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Digital Plotting with KOMPSAT-1 EOC Stereo Images using Digital Photogrammetric Workstation

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Abstract : In 1999, Korea has become a country that holds Earth observation satellite in orbit as they had succeeded in the launch of KOPMSAT-1, the first Korean Earth observation satellite for the practical purpose. For the wide application of the satellite imagery, various application techniques are required, and topographic mapping is essential technique for the application in various fields. Moreover, considering that the main mission of the KOMPSAT-1 is to provide the satellite imagery for the mapping of Korean peninsula, the topographic mapping using KOMPSAT-1 EOC imagery is very significant.

In this paper, we showed the possibility of digital plotting using KOMPSAT-1 EOC stereo images to produce topographic map. For the purpose, we implemented experimental stereo plotting using digital photogrammetric workstation and analyzed the procedure.

As a result of this paper, we showed that some elements consist in 1:25,000 scale map can be plotted from KOMPSAT-1 Stereo images.

Key Words : Plotting, Topographic Mapping, KOMPSAT-1, Digital Photogrammetric Workstation.

1. Introduction

KOPMSAT-1 was developed and launched in December 1999 by Korea Aerospace Research Institute. The satellite has three sensors including EOC, 6.6 m high-resolution electro-optical camera. The main mission of KOMPSAT-1 is image collection for the mapping of Korean peninsula and monitoring of worldwide oceans and data collection for the investigation of space environment. Also, KOMPSAT-2 with 1m high-resolution camera is planned to be launched in 2004 (Korea Aerospace Research Institute, 1999).

As the satellite design and assembly techniques were secured, Korea can cope with the dependencies on the foreign satellite imagery to acquire topographic information. However, various application techniques are still needed to apply the images acquired by KOMPSAT-1 and KOMPSAT-2 to the various fields such as land management, resource monitoring, national defense, etc. Topographic mapping will be one of the most essential techniques among the various application techniques (Jeong *et al.*, 2000).

High resolution satellite images on the wide area can be acquired more repeatedly and economically compared to the aerial photos (Fritsch and Stallmann,

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2000). Moreover, satellite can acquire images for the inaccessible area. So, the mapping with satellite imagery prospects well in R&D and market (Fraser, 2000).

Stereo plotting with aerial stereo photos using analytical plotter have been the most popular method in topographic mapping (Kraus, 1993). However, only film format images can be used in analytical plotter. So, digital images cannot be applied by the system. Satellite images in digital format could be photogrammetrically processed only after the advent of digital photogrammetric workstation (DPW) (Schenk, 1999).

Until now, many countries including Korea have developed the mapping techniques using satellite imagery such as SPOT stereo imagery (Orun and Natarajan, 1994) and almost all of them have shown the possibilities to produce maps from satellite imagery through digital elevation model generation, thematic feature extraction, etc. in allowable accuracy (Chen and Lee, 1993). The mapping processes and standards for satellite images has not been well defined compare to the conventional aerial photographs. Only a few methods and possibilities were presented and standard processing or workflow has not been fixed yet. So, experimental research is needed to check out the possibility of three dimensional plotting of KOMPSAT-1 satellite stereo images and to setup the standard process of stereo plotting for topographic mapping.

In this paper, we tried the experimental stereo digital plotting in 1:25,000 scale using DPW to investigate the possibilities and verify the extents of the use of KOMPSAT-1 images in topographic mapping.

2. Data and Experiment

1) Stereo Images and Ground Control Points

The Object area of the KOMPSAT-1 stereo images was Pusan. Table 1 shows the specification of each image.

Table 1. Stereo image specifications.

Area		Acquisition Day	Incidence angle
Pusan	Left	1/May/2000	-18°
	Right	28/Apr/2000	12°

As shown in Table 1, the time span of stereo images were 3 days and that's very good condition in general. The quality of the images was categorized by brightness, contrast and noise, and each category was measured in the 4×2 divided areas in each image. As a result of the measurement, there was no problem in the image quality except that contrast was somewhat poor. But the problem could be resolved by adjusting the contrast using the image processing function of the DPW(Socet Set®) used in this research.

The topography consists of 42% urban area, 35% mountainous area, 15% farmland, and 9% water system.

The number of GCPs(ground control points) was 26 and they are achieved by GPS surveying. The datum was WGS84 Ellipsoid and the projection was UTM. 20 Check points was achieved from 1:5,000 scale digital map to estimate the accuracy.

