FUSION OF LASER SCANNING DATA, DIGITAL MAPS, AERIAL PHOTOGRAPHS AND SATELLITE IMAGES FOR BUILDING MODELLING

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ABSTRACT For a quick and accurate 3D modelling of a building, laser scanning data, digital maps, aerial photographs and satellite images should be fusioned. Moreover, library establishment according to a standard structure of a building and effective texturing method are required in order to determine the structure of a building.

In this study, we made a standard library by categorizing Korean village forms and presented a model that can predict a structure of a building from a shape of the roof on an aerial photo image. We made an ortho image using the high-definition digital image and considerable amount of ground scanning point cloud and mapped this image. These methods enabled a more quick and accurate building modelling.

KEY WORDS: Laser scanning, 3D building Modelling, data fusion, 3D frame Building Library

1. INTRODUCTION

Building modelling is an essential task in the establishment of cyber city for city planning, management, and various applications. Building reconstruction may be performed by a photogrammetric procedure using aerial stereopairs. A number of researches have shown the approaches of combine data for building modeling, e.g. (Liang-Chien Chen,2004) THREE-DIMENSIONAL models of the urban environment are required for a variety of tasks such as urban planning, network planning for mobile communication, tourism information systems, and spatial analysis of air pollution and noise nuisance. The development of algorithms to automatically reconstruct 3D urban models is an active research area in photogrammetric and computer vision disciplines. For a long time, the only data source used for this research were digitized aerial photographs. More recently, advancements in airborne laser scanning (LIDAR) enabled the acquisition of dense point clouds. With point densities of up to several points per square meter laser scanning data have become a valuable additional data source for the reconstruction of building models. (Vosselman 2002)

In many previous researches, the given goals were combined by compounding the aerial photograph images, satellite images, LiDAR data, digital map, and surveying data. However, automated modelling is still not being practiced, and the intervention of the operator is required in many parts of the work. Recently, with the distribution of Laser scanners, terrestrial LiDAR measurement is being actively conducted, being used for three dimensional modelling of precise side-walls of buildings. LIDAR (LIght Detecting And Ranging) and aerial image (Rottensteiner and Jansa, 2002), LIDAR and three-line-scanner image (Nakagawa, et. al., 2002), LIDAR and high satellite image (Guo, 2003), LIDAR, aerial image and 2D map (Vosselman, 2002).

In this research, the aim is to experimentally accomplish a three dimensional modelling regarding the buildings and residences in the Multi-functional Administrative City region, which is being pursued in a national level. A 1:1000 dimensional map, IKONOS satellite image, aerial photogrammetric map, and on-ground LiDAR data were used. Especially, since the aerial photogrammetric map includes three dimensional information about the roofs of the buildings, the efficiency of the modelling is greatly enhanced.

2. STUDY AREA

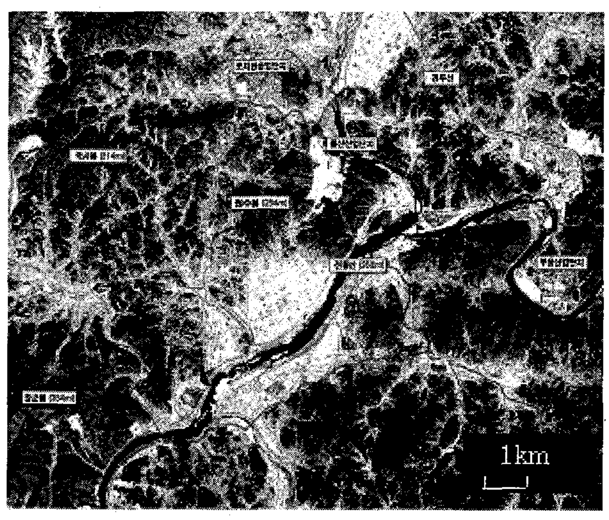


Figure 1 The KOMPSAT1 image of study area

About 72.6 in the Yeonki-gun area of Chungchung nam-do.(11.2km*9.8km). Lower left(220023.1319m, 328988.3876m) upper right(231269.8366m, 338805.0119m) region with the ITRF2000 coordinate system based on GRS80 ellipsoid. Figure 1 is the image of the target region, taken from KOMPSAT No. 1.

