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A Study on the Application Technique of 3-D Spatial Information by integration of Aerial photos and Laser data

항공사진과 레이져 데이터의 통합에 의한 3차원 공간정보 활용기술연구

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Abstract

A LiDAR technique has the merits that survey engineers can get a large number of measurements with high precision quickly. Aerial photos and satellite sensor images are used for generating 3D spatial images which are matched with the map coordinates and elevation data from digital topographic files. Also, those images are used for matching with 3D spatial image contents through perspective view condition composed along to the designated roads until arriving at the corresponding location. Recently, 3D aviation image could be generated by various digital data. The advanced geographical methods for guidance of the destination road are experimented under the GIS environments. More information and access designated are guided by the multimedia contents on internet or from the public tour information desk using the simulation images. The height data based on LiDAR is transformed into DEM, and the real time unification of the vector via digital image mapping and raster via extract evaluation are transformed to trace the generated model of 3-dimensional downtown building along to the long distance for 3D tract model generation.

Keywords : Ubiquitous, 3D Spatial Image, LiDAR, DEM, GIS

1. Introduction

The practical use of 3D Perspective image map in construction fields is on an increasing trend after going through many changes in creating method and technology, and ever since the composition of a various geographic information became possible by ortho projection technique using digital map and satellite images (Yeon, 2004; Kim, 2002). The construction planning and designing through the composition of pictures, image data and three-dimensional presentation of digital topographic map are possibly carried out. The application of spatial information system to the construction field is being considered as a great solution for a new construction planning technique. Because high resolution images can substitute for the existing digital topographic map and thematic map, the detailed topographic information about the routes of expressway and local road under construction can be collected and stereo terrain analysis of planned construction routes can be carried out to provide basic spatial information for searching the most reasonable route selection (Yeon *et al.,* 2007). To get local environmental information about the chosen districts, researcher have collected topographic map, air-photo and satellite image data and created 3D perspective image map. To explain the steps that took in this study briefly; An Ortho-Image of Yangsan is firstly created using satellite images from Kompsat-1, LANDSAT TM, SPOT and topographic map made by National Geographic Information Institute(NGII) and other information about the target district and then a 3D perspective image map is created using the ortho image and DEM. Also digital map data having a 1/5,000-reduced size was made by National Geographic Information Center in Korea to construct the three dimension-

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al image using DEM trans formation. This research aims to convert the contour lines on a digital map into the altitudes on the 3D map, and to describe our rigorous tests in various aspects, for example, with virtual navigation on the digital solid map which can be used to provide the useful information for the purpose of touring virtual sites in the cyber space with reality. Fig. 1-2 shows the Aerial photos 2D, 3D perspective view in the study area.

Fig. 1. 3D Aerial photos of 2D perspective view in study area.

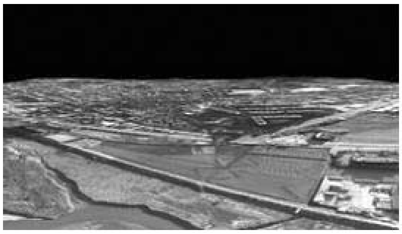


Fig. 2. Aerial photos of 3D perspective view in study area.

2. Spatial Image

There are several kinds of instruments and methodologies to acquire Images from the terrain surface, which we can categorize into three types; terrestrial image, airborne image, and satellite image.

2.1 Terrestrial Image

As a common type of image acquisition on the ground, digital camera, ground LiDAR(Terrestrial Light Detection and Ranging) can be considered. The image acquired by using ground payload has advantage that the image established can provide spatial information similar to the sight information of human. For terrestrial LiDAR, this sends laser with wavelength range of visual or near infrared spectrum, receives returning laser by reflecting from the spatial feature, with which measures the distance and accurate horizontal and vertical angle of laser beam, and converts the data into 3D coordinate. There are time of flight method and triangulation method for distance measuring method of 3D laser scanning. While triangulation method is to discharge laser to the target, and then determine the position by the inverse calculation with trigonometry for the reflecting beam formed on photoelectronic device(CCD), time of flight method is to discharge laser to the target, and then determine the position by calculating the time difference of reflected and retuning laser(Kim, 2008).