2) Digital Plotting Procedure with KOMPSAT-1 Satellite Images

To setup an adaptive digital plotting method for KOMPSAT-1 EOC stereo imagery, two points of view should be considered; qualitative view and quantitative view.

In the qualitative view, interpretability of the image should be considered. Interpretability means the possibility of feature extraction. High interpretability affords to extract more features from images and the plotting result will have more rich contents. In general, stereo viewing enhances the interpretability in comparison with the single image viewing.

In the quantitative view, stereo image modeling is required to enhance the positioning accuracy. Because there is no DPW to handle the KOMPSAT-1 EOC ancillary data, only mathematical method such as DLT(Direct Linear Transformation), polynomial modeling and RFM, can be applied. So, the DPW that supports those math models can only be used in our research. Also the DPW should support the stereo feature collection functions based on the epipolar images.

In this research, we used Socet Set® system, developed by LH Systems. Three functions were needed for digital plotting of this research; image importing, stereo modeling and feature collection. Socet Set® system supports data import functions for not only almost all commercial Earth observation satellite but also general raster formats such as TIFF format. We can load KOMPSAT-1 images in HDF format on the display module in Socet Set® by converting the format into TIFF format.

Socet Set® system provides not only exclusive sensor models for specific sensors but also general mathematical models such as polynomial fitting, DLT, etc. to guarantee the processing of brand-new images. So, we can implement the stereo modeling of KOMPSAT-1 using DLT model of Socet Set®.

The Socet Set® feature collection pack includes hardware and software components. The feature collection and editing is implemented in the Bentley Systems MicroStation® GeoGraphics® environment. Three kinds of stereoscopic viewing hardware are supported; passive, active, wired. TopoMouse 3D control device of LH System was convenient to control the Socet Set® cursor.

3. Results and Discussions

1) Stereo Modeling

We used DLT model as a 3D modeling because Socet Set® system does not include rigorous geometric model for KOMPSAT-1 EOC like other commercial DPW. And, we used polynomial method to implement epipolar resampling for stereo plotting.

GCPs are used in 3D modeling. For the accuracy estimation, both GCPs and check points are all used. At first, only 6 points which is the least number of points for the DLT model were used. Then, the number of GCPs was increased finding the optimum number of GCPs. The position accuracies of GCPs and check points are best when the optimum number of GCPs are used, and no more GCPs would contribute to enhance the accuracies. GCPs are evenly distributed in the entire images because the accuracy of DLT is sensitive to the arrangement of GCPs. Check points are located far from GCPs because the position accuracy of check points are as low as the distance from GCPs is far.

As the result of this study, RMSE of position accuracy of GCPs was less than 1 pixel and those of check points was less than 2 pixels, when we use more than 10 GCPs.

2) Interpretability and Possibility of Dgital Plotting

The analysis on the interpretability and the possibility of digital plotting of KOMPSAT-1 satellite EOC image was based on the features from 1:25,000 scale map standard published by Korean National Geography Institute.

Interpretability was rated by 4 levels; I(Identify), B(Distinguish Between), D(Detect) and N(Not Detect), based on the NIIRS(National Imagery Interpretability Rating Scales) published by IMINT(Image Intelligence) in USA. Also, possibility of 3D plotting was rated by 4 levels; Complete, Almost, Occasional, and Impossible.

The total number of features to analyze was 76 excluding what are not visible on the images such as administrative district, and 43 features were classified to

Table 2. Analysis of imagery interpretabilities.

Grade	Identify	Distinguish between	Detect	Not Detect	Total
No.	20	15	8	33	76
(%)	26.32	19.73	10.53	43.42	100

Table 3. Analysis of possibilities of 3-D plotting.

Grade	Identify	Distinguish between	Detect	Not Detect	Total
No.	25	9	8	34	76
(%)	32.89	11.84	10.53	44.74	100

I, B and D from stereo images. Table 2 shows interpretabilities and Table 3 shows possibilities of 3-D Plotting