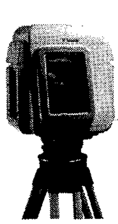
3. DATA PREPARING

3.1 Digital Map

The contour line layer was extracted from the digital map, using a 1:1000 digital map of the target region and the aerial photogrammetric map. From the aerial photogrammetric map, the 3D data of the roof of the building was prepared, as well as the road, waterways, inclination conversion line layer for the break line process when generating the DEM.

3.2 Scanning Cloud Data

In the case of buildings, laser scanning was conducted regarding the Keumnam Bridge (total length 600m) as for typical farming village residences and structures within the region, and the Multi-functional Administrative City Construction Agency(MACCA) for buildings. Trimble GX 3D and Optech ILRIS-3D each were used for the scanning. (Figure 2, 3) The completed model must be compounded with the 3D topography model, and therefore the coordinate system must be in accor-dance; for this, the scanning network of the three regions in the DGPS mea-surement techni-que was used.



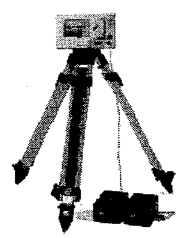


Figure 2 GX3D Figure 3 ILRIS-3D

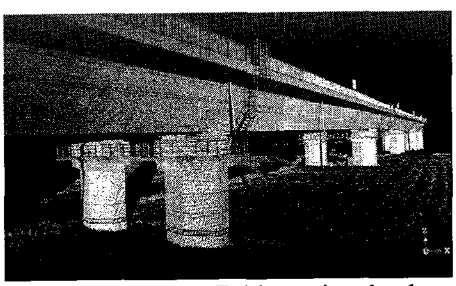


Figure 4 Kumnam Bridge point cloud

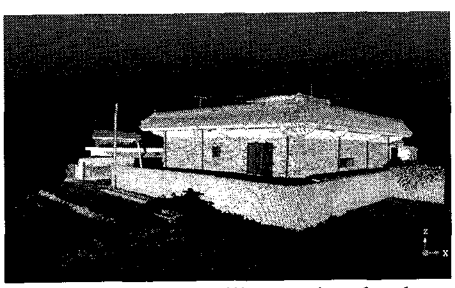


Figure 5 Country village point cloud

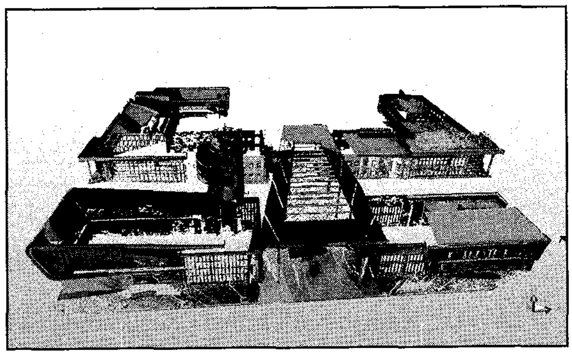


Figure 6 MACCA bulding point cloud

Figure 4 and 5 are the point cloud obtained by scanning with the Optech scanner, and Figure 6 is the result of scanning with the Trimble scanner. While Figure 4 and 5 only contain intensity information, Figure 8 includes color information. With the existing scanners, only intensity information could be obtained, but the recent new scanners enable the user to obtain color information as well, enhancing the efficiency and reality of the modelling work.

3.3 Satellite Image

The IKONOS image and the 1:20,000 color ortho photos were used. The entire target region was coated with the IKONOS image, and the aerial photo image was used only for specific regions. This was for comparing the resolution and preciseness after completing the 3D topography model, and to evaluate the economic efficiency as well as its reality.