2.2. Airborne Image

Most of the platform acquiring Airborne Image are aircraft and satellite. However, oblique image can get much more information, as it acquires side image of building, tree, or others, whereas ortho image can acquire only top surface information of object when look at the building or tree from the air. For representative instance, Pictometry company takes images with system and generates and offers 3D space modeling data (Kim *et al.,* 2010).

This system consists of Laser Scanner, GPS, and INS. Among them, Laser Scanner is divided into distance measuring part and scanning part, which are integrated, operated, and controled through control part. Its principle is that INS measures the posture of sensor, GPS does for the location of sensor, and laser scanner does for the distance between ground surface and the sensor, and eventually determine 3D coordinate for the altitude on the ground.

2.3 Satellite Image

Meanwhile the spatial resolution of commercial satellite image is much inferior than that of aviation photo, thus it has been limited for science research areas including climate and environment, but with recent distribution of spatial resolution image which has sub meter level, KOMPSAT-2 is in operation in our country as well extensive high resolution images cross over the country have been acquired continuously. To improve user's visual interpretation and information providing service, many kinds of systems also provide 3D realistic screen by blending satellite image and DEM data using the stereo matching method of satellite image, LiDAR, and digital map.

With the improvement of spatial resolution satellite image, the hyperspectral satellite image that has hundreds of band, SAR image that can overcome some limitations of impact by cloud and rain. In the situation that the input/output interface of service systems provided in U-City and their utilizability as a core information have been increased according to advanced satellite image, we intend to examine the functions that can support the analysis of high resolution satellite image from U-City service system.

3. Spatial Height

Spatial height consist of contours, spot height, EDM and etc. Recently, DEM is preferred to others, because of integration with other geographic data and automation. In this paper, 3 major techniques of DEM generation are reviewed; Aerial photogrammetry, LiDAR and conversion of digital maps.

3.1 Aerial Photogrammetric Heights

The present procedures with up-to-date photogrammetric systems are as follows. The DEM generation using photogrammetric technique should start from scratch and a new DEM will be derived by means of at least two images, each one in several levels of resolution. The method and results with it are described in the literature, for example in Heipke (1995). Professional photogrammetric workstations contain elaborated software packages, and the photogrammetric practice uses the automated photogrammetric generation of DEMs on a routine basis with digitized images taken by analogue cameras or digital aerial photos. If a DEM already exists, its accuracy and completeness may also be improved. The existing heights are used as approximations in the generation of the DEM. The corrections to an existing DEM can also be derived from horizontal parallaxes between two overlapping image pairs. The process can be carried out automatically. This approach was first presented in Norvelle (1994) and further refined and tested by other authors. Both approaches have the following steps of production: Acquisition of images, aerial triangulation of images, DEM generation or DEM improvement, editing, and quality control.

3.2 LiDAR Heights

Principles of ranging with laser is using pulse and using phase difference. With phase difference, LiDAR measures round trip time and distance using CW(continuous wave) laser system which emit continuous light(Elaksher, 2008). With pulse, LiDAR measures round trip time and distance using higher energy than CW laser.

For the present, aerial laser mapping systems usually use pulse system. Aerial laser mapping system produces precision DEM by gathering 3 dimensional information of high resolution irregular point for earth's surface and its reflectance in digital form. The procedures of aerial laser mapping are divided in three parts. First step is convert aerial laser scanning data into 3D data, here position and attitude of laser sensor are determined by IMU (Inertial Measurement Unit), GPS, and point data with horizontal coordinate and vertical height are derived from post-processing. Second step contains converting the height of point data from ellipsoidal height to normal height, checking the errors, eliminating noises, and classifying points into earth surface, building and forest with filtering. Then, at last point data is interpolated to rasterized DEM and DSM (Digital Surface Model) (NGI, 2002).

Aerial laser mapping data is used as basic information for adding the height to building in construction of 3D city model. In legacy city model 2D building polygons are extruded to the building height. By adopting LiDAR, not only simple building model but also minute structures in rooftop can be modeled, precision and automation of 3D surface model is improved dramatically. By this reason large amount of 3D city model can be produced effectively (Jeong *et al.,* 2005).

