Free and Open Source Software for Geospatial (FOSS4G) Conference Proceedings

Volume 15 *Seoul, South Korea* Article 10

2015

Introduction To A New Geo-Referenced Street Level Content: 3D GEOPANO

Boram Yoon
Department of Geoinformatics, The University of Seoul

Impyeong Lee
Department of Geoinformatics, The University of Seoul

Recommended Citation
Yoon, Boram and Lee, Impyeong (2015) "Introduction To A New Geo-Referenced Street Level Content: 3D GEOPANO," *Free and Open Source Software for Geospatial (FOSS4G) Conference Proceedings*: Vol. 15 , Article 10.
DOI: https://doi.org/10.7275/R5JD4TZN
Available at: https://scholarworks.umass.edu/foss4g/vol15/iss1/10

PO-15

INTRODUCTION TO A NEW GEO-REFERENCED STREET LEVEL CONTENT: 3D GEOPANO

Boram Yoon[1] and Impyeong Lee[2]

[1]Department of Geoinformatics, The University of Seoul
163, Seoulsiripdae-ro, Dongdaemun-gu, Seoul 02504, Rep. of Korea
Email: hoyohoo@uos.ac.kr
[2] Department of Geoinformatics, The University of Seoul
163, Seoulsiripdae-ro, Dongdaemun-gu, Seoul 02504, Rep. of Korea
Email: iplee@ uos.ac.kr

ABSTRACT

Geospatial mash-up is to produce a new worthy value by combining geo-referenced contents and different kinds of service. Despite of its high popularity in aerial view contents such as Google Earth, it is hardly achieved especially in street level due to the poor georeferencing quality of the underlining street level contents. In this study we propose a new street-level georeferenced panorama image content, '3D GeoPano'. While the most existing contents provide only the location and orientation for each entire image not for each pixel, this new content is accurately georeferenced pixel by pixel so that one can derive 3D absolute coordinates for every pixel. Based on the precisely determined 3D ground coordinates per every pixel, GIS database linkage can be more close, flexible and organic. This can improve the quality of geospatial mash-up service in street level. Such '3D GeoPano' will be developed in open source community. By doing so, we expect to activate the geospatial mash-up in street-level as well as to spread the geospatial technology.

1. INTRODUCTION

Geospatial mash-up is to produce a new value by combining geo-referenced contents and existing resources at a low cost. The most successful of the mash-up case is Google Earth. Google Earth have produced a lot of map based services. The key of the success is the high quality of Google Earth in terms of its user interface and a detailed description of real world etc. This means that the mash-up is highly depending on the base resources like Google Earth. Mash-up service is influenced by what the base resources to provide and how to provide.

Despite of the success of aerial view geospatial contents represented by Google Earth, it is still depressed to mash up with geospatial contents in street level. In this study, we try to understand in aforementioned context of mash-up. By analyzing the current geo-referenced contents especially in street level, we draw some limitations to mash-up. Furthermore, we suggest a solution to overcome the depression in the street view contents. We call our proposed content 3D GeoPano. This new geo-referenced street level content is worthy of notice for its pixel by pixel geo-referencing technique. Based on the geo-referencing result per every pixel, GIS database linkage can be more close, flexible and organic. We expect 3D GeoPano to improve the quality of geospatial mash-up service in street level. This paper describes the details of analysis of current street view contents and our proposed solution 3D GeoPano.

2. CURRENT STREET VIEW CONTENTS

2.1 2D image based street view contents

Figure 1. Movie-Map (left) and Google Street View

Although a map of aerial view, a long-standing representative of geospatial contents, has high quality in terms of position accuracy and visibility etc., it is not able to depict the real world in street level due to its limitative field of view. This cause appearance of a map in street level such as Google Street View. There was an early version of map at the viewpoint of street in the late 1970s, which is called Movie-Map. Movie-map is an image based hypermedia system which provides street image sequences of Aspen city in the place of a driver for military purpose (Lippman, 1980). When troops get into strange area, the map can help them quickly and intuitively become familiar with that area. Surprisingly, as you see Figure 1, it gives several functions to handle the map even in the late 1970s as Google Street View does the graphic user interface on the content today.

Map services in the street level, such as Google Street View and Daum Road View, represent the real world as the scenes come to eyes of a walking man or a car driver. They mainly reflect the side of structures on the ground, for example building façade. This representation can intuitively give massive information based on the way a user recognizes the real world. That’s the main reason why the Movie-map was developed for military purpose and the street view services are widely used today. Such street view maps are applied to not only the outside but also the interior of buildings. Especially assimilating with the augmented reality technology, they are used for navigating a complex building, advertising a store and guiding a tour of museum.