4. DEM GENERATION

The contour layer, roads and waterways layer were extracted from the 1:1000 350 digital map(1:1000) for the establishment. Due to the limit of the PC, the whole was divided into 6 zones, and DEM rasters were made for each of them. The work was completed by compounding them. (on the Dell Precision 690 workstation)

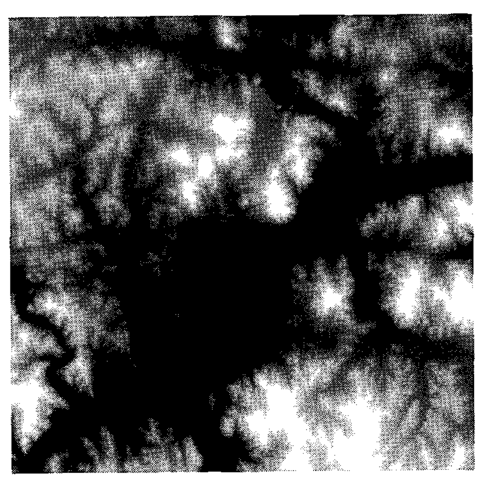


Figure 7 DEM Generation

5. CLASSIFICATION OF BUILDING STRUCTURE

For a more efficient 3D modelling of the buildings, there was an attempt to classify the structures of the buildings in the target region. About 300 buildings were designated as the sample region, and were classified into 10 groups: A~I and others. The F type contained 106 households, followed by C→B→H→G→E→A→D →I→etc.

Table 1 The number of building type

Type	A	B	C	D	E	F	G	H	I	etc	Σ
The#of	9	45	61	5	16	106	25	27	4	2	300

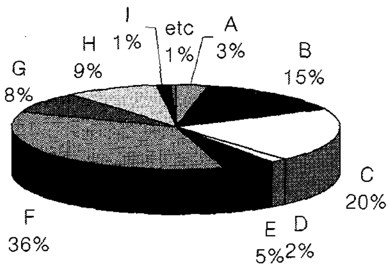


Figure 8 The ratio of each building type

Figure 8 shows the proportions of each type. The F type showed 36%, and the least, the I type, was 1%. Figure 9 is the form of the roof shown in the satellite image and the actual view of the residence, photographed on-ground. Here, it was possible to implement the concept that enables the prediction of the 3D structure on the ground, in the form of the roof

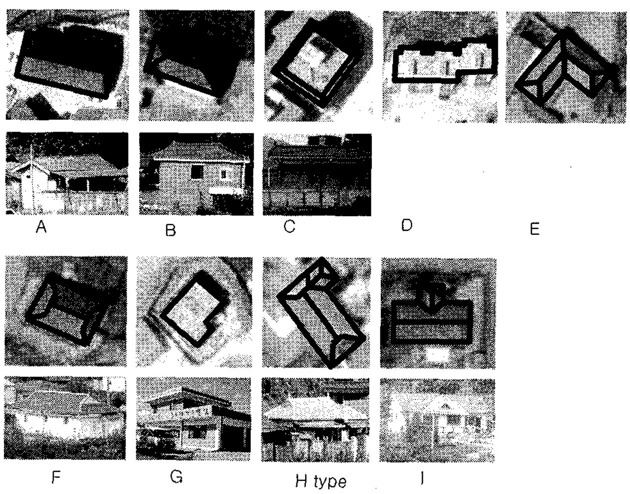


Figure 9 Buiding Classification

6. BUILDING 3D MODELLING

By researching the form of the roof shown in a aerial image and the on-ground structure simultaneously, it was possible to construct a building structure DB by using their correlations.

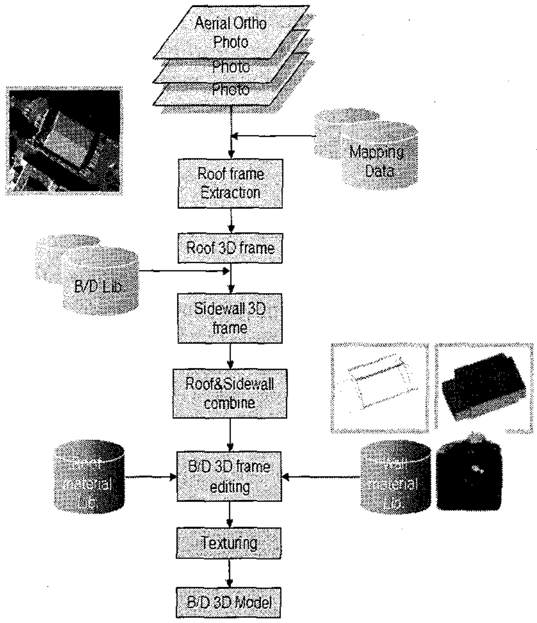


Figure 10 Work flow of building 3D modelling

In other words, the roof and the walls were built separately in the modelling process. 3D information regarding the roof may be obtained from the aerial phorogrammetric map for making the digital map, and as for information regarding the walls, the information in the DB can be called up and compounded with that of the roof through simple editing. That is, it is possible to obtain a 3D frame like the one shown in Figure 10. Detailed modelling of the side wall can be done with the laser scanning data, and the texture of the outer wall of the building, photographed with a digital camera, can be textured on it.

