

# CREATION OF DIGITAL CITY MODEL FROM A SINGLE KOMPSAT-2 IMAGE

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**ABSTRACT** ... A digital city model represents a 3D environment of a city with various city object information such as 3D building model, road, and land cover. Usually, at least two satellite images with some image overlap are necessary and a complex satellite-related computation needs to be carried out to create a city model. This is an expensive technique, because it requires many resources and excessive computational cost.

The authors propose a methodology to create a digital city model including 3D building model and land cover information from a single high resolution satellite image. The approach consists of image pan-sharpening, shadow recovery, building occlusion restoration, building model extraction, and land cover classification. We create a digital city model using a single KOMPSAT-2 image and review the result.

**KEY WORDS:** Digital City Model, KOMPSAT-2, Building Extraction, Occlusion Restoration, Shadow Recovery, Classification

## 1. INTRODUCTION

During the past few years, improvement in resolution has broadened the number of applications for satellite images to include areas such as GIS database construction and updating. Creation of a Digital City Model (DCM) from high resolution satellite imagery is an active research topic. DCM is an accurate representation of a city in a 3-D environment, including 3D building models. It is used in a variety of applications such as simulation and training systems, visualization, telecommunication planning, maintenance and analysis. Chan (2005) generated a DCM of Beijing city through combination of various data such as QuickBird images, aerial photos, and thematic maps. Poli (2006) generated a 3D city model using Cyber City-Modeller (CCM) and stereo aerial photos and stereo QuickBird images. Typically, at least two satellite images with some image overlap are necessary and combinations of satellite-related computations need to be carried out to arrive at a satisfactory result. This is an expensive technique, mainly because it requires significant resources. Paul (2006) proposed a DCM creation methodology using a single off-nadir high QuickBird image.

We aim to create a DCM including 3D building model and land cover information from a single high resolution satellite image from KOMPSAT-2. The methodology consists of image quality enhancement, building and shadow extraction, and land cover classification. In order to enhance the image quality, we performed a pan-sharpening, a shadow recovery, and a building occlusion restoration. 3D building model was extracted based on the Triangular Vector Structure (TVS) hypothesis (Kim, 2006). Then, land cover classification with segmentation was applied to the non-building area of the image. A DCM can be generated by integrating the land cover map

and the 3D building model. The entire workflow is illustrated in Figure. 1.

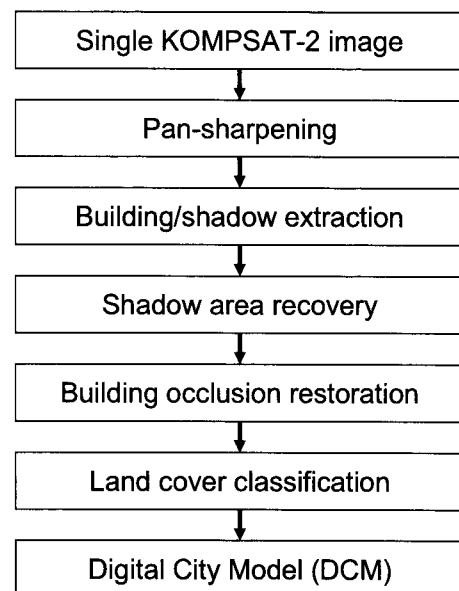


Figure 1. Flowchart

## 2. BUILDING AND SHADOW EXTRACTION

To enhance the image interpretation, a high resolution multispectral image is created from a panchromatic image and multispectral image. In our approach, we used the pan-sharpening module of the PCI Geomatica. The 3D building model and shadow region are extracted semi-automatically using TVS hypothesis. Its basic concept comes from this fact: the triangle consisting of each building's bottom point, its corresponding roof point and the shadow end point are always similar to one another in a single satellite image, because the altitude of the satellite and the sun are high enough to assume their

projection angles are in parallel. Through this, we can extract the building model information including height and 2D footprint, and shadow region. In this approach, we extracted the buildings that were larger than 100 square meters.

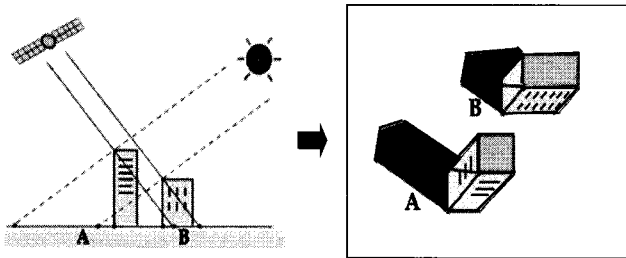


Figure 2. Conceptual diagram of building extraction

### 3. SHADOW AND BUILDING OCCLUSION RESTORATION

The building shadow in the high resolution satellite imagery interrupts image analyses such as feature extraction and classification. We performed shadow recovery by linear stretching and edge smoothing. The non-shadow area used as reference for recovery was obtained using morphological filtering of the shadow region. Then, shadow pixels were stretched linearly, based on the mean value of the surrounding non-shadow area; the shadow edges not bordering the building were smoothed.

