be reached through query operation.

2.2 Service requirement on Web 2.0

According to the requirement of web 2.0, the services of geo portal provided for users need to satisfy the following six characteristics: Certainty, Experience, Communication, Variation, Creativity and Relation. As regards geo-spatial services, searchable is the basic attribution; visible is the basis of Experience (e.g. Google Earth and Microsoft Virtual Earth); measurable is the guarantee of Variation and Creativity; minable is the guarantee of Relation (Rapple, Charlie, 2006; Skiba,2006; Helft,2006; Ratcliff, E., 2007). So we make the conclusion that searchable, visible, measurable, minable are the four functions of geo-information services. Service platform based on geo-spatial grid can integrate Web 2.0 technology such as Ajax and provide interactive intercommunion service

for users. The architecture of geo-spatial information services of Digital Earth is illustrated through Figure. 1.
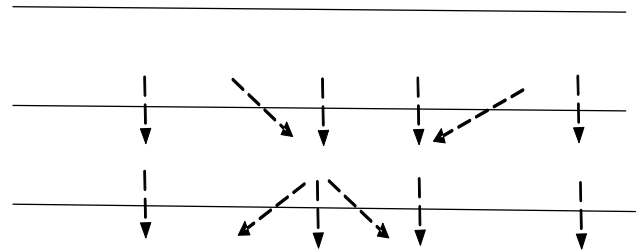

Figure 1 Geo-Spatial Information Service Requirements on Web 2.0

3. METHODLOGY

3.1 DMI data collection technique

Land based mobile mapping system can be taken as one of DMI data collection technique which integrates geodetic quality GPS, digital stereo cameras and inertial navigation system (INS) that are mounted on a land vehicle. It proves to be the most rapid, convenient, accurate and economic tool of collecting and updating geo-information data together with DMI as figure 2.
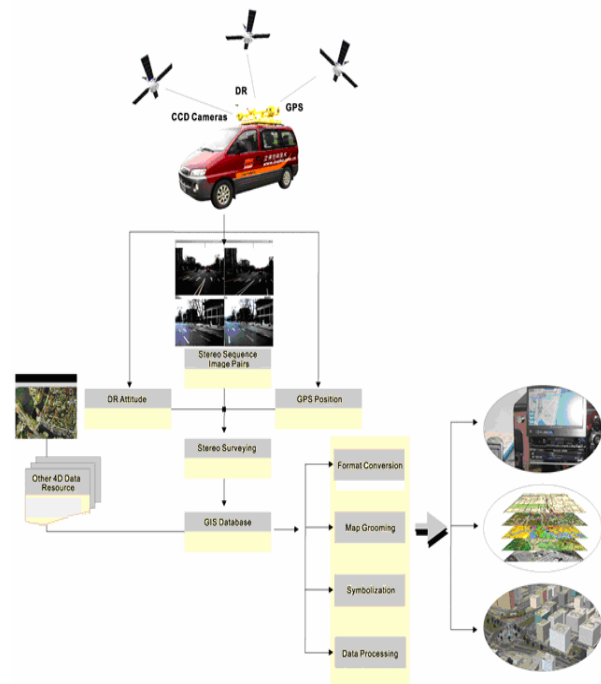

Figure 2 A land-based mobile mapping system

Eight cameras are used in the land based mobile mapping system to form stereo image model. GPS/INS provides the orientation parameters for the stereo model. With the unit GPS UTC time from time table and calibration parameter from the control site, the directly geo-reference model of DMI is described as equation (1).

$$r_p^m = r_S^m + \mu_S^m R_S^m r_p^S \qquad (1)$$

Where r_p^S is the coordinate of a point in the MMS imaging sensor's coordinate frame which is related to the mapping coordinate frame r_p^m. r_S^m is the position of mapping sensor in the mapping coordinate frame. μ_S^m and R_S^m are respectively scale factor and rotation matrix between the mapping sensor coordinate frame and mapping coordinate frame which can be calculated from the system calibration.

Land based mobile mapping system is a close range photogrammetry system of direct geo referenced which is more similar to the view of human and it can collect $360°$ street view stereo image pairs with a speed over than 100km/h. It can export vector map, attribute data and sequence digital measurable images. With the orientation data fro DGPS/IMU, ti can realize absolute surveying till 0.5m accuracy and relative measurement of centimeter level. And DMI records the environment information toward the direct reality which can be used for the POI guide and navigation. The geo information from land based mobile mapping system can overcome the probe error by labour work thus it can obtain high quality geography information data.