3.3 Converted Height of Digital Maps

Generating DEM from contour lines is still one of the major methods to get grid DEM because of its low cost and the convenience to get contour maps. One of the most important parts of DEM building is interpolation. Watson (1992), Wood and Fisher (1993), Wood (1994), Li (1994) and Carrara *et al*. (1997) compared different algorithms of interpolation. Generally, generating DEM from contour lines are two distinct methods; One is DEM is generated directly from contour lines and the other is DEM is generated from TIN(Triangular Irregular Network).

In direct method, during generating DEM from contour lines, the vector contour lines generally need to be converted into raster model data before local interpolation methods can be used. In the implementation of GIS software, usually the elevation of a cell with only one contour line is simply assigned with the contour line elevation. We call this kind of cells single-value cell (SVC). Another kind of cell is the one with more than one contour line through it. We call this kind of cells multi-value cell (MVC). An effective method to deal with such kind of cells was given by Kunqing Xie *et al.,* (2003). And the elevations of the cells without any contour lines through, which are called no-value cell (NVC), are interpolated according to nearby SVCs and MVCs.

Using TIN method, TIN can be generated based on the geometry of the thiessen polygons. Thiessen polygons are generated from mass points in polyline of contours, points of spot heights and points in break-lines, then DEM is interpolated from TIN.

4. Spatial Data Integration

4.1 Data Preparation

For the 3D Terrain Analysis of satellite images, collect satellite images of target district according to the purpose and property of objects and use them after color-composite. Differentiate Road network files from Contour Line files of Digital Topographic Map, which was made to get DEM (Digital Elevation Model) of target district and use the suitable software for processing of collected topographic information. The three requisites, which should be primarily prepared for this study, are as follows: The initial file of the HDF formatted satellite image of target district captured by EOC sensor of Kompsat 1 and the IMG formatted satellite image of the same district captured by TM sensor of LANDSAT. The files of 1:5,000 topographic map made by NGI in Korea as a digital map and road's planned route data, the CAD files of road's planned route of the target district. Then survey the suitable s/w solution for integration of the vector and raster.

4.2 Procedure for Integration

After preparation of images and data, which is suitable for the purpose of this study, I got to find the precise geographic coordinate of target district on the images. For this reason, it carried out geometric correction using to make three images, which are different from each other in resolution, fit into geographic coordinate and after that, carried out close orthodox correction using TM coordinate, a geographic coordinate especially used for the current construction design. The basic map projection method for ortho correction image mapping is TM E002 Projection. And that is the map projection method being used by National geographic institute for mapping. For data Input, The primary satellite image used in this study is the image from Kompsat 1. The HDF formatted panchromatic Band 1 captured by EOC sensor, and calculate the orbit information of the moving satellite. And then, for DEM creation, the convert DXF formatted file of 1/5,000 topographic map to raster image file. After format conversion, you can create DEM. For ortho-projection correction image mapping, it processed of collecting GCP. To get precise ortho-correction image, it collected coordinate values of GCP corresponding to specific points of satellite image using files of 1/5,000 topographic map and DEM files. In this study, once it found the location of a fixed construction such as a building roof, end point of a bridge and a corner of road, it could get TM coordinate and the altitude of the construction on digital map. And the correction estimation was to create ortho-projection image, it carried out the following two corrections use of BAM(Bundle Adjustment Method) for estimation of exterior orientation using GCP.

Table 1. Matching point of image and map for GCP

GCP	Col. (x)	Row (y)	X coord.(m)	Y coord.(m)	h (m)
G001	262.0	362.0	129722.9323474	404132.4205284	256.005
G002	186.0	419.0	129302.1066103	403677.9346743	244.722
G003	229.0	238.0	129318.4339672	404912.2170734	257.712
G004	376.6	429.3	130570.0526935	403826.6145471	251.024
G005	395.6	222.5	130376.9777344	405205.1795519	278.005
G006	353.4	512.5	130547.2260974	403245.3045438	251.908

4.3 Perspective Image Mapping by Projection View

In this study, Perspective Image Mapping model was made through the composition of various files to express in perspective mapping programs. To describe it briefly, the process is as follows; Inputting RGB channel, DEM channel and vector layer through program module creating projected image through Image Projection Algorithm of perspective module showing the results on the computer screen through view module creating the files of 3-D perspective image map (Yeon *et al.,* 2007).