3) Digital Plotting vs. Auto-matching Technique

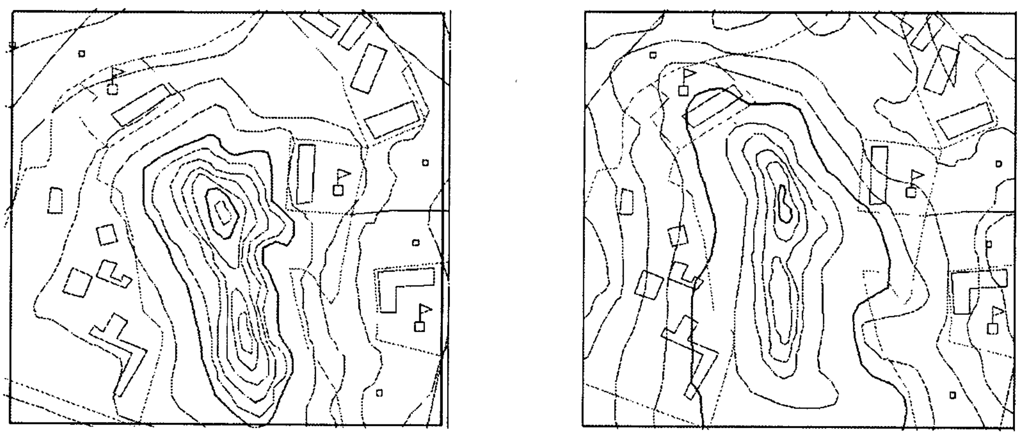
Two contour maps were generated; one is generated by digital stereo plotting and the other by auto image matching. Auto image matching was implemented using the image matching module contained in Socet Set® System.

Comparing the two cases, the contour map from digital plotting was matched well with real topography. That is, in case of digital plotting, contour lines were not affected by features on the topography. Also, the changes in the terrain were detected well during the digital plotting procedures. But in case of auto image matching, contour map had some noises, mainly affected by the high buildings. Also, the topographic changes were not fully reflected in the result. Two contour maps are presented in Fig. 1.

4) Plotting in 1/25,000 Scale

The result of stereo plotting is presented in Fig. 2. In this figure, we can see the fact that almost all main features of 1/25,000 scale map were described. Details of certain features are presented in Fig. 3 to Fig. 10.

Comparing detailed plotting result with the corresponding topographic map, we can find many changes in topography; new road, new building, cutting



(a) Contour by digital plotting (b) Contour by automated matching

Fig. 1. Comparison of contours between stereo plotting and automated image matching.

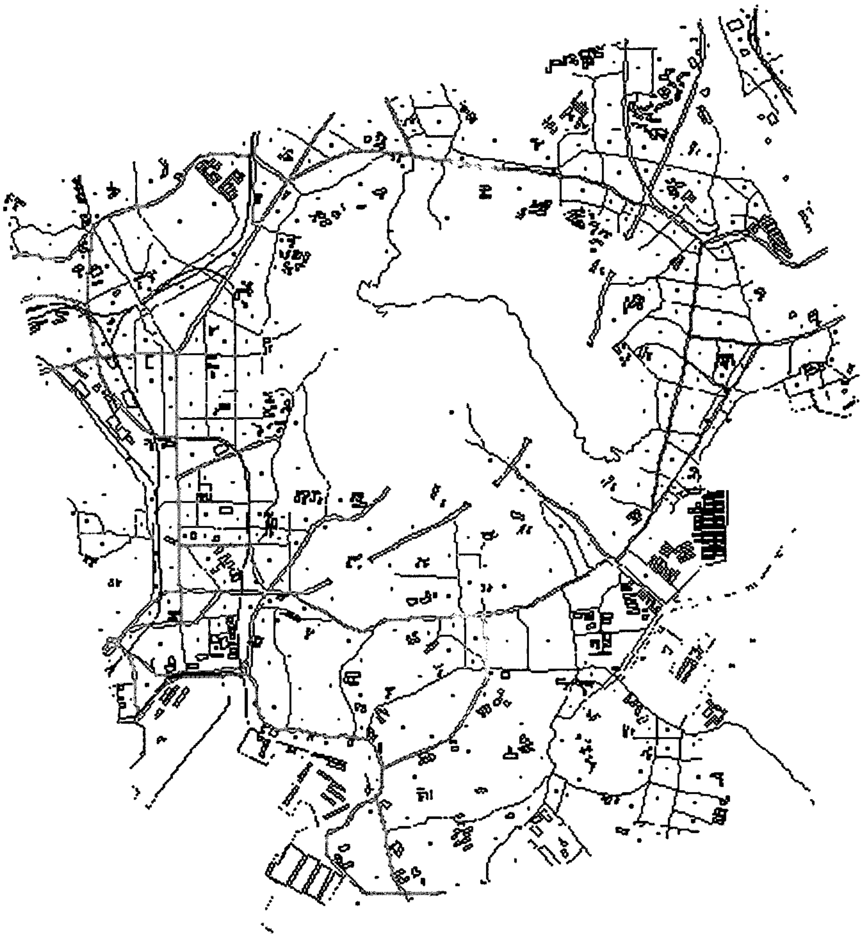
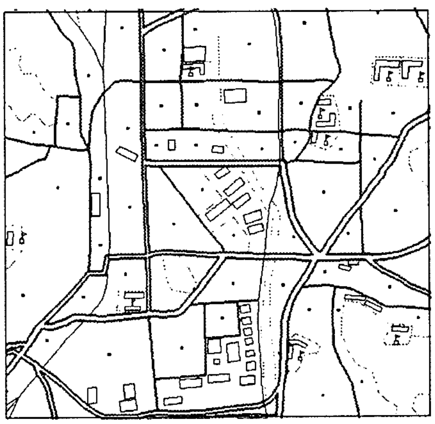
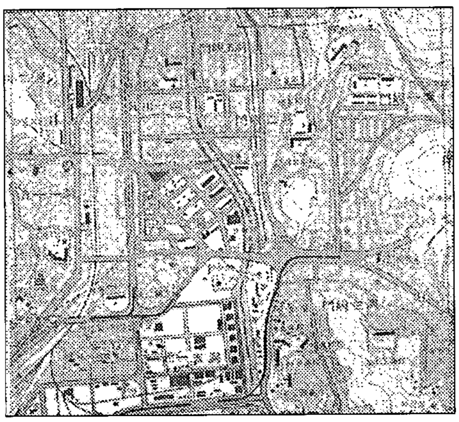