DMI from land based mobile mapping system can provide $360°$ street view images which can fulfil the requirements of the geo-information service on web 2.0 by user's annotation operation and it can be measured with the photogrammetry measurement service as the demand of user.

3.2 Geo-information produce procedure with DMI

In order to obtain high quality DMI, a DMI data collection procedure integrated with remote sensing image and related quality control methods are designed as figure 3.
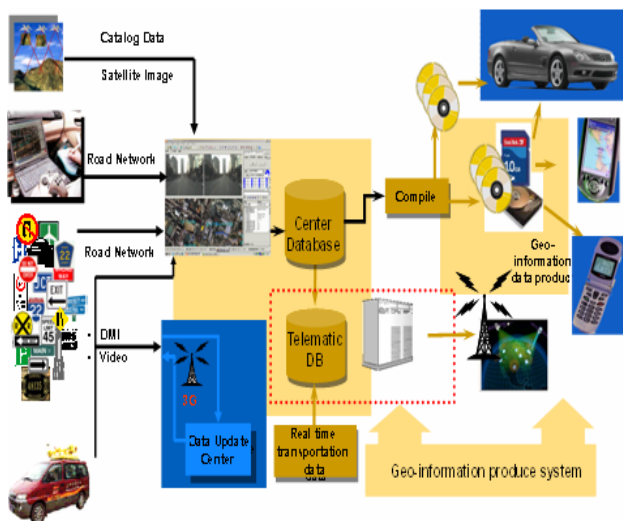

Figure 3. Geo-information data produce system based on DMI

As figure 3 shown, the digital map is taken as one of data sources with the remote sensing images for the geo-information. Most of the navigation information and service information come from land based mobile mapping system and field probe system. The third part POI can be integrated together with the real time transportation data in the centre database. The system can compile all these data for different applications such as the car navigation device, portable navigation device (PND) and web map service. Digital measurable image is taken as the core data source to extract all kind s of information for the navigation and local based service. Compare to other geography information integration system, it can both extract information from digital measurable images and add geo referenced stereo images as a new spatial data source for navigation network and POI. In this paper, the author propose a new web based geo-information service approach which extend map, satellite images to ground street view with more detail local representation toward direct reality.

3.3 Geo coding of DMI

DMI from land based mobile mapping system has large volume. Usually, four to eight CCD sensors are installed on the land based mobile mapping system. And the data collection of DMI can be defined as distance trigger of $8\sim20$ meter or time trigger of $0.5\sim1.0$ second . One image has a volume size of $1.4\sim2.0$MB. A city about 200km^2 is about 1 TB volume. In order to manage, process, query and release the large volume images data, a geo coding technique of DMI is proposed. The digital measurable images are geo referenced together with unique GPS time target. Firstly, a position index of GPS time is built together with the orientation. Secondly, a time coding of each image is generated with two level indexes. 0 level records year to second. 1 level records milliseconds of each 0 level index item and its reservation information such as the sensor ID as figure 3 shown.
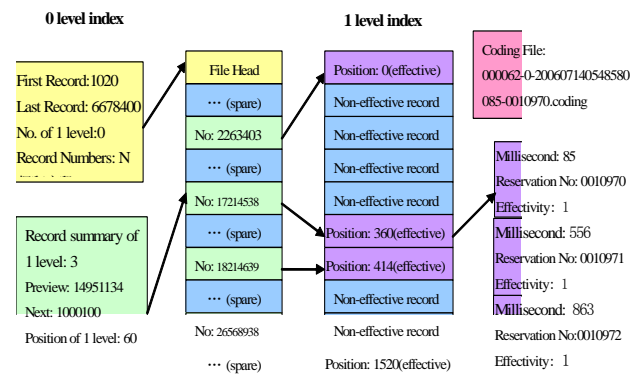

Figure 3 DMI time coding file structure

Each image will generate one time coding file once it is captured. With the spatial position, it can query the image exposure time from the spatial index file. Then it can restore images file with image time and find the image with the coding file. Different volume images are adapted to test the image query response time as table 1 shown.

	Data Volume	Image Number	Response time
Hanyang District	323GB	201876	0.08s
Wuchang District	745GB	465624	0.08s
Hankou District	1023GB	639374	0.11s
Wuhan City	2091 GB	1306874	0.15s

Table 1 DMI coding query response result

As table 1 shown, the data volume of the total Wuhan city is about 2TB. The image query response time is related to the data volume of different district. And the average response time of large volume images is less than 0.2s with the DMI coding technique. It can fulfil the city level DMI service on the website to realize the query response requirement.