The state of the art of the street view map is Street View of Google. Its reputation is based on that Google Street View provides high quality of virtual user experiences. It gives image based spatial information over almost the whole world and well organizes them so that a user can easily navigate the virtual world like car driver. To do that, various kinds of data are collected by cameras, laser scanners and navigation sensors. Such sensors are mounted on several kinds of platforms depending on where data is acquired, for example a passenger car, a snow mobile and even a kite. Acquired data mainly generates panorama images with high resolution and position information. After that those products are integrated with probabilistic

Figure 2. 'Click-to-go' function of Google Street View

Figure 3. Microsoft Street Slide (Vincent, 2007)

graphical model representing the road networks and they are linked with Google Maps. Where we can easily find the effort to provide high quality of virtual user experience in Google Street View is the function called click-to-go. Click-to-go is the function helps a user see a specific region of interest at desired location and direction with a floating white window. In Figure 2, you can see different building façade at different viewpoints.

Despite of the fact that Google Street View is state of the art and provides outstanding user interface and virtual experience, it has limitation on augmenting attribute information of GIS as well as user-defined information over the map. Furthermore it also cannot gives an overview of one side of a street. When a user want to scan a street, user should manually change the view point following the road. To overcome those limitation, Microsoft studied Street Slide as Figure 3. Street Slide is based on multi-perspective strip panorama image which is orthographic projection image of one side of street. This representation can provide intuition for wide area. Moreover related attribute information can be augmented over the content more intuitive than Google Street View like map of aerial view. However it is lessen the user satisfaction of virtual experience.

2.2 3D model based street view contents

There have been a lot of efforts and needs for 3D model based geospatial information. The high quality of 3D geospatial model is required to have complete geometrical figures, high resolution of texture information and user-interactive functions regardless of the indoor and the outdoor (Na *et al*, 2013). It is quite cost-consuming and labor-intensive to achieve those requirements.

The most successful case of 3D geospatial service, Google Earth, also have undergone several trial and error. When constructing a 3D model of a building using aerial images or satellite images, the quality and the accuracy of the model are not good enough. To improve

Figure 4. Improved 3D building layer of Google Earth (Anguelov, 2010)

them, Google launched a user participation pipeline, SketchUp, to encourage user to manually build 3D model and to open in the Google Earth. However, this cannot meet the large demand for 3D models. Google's another approach to improve the low quality of 3D model is to exploit the data produced by Google Street View project (Anguelov, 2010). Point cloud data from laser scanner is used to build geometric model framework, and optical image from street view camera and aerial/satellite image are used for texture information of the façade and the roof of the model. The accuracy and the resolution of 3D model can be improved by this approach like Figure 4.

Building indoor 3D model approaches can be divided into two parts. One is based on the laser scanning data, the other is based on the blueprint of a building. Each methods has own strengths and weaknesses. Laser scanning data based 3D model can achieve its high position accuracy and resolution and can be built even in the absence of the blueprint of a building. However it takes large amount of time and cost to acquire and process the primitive laser scanning data. What is more it require cost-consuming and labor-intensive procedure which each components of the model is discretized so that each of them has own attributes (Ministry of Land, Transport and Maritime, 2013). Unfortunately, this step is too complicated and difficult to be fully automated by a computer. On the other hand, the blueprint based 3D model is easy to assign the attribute information to each components of it. Besides, the blind spot of data acquisition can be easily modeled. Nevertheless, there is the disagreement between the blueprints and the constructed objects. Above all, geo-referencing procedure which locates the model in the real world coordinate system is so complicated and result of it is not reliable enough (Seoul, 2014).

3. 3D GEOPANO

To assess aforementioned current 2D/3D street view contents, user's virtual experience and visual satisfaction are considered as being the most important. As Bleisch (2012) mentioned, the way and the effect to express various information on the virtual space are less discussed. This is the limitation of current geospatial contents to active and in-depth application. When various kinds of information and data can be appropriately represented on the geospatial contents, powerful strengths of the geospatial contents, spatial intuition and effective visibility, can be meaningfully maximized and valuable enough.