Perspective Image Map that is supposed to be made through this study is a 3D Image viewed from 45 angles in the four cardinal directions.

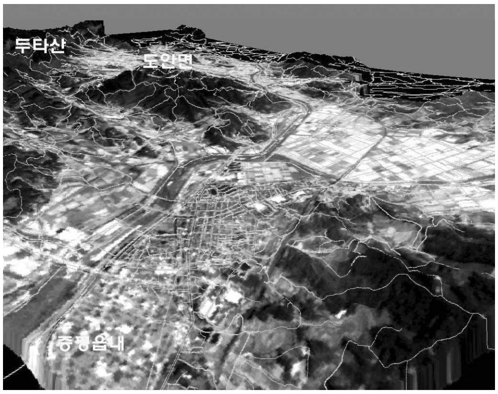
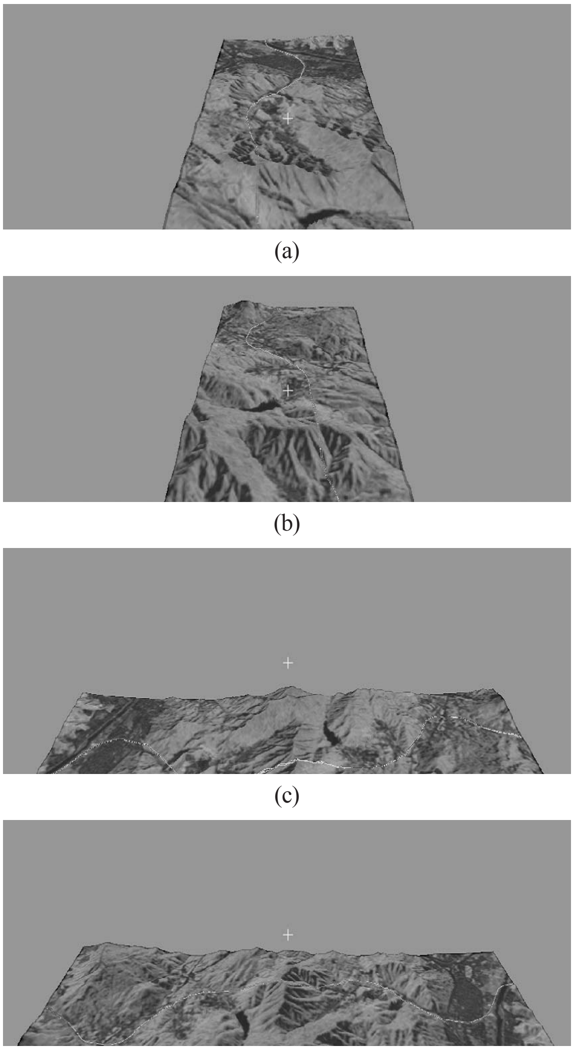


Fig. 3. Perspective image (EOC-1) from the east.



(a)

(b)

(c)

(d)

Fig. 4. Perspective views; (a) east (b) west (c) south (d) north.

4.4 The integration and application test result of urban spatial aerial photo, the laser data

When the high resolution digital camera was mounted in an aircraft and the aerial photograph was performed in the second ten days of a month in April 2008 and the exact map image was prepared through the minute investigation correction work in order to take a photograph the topographical space information of the urban space in which it go on living most precisely.

The spatial resolution of a terrestrial was done by 1m and it synthesized in RGB, that is the 3 channel of the light, and the color photo was produced. The Laser measurement about this region was conducted in the public and the slant distance

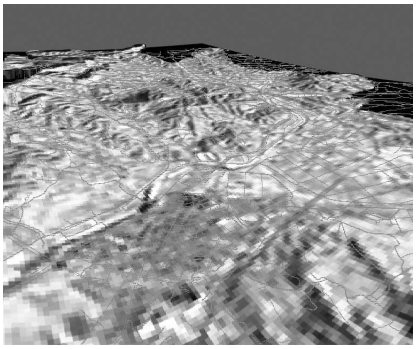


Fig. 5. 3D Perspective view from the east.

about each lattice point was obtained length and breadth about 10m and it converted to the vertical gap and it produced at DEM.