The next procedure is to connect the digital measure images with navigation network and POI. With the geo coding DMI, an environment navigation data model is a entity relation model between the navigation data and images which is designed to integrated DMI and navigation map. The environment navigation data model has two parts. One is the navigation network link model. GDF is a common data model for the navigation link arrangement. Another part is DMI database based on the geo coding images. As the geo coding model of DMI, each image has a spatial position index and time target. We call environment navigation index database. In the environment navigation index database, each record has a unique ID of node, image name, time target, position coordinate and link ID. With the spatial reference, it can be attached to the navigation link and POI. Thus the navigation link, POI and DMI can realize query among the spatial position, time and attribute. For example, when we query the image of POI, attribute such as the POI name or telephone information is converted to position. With the position of POI, the time target of position is found and then the image name can be generated. When a navigation route is generated, the sequence digital measurable images along the route can be found from the interpolate position of the route. The environment navigation data model is shown as figure 4.

3.4 Data model of DMI based geo-information service

Complete data model of geo-information service is to integrate DMI, DOM, DRG, DLG and DEM. In this integration model, DOM can provide an experience of the total area from a sky view or bird view. DLG and DRG can be taken as a background and spatial database for spatial query and analysis. DEM can build the virtual terrain surface together with DOM image (A. Demoulin, 2007). And DMI can provide the reality experience fro the view of street. The interactive activity among these data is realized through the plug-in and ActiveX technique provided by DMI. Figure 5 is an example of DMI, DEM and DOM integration. Figure 6 is an example of DMI, DEM, DLG and DOM integration.
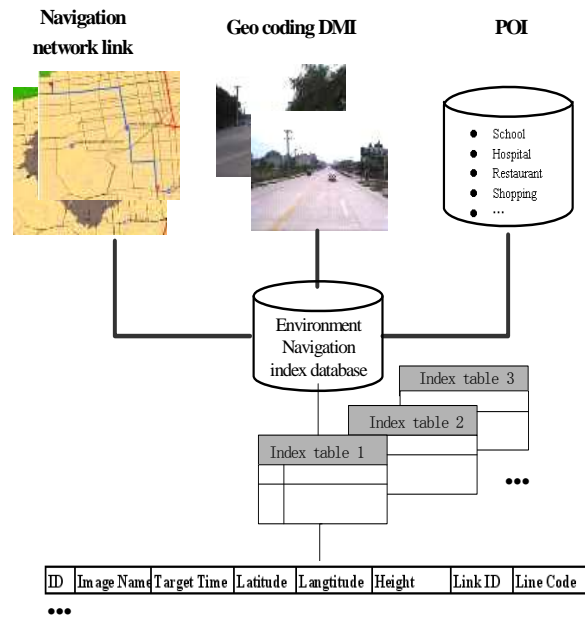

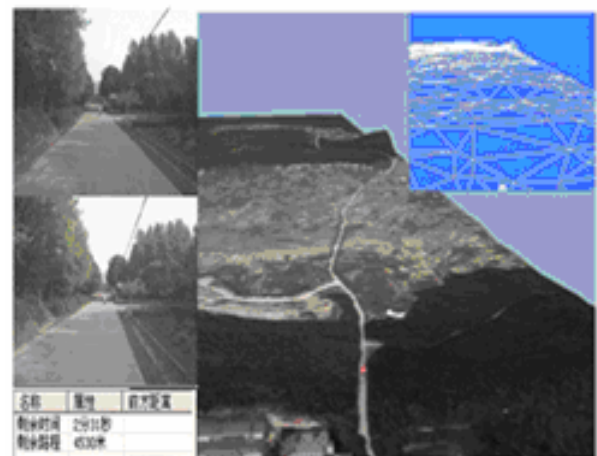
Figure 4 Environment navigation data model
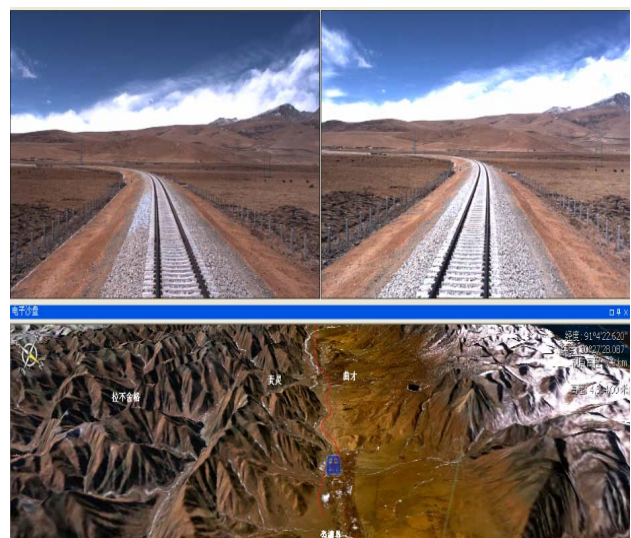