In an effort to activate the geospatial contents, we propose new type of geospatial content in street level. Designing such geospatial content, we set three directing points of our proposal as follows: (1) the real world should be projected to texture information of our proposal as it

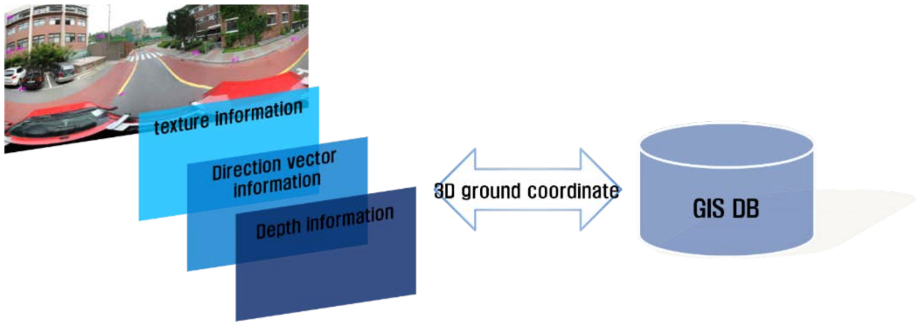

Figure 5. The conceptual structure of 3D GeoPano

is; (2) our proposal should provide 3D geometry of each discretized polyhedral model; (3) attribute information of each ground structures can be flexibly and organically linked to our proposal. Existing geospatial contents are also developing toward these points. However most of them have difficulty building the high quality of 3D model. Because they mainly focus on the visual experience of user not the way to represent other types of information, their 3D model is just aimless 3D contents for only 3D as Shepherd (2008) mentioned. We look at the problem with the opinion that a complete 3D model is not essential and fully textured 2D image is enough to augment other various information on the contents. By separating the texture information and 3D geometry, the linkage between the contents and other attribute information can be more flexible.

Our solution is omnidirectional panorama image called 3D GeoPano, which can be accurately georeferenced per every pixel. This can represent the real world as it is, and implicitly contains accurate 3D geometry. The difference compared to current Google Street View and Daum Road View is it is possible to determine the 3D ground coordinates corresponding to each pixel on the content. The 3D ground coordinates derived from 3D GeoPano play a role as a key of reference in the GIS database which makes flexible connection with database possible. In addition, such 3D GeoPano is able to economically construct and maintain the 3D virtual model and GIS database.

Figure 5 shows the conceptual structure of 3D GeoPano. The 3D GeoPano consists of three kinds of information, texture, direction vector and depth. Texture is an image the real world is projected. Direction vector and depth information participate in estimating the 3D ground coordinates. Direction vector is the unit vector heading from the center of projection of the texture to the point of real world corresponding each pixels of texture, and depth is the distance between the projection center and the ground point. These three kinds of information make up each layers of the 3D GeoPano.

Table 1 is the functional comparison of the 3D GeoPano and Google Street View. A user is passively provided with image contents corresponding given ground coordinates and orientations using Google Street View. However a user can access to the 3D coordinates of real objects in the world as well as the high resolution of image contents using 3D GeoPano. This characteristic of our proposal enables following functions. As previously mentioned, a variety of information can be easily augmented on the content based on the 3D ground coordinates as a key of reference. Furthermore, building 3D geometric model is possible from the content and existing 3D model is able to be augmented on the content. Lastly, it is also possible to measure the geometric size of given real object from the content.

Figure 6 is a designed software architecture for 3D GeoPano. There are two main modules for 3D GeoPano generation and database interaction and other supporting modules.

In the 3D GeoPano generation module, three main components of 3D GeoPano are produced and combined. On the other hand, there are four sub-modules in the database interaction module. They respectively are in charge of 3D world coordinate determination, augmentation, measurement and 3D model construction.

Table 1. The Functional comparison of 3D GeoPano and Google Street View

	3D GeoPano	Google Street View
3D ground coordinate	Possible to determine the 3D ground coordinates of spatial object in the content as well as the content itself	- Possible to render the content corresponding given ground coordinates and orientations - Impossible to acquire the 3D coordinates of given content and spatial object in the content
Measurement (length, area etc.)	Possible to measure the geometric size of spatial object in the content	impossible
3D modeling	- Possible to build the 3D geometric model from the content - Possible to augment the 3D model on the content - Possible to separate the each object model	- Mesh model of building façade from point cloud data - Geometric model information is given as lookup table of 3D planar equation in runtime(user cannot directly access and utilize the geometric model information) - Not separated model object by object
Content augmentation	possible to augment various information based on the 3D ground coordinates as a reference key	- Simple attribute marker is augmented, but its location accuracy is low. - User cannot augment various information on the content