In order to restore the occlusion caused by lying building on the image, we applied the inpainting method to the occlusion area. Image inpainting is the algorithm to remove certain parts of an image, scratches on a photo or unwanted occluding objects (Bertalmio, 2000). Among the various inpainting methods, inpainting based on the Fast Marching Method (FMM) was used in our approach (Telea, 2004). The FMM inpainting is appropriate for large images because the calculation is simple and fast.

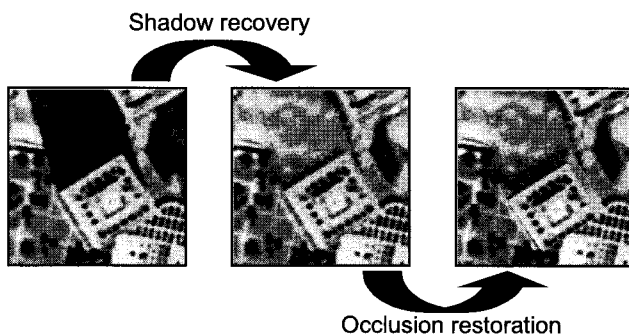


Figure 3. Shadow recovery and occlusion restoration

### 4. LAND COVER CLASSIFICATION

From the results of the building shadow and occlusion restoration, the area except for the buildings is classified to generate the base land cover map of the DCM. The general classification methods using only multispectral information are not fitted to the high resolution satellite

image, due to the complex spatial arrangement and spectral heterogeneity. For this, we carried out Maximum Likelihood Classification (MLC) with 6 classes including water, grass, road, tree, small building area, and bare soil. Then, the land cover map was obtained by integrating the MLC result and segmentation image of the original satellite image. The DCM can be created by integrating of the land cover map and the 3D building model.

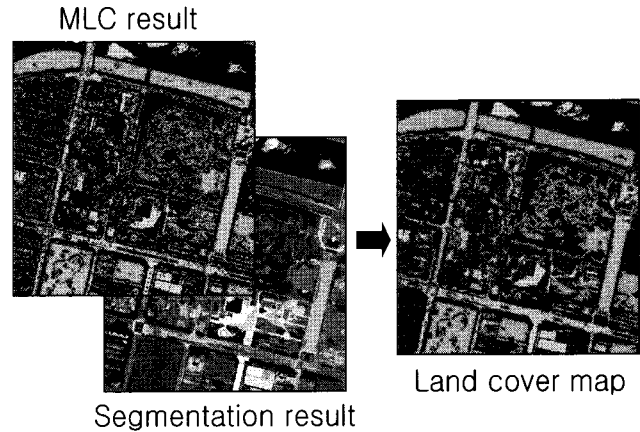


Figure 4. Land cover classification

### 5. EXPERIMENTAL RESULTS

To evaluate the suggested methodology, we applied it to a single KOMPSAT-2 image, which was acquired 31<sup>st</sup> August, 2007 in Daejeon, Korea.



Figure 5. Test Site

By overlaying the 3D building model on the land cover map, we could create the DCM of the test site. By assigning a height value to each of the buildings it is possible to generate a 3D effect with a fly through mode as shown as Figure 6. The DCM include all of the information as much as possible to get from a single high

resolution image, such as 3D building information and land cover attribute

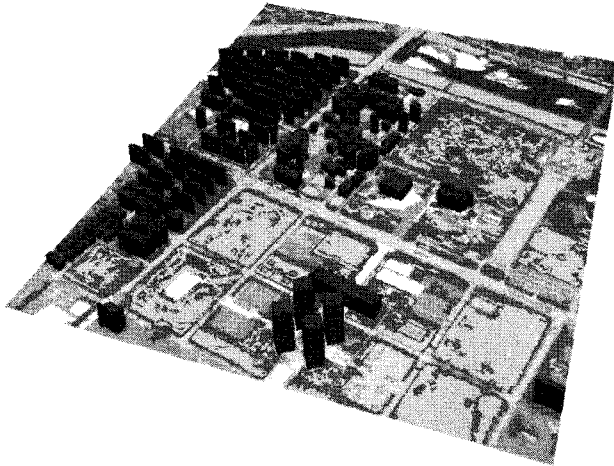


Figure 6. Digital city model

## 6. CONCLUSION

In this paper, we propose a useful methodology for DCM generation using a single off-nadir high resolution satellite image of KOMPSAT-2. With our experimental results, DCM can be created by incorporating several manual and semi-automatic techniques including building model extraction, building shadow and occlusion restoration, and image classification. This method provides a cost effective alternative to the use of multiple satellite images or aerial photography, as processing time is shorter since there is no need to perform complex algorithms or computations. The generated DCM can give a true representation of the ground that is free from building lean and shadow effects.

In order to evaluate our approach, it is necessary to apply it to more varied sites and estimate the accuracy of the 3D building model and land cover classification. Moreover, we aim at development of classification method using ground feature information to enhance the quality of the land cover map. These are now the topics of our ongoing research.

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