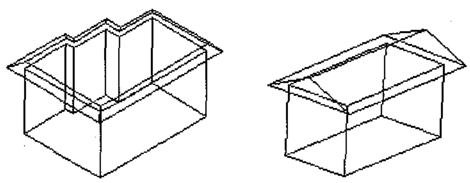


Figure 11 Building 3D frame

6.1 Modelling of the MACCA building

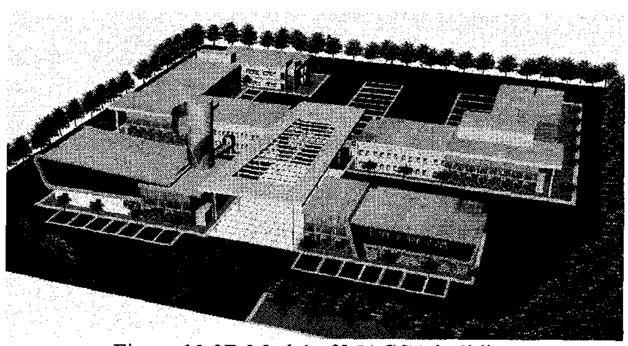


Figure 12 3D Model of MACCA building

The point cloud obtained by laser scanning is compounded within the same coordinate system by the GPS network, and was modeled with the Trimble 3D Resource® modelling software. Figure 12 shows the 3D model of the MACCA building

7. BUILDING 3D MODELLING

A terrestrial 3D model was built as shown in Figure 13, using the 1m DEM and IKONOS image obtained from the 1:1000 digital map. The figure shows the 3D model of the Construction Agency of the Multi-functional Administrative City on the respective coordinates location, made in the previous step. (Figure 14)

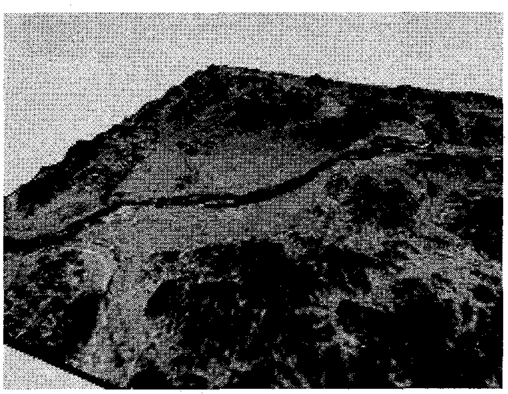


Figure 13 3D model using KOMPSAT image

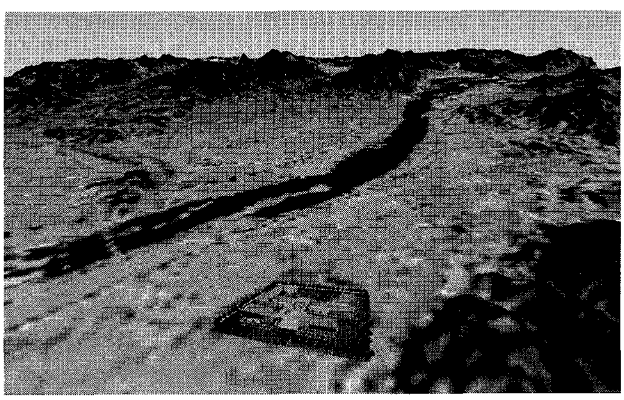


Figure 14 Combined Terrestrial 3D model and MACCA building model

8. CONCLUSION

1) The scanning point was determined with the GPS network for the building's 3D modelling, and the point cloud set was compounded to the identical coordinate system.
2) The shapes of the buildings regarding the respective sample area were classified through statistic analysis, and the possibility of building a 3D frame DB in connection with the on-ground 3D structure was confirmed.
3) A real 3D model was built by using high resolution DEM and high resolution satellite image. It was compounded with the building's 3D model.

ACKNOWLEDGEMENT

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