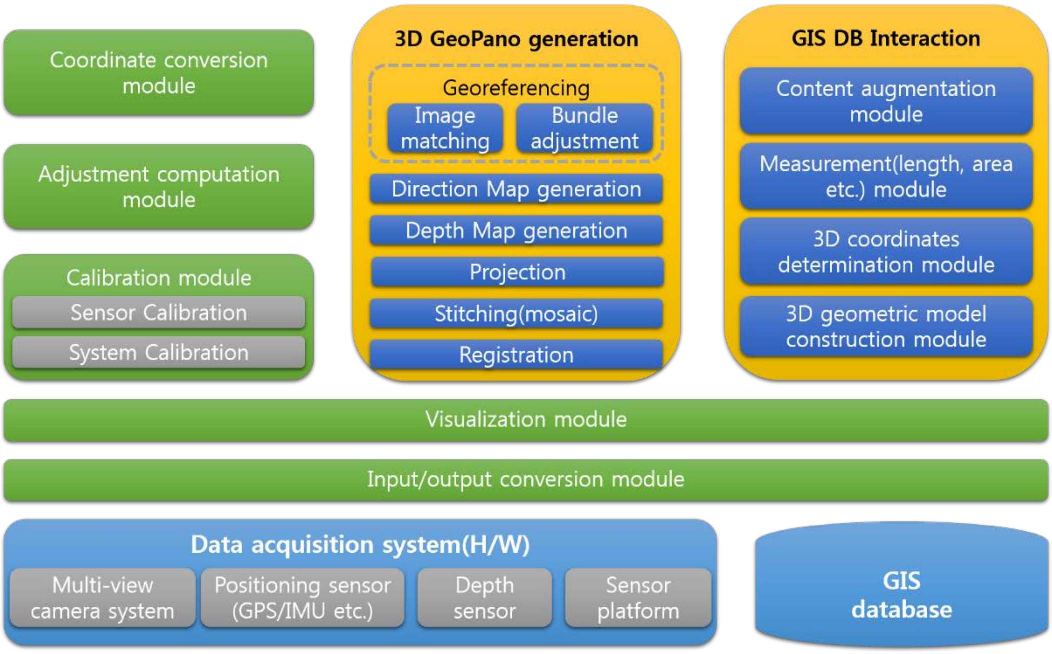

Figure 6. Software architecture of 3D GeoPano

4. CONCLUSION

The high popularity of geo-referenced mash-up improves the quality and availability of geo-referenced contents. Such contents which accurately reflect the real world in street level as well as in aerial level have appeared. Despite the advent of geo-referenced contents of street level, it is still hardly used for mash-up. In this study, we thus find out its limitations to geospatial mash-up and propose solution to overcome them. By analyzing the current geo-referenced street view contents with respect to their method and the way of representation, we draw the limitations of current street level contents. Furthermore, we propose the 3D GeoPano as a solution to overcome those limitations. With 3D GeoPano, it is able to determine the 3D coordinates of given object in real world. Using those coordinates, database linkage can be much closer, flexible and organic. Such 3D GeoPano will be developed in the open source community Github. By doing so, we hope contribute to activation of geo-referenced contents in street level and its mash-up.

5. REFERENCES

Anguelov, D; Dulong, C; Filip, D; Frueh, C; Lafon, S; Lyon, R; Ogale, A; Vincent, L; Weaver, J. 2010, Google street view: Capturing the world at street level, *Computer*, 43(6):32-38.

Bleisch, S. 2012, 3D Geovisualization-Definition and Structures for the Assessment of Usefulness, *the ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences*, Melbourne, August 25 - September 1.

Lippman, A. 1980, Movie-maps: An application of the optical videodisc to computer graphics, *ACM SIGGRAPH Computer Graphics*, 14(3):32-42.

Ministry of Land, Transport and Maritime, 2013, Research on integrated management system for indoor spatial information and location search.

Na, J. Y; Hong, C. H. 2013, A Study on the Weight Lightening Algorithm of 3-Dimensional Large Object based on Spatial Data LOD, *Journal of Korea Spatial Information Society*, 21(6):1-9.

Seoul, 2014, Research on 3D indoor space modeling construction and application method in Seoul.

Shepherd, I. D. 2008, Travails in the third dimension: a critical evaluation of three-dimensional geographical visualization. *Geographic Visualization: Concepts, Tools and Applications*, Wiley, pp. 199-222.

Vincent, L. 2007, Taking online maps down to street level. *Computer*, 40(12):118-120.