Figure 5 DMI, DEM and DOM integration

Figure 6 DMI, DEM, DLG and DOM integration

DMI integration with DEM, DLG and DOM can be used in the digital city and related spatial information visualization system. It can obtain direct reality with DMI and reduce visualization time. With the plug-in, ActiveX and API service, it will encourage customs to construct virtual reality 3D model or digitize objects from the DMI via internet.

4. PROTOTYPE ANALYSIS AND CONCLUSIONS

4.1 Image City: A prototype of Wuhan

A prototype of the DMI based geo information service website is discussed for the new approach of web map service. Image city of Wuhan aims to provide a public geography information website. It has more than 2TB digital measurable images together with 300,000 POI and provides the "Truemap$^{®}$" spatial information service for personal users and enterprises. Figure 7 is a prototype of Image City-Wuhan.

Figure 7 Image City: Wuhan

Image city of Wuhan gives a prototype of the new approach of geo information service based on the digital measurable image. Comparing to the current web map service, the image city combine the street image with map. It can provide more detail information than the map database. And this new geo information service approach can be taken as a spatial data infrastructure in the world of web 2.0. The user can be taken as an information collection voluntary sensor with the annotation tool provided by the website. Once the annotations of the web user are confirmed, it can be a new item of the data infrastructure database and then share to the other user. With the image city, we can realize collaboration produce of the geo information and this will encourage the share and spread of geography information. Whereas the early web was primarily one-directional, allowing a large number of users to view the contents of a comparatively small number of sites, the new Web 2.0 is a bi-directional collaboration in which users are able to interact with and provide information to central sites, and to see that information collated and made available to others. With the development of web 2.0 technique, image city can be a new approach for the geography information collection and update.

Figure 8 shows a procedure of the user to annotate information from the image city.
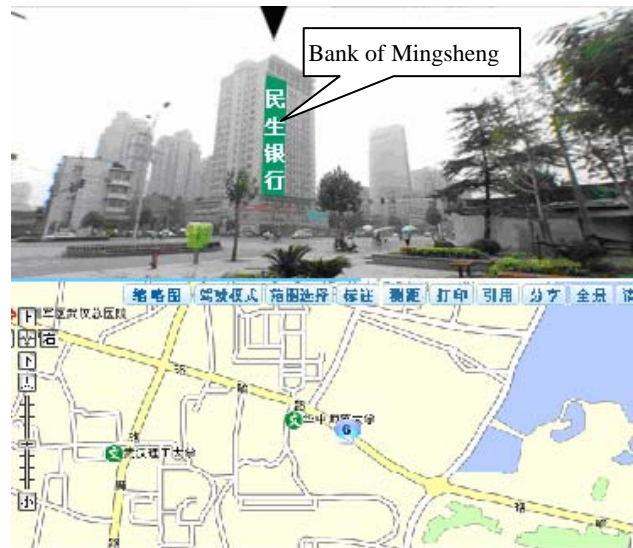

Figure 8 Annotation of Image City

As figure 8 shown, user can annotate object with through website with more detail information than the spatial information service provider. This mode calling it volunteered geographic information (VGI) can be taken as a third options of the collection of spatial information same as the Wikimapia (www.wikimapia.org). Most of VGI from image city is well-meaning. After formal institutional frameworks, it can be accepted as a part of spatial data infrastructure. VGI can be a new approach for the geography information collection and verify especially for the attribute information. And the geography attributes information collection and update such as place name and POI is a big problem of the remote sensing and probe work while Image city based on the DMI can be a good solution (Masser, I., 1998; Masser, I., 2007; Onsrud, H.J., 2007).

4.2 Discussions and Conclusions

For the recognition of computer, the object coordinates can be a effective information while it is difficult for people to identify object with coordinate in the reality world. Address is usually used for people to find where to go. Even though, the address with text and number description is difficult to memorize which make many confuse in the people daily life. People usually identify the object by the environment such as a building. That means people can memorize object with imaging building more than address. Image plays a very important role for the people recognition. When people introduce one site to help other people to location the site, they always describe the referenced objects to the site. Indeed, the site image is in his head while he has to convert them text, number and other communication language. Different people will have different description of the same site. Even the same people in different time will have different description. The text, number and coordinates have a relationship of one-to-many. Thus it makes the address location and navigation confuse. It greatly affects the function and quality of geo information service. Thus the authors propose to use the image to replace the address description for the location and navigation. Image can be stored in the human head and it's the best representation of the reality world. With the address

743

image, it can improve the reliability of spatial information service.