The elevation value of DEM in which it is vertically converted on the hardness at the aerial photo of the orthogonal view, and the horizontal coordinates of the latitude with the point-to-point mapping value was connected and 3D topographical space was produced and the seeing through air view after the aerial photo of the test objects region and DEM matching were freely reflected in the angular orientation (Fig.6 and 7).

Fig. 6. Aerial photo (1m).

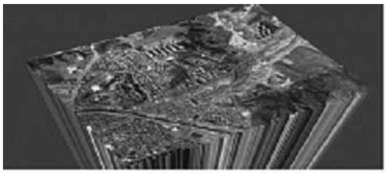


Fig. 7. Perspective image.

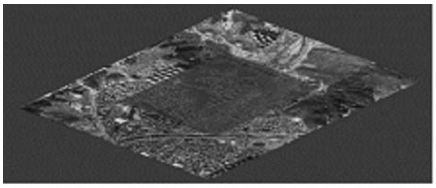


Fig. 8. Laser scanning with aerial photo(10m grid).

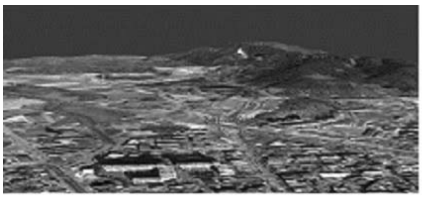


Fig. 9. Perspective image after matching aerial photo and digital elevation maps

By using elevation data by the laser scanning grid view in which it can produce the perspective view analysis, the seeing through birds eye view, and the earth-volume estimate for the three-dimensional terrain analysis of the test objects region, and then the plan cross-sectional view was produced from the aerial photo (Fig.8, Fig.9, Fig.10).

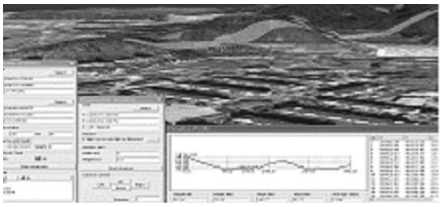


Fig. 10. Terrain Cross Section volume from 3D perspective integration result image.

5. Conclusions

Recently in the local government, it is interested in the U-city business of construction. The U-city business, that is the kernel of the digital age, is promoted to establish the goal of the U-city construction in which many local governments can improve the quality of life of a citizen. Firstly existing data, including the topographical elements, are collected to apply a lot of 3D spatial information for the corresponding U-city applications. From such collected data, the unnecessary archaic investigation and work load can be reduced. In case of Korea across the country 3D spatial information having been used for building the wire/wireless communication facilities and sensor network using the completed digital topographical map and data of the aerial photo. Especially, in 3D U-city, since 3D graphic model is minute about a part of the specific area, it is reconstructed and can be provided for a Ubiquitous Sensor Network (USN) if necessary (Wilson, 1989). Since there are many cases that fuse the various raw spatial information with other information, it is required to provide a service for the modeling work of the delicate topographical space. In case of that, it is usable for an enterprise of intelligent national land information from many sides.

Accordingly, it is determined as the most optimal information gathered. In addition, it means that collects the spatial information of the high density with high precision like the aerial LiDAR for a production and that utilizes more efficient of a 3D U-city and it is one of the most ideal method for serving the recent 3D space cities (Yeon, 2009). Because of the topography simulation technique, general analysis modeling of three dimensional spaces is able to feel the stereoscopic perception in the moving picture of a real time basis rather than the plane landform analysis. Various graphics and the region scenes are suitable for establishment and design of the community development plan. 3D method for simulation of this kind for the topographical space changes under the given condition provides more reality of movement feeling and 3D simulation of such topographical space shows the quick simulating method to process an image. In addition, it will be expanded to our construction over whole industries and it let us lead the real life freely in three dimensions.

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