Images fit the habit of human vision and memory. It has uniqueness to represent the address. DMI excludes the symbol represent error of the map system and include large spatial semantics and non-spatial semantics of map symbol system. Land based mobile mapping system provides a fast tool to build the address image database. And the image from the mobile mapping system is geo referenced with position parameter and orientation parameter to measure. For the professional user, DMI can be used to extract information to meet the application requirement. For the personal web user, DMI has the contact of between the human recognition and environment. Comparing to the satellite image map and two dimension maps, DMI based geo information service has higher ability of spatial information value-added service. This will be a new approach towards direct reality for the environment navigation. With the development of wireless communication, web service technique and intelligent vision, DMI based geo information service promise a trend of the web map service.

ACKNOWLEDGEMENTS

REFERENCES

Chen Ai-Jun, Li Qi, Xu Guang-You, 2002. Geospatial information layer sharing model for digital earth, Ruan Jian Xue Bao/Journal of Software, v 13, n 8, August, p 1436-1440

Nakayama Masaya, Matsuura Satoshi, Esaki Hiroshi,Sunahara Hideki, 2006. Live E-Project: Sensing the earth, Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), v 4311 LNCS, Technologies for Advanced Heterogeneous Networks II - Second Asian Internet Engineering Conference, AINTEC 2006, Proceedings, p 61-74

Demoulin, B. Bovy, G. Rixhon and Y. Cornet, 2007. An automated method to extract fluvial terraces from digital elevation models: The Vesdre valley, a case study in eastern Belgium. Geomorphology, In Press, Corrected Proof, Available online 3 February 2007

Bin Jiang and Xiaobai Yao, 2006. Location-based services and GIS in perspective. Computers Environment and Urban Systems. Volume 30, Issue 6, Pages 712-725

Chao Li, 2006. User preferences, information transactions and location-based services: A study of urban pedestrian way finding. Computers, Environment and Urban Systems, Volume 30, Issue 6, Pages 726-740

Jae-Kwan Yun, Dong-Oh Kim, Dong-Suk Hong, Moon Hae Kim and Ki-Joon Han. 2006. A real-time mobile GIS based on the HBR-tree for location based services . Computers & Industrial Engineering, Volume 51, Issue 1, Pages 58-71

Skiba, Diane J, 2006. Web 2.0: next great thing or just marketing hype? Nursing education perspectives 27(4):212-4

Rapple*, Charlie, 2006, Users should be at the centre of Web 2.0 plans. Research Information, no. 25, pp. 15-16.

Lewis , Daniel . 2006, WHAT IS WEB 2.0? Crossroads, no. 13.1, pp. 23-24

Burrough, P.A. and I. Masser, editors, 1998. European Geographic Information Infrastructures: Opportunities and Pitfalls. London: Taylor and Francis.

Goodchild, M.F., P. Fu, and P. Rich, 2007. Sharing geographic information: an assessment of the Geospatial One-Stop. Annals of the Association of American Geographers 97(2): 249-265.

Helft, M., 2007. Map making for the masses, online. International Herald Tribune, July 26.

Hill, L.L., 2006. Geo-referencing: The Geographical Associations of Information. Cambridge, MA: MIT Press.

Masser, I., 1998. Governments and Geographic Information. London: Taylor and Francis.

Masser,I., 2007. Building European Spatial Data Infrastructures. Redlands, CA: ESRI Press.

Onsrud, H.J., 2007. Research and Theory in Advanced Spatial Data Infrastructure Concepts. Redlands, CA: ESRI Press.

Ratcliff, E., 2007. Google Maps is changing the way we see the world. Wired 15.06, http://www.wired.com/techbiz/it/magazine/15-07/ff_maps

Scharl, A. and K. Tochtermann, editors, 2007. The Geospatial Web: How Geobrowsers, Social Software and the Web 2.0 are Shaping the Network Society. London: Springer.

Goodchild, M.F., 2007. Citizens as Voluntary Sensors: Spatial Data Infrastructure in the World of Web 2.0, International Journal of Spatial Data Infrastructures Research, 2007, Vol. 2, 24-32.