Fig. 2. Results of stereo plotting for PUSAN.

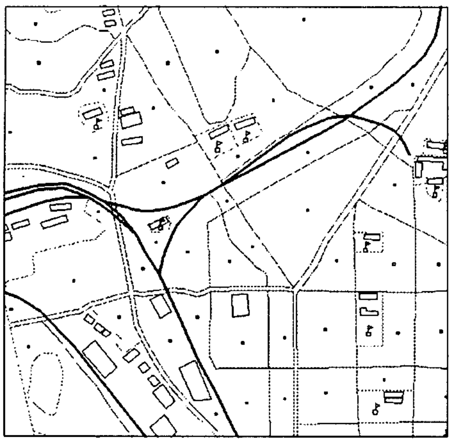


(a) Plotting result

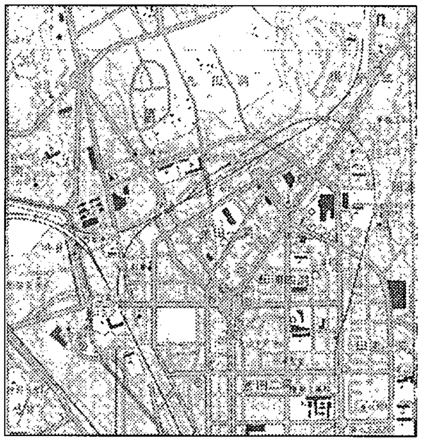


(b) 1:25,000 scale map

Fig. 3. Stereo plotting of road.

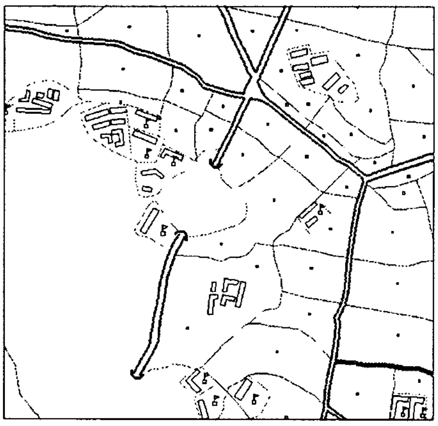


(a) Plotting result

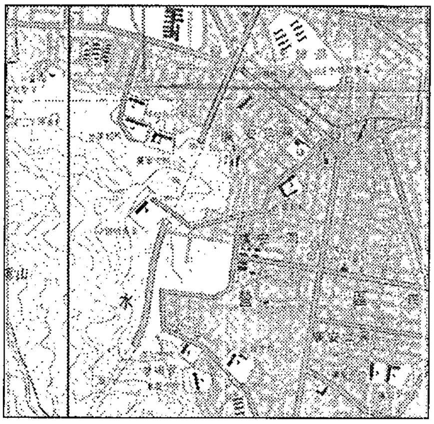


(b) 1:25,000 scale map

Fig. 4. Stereo plotting of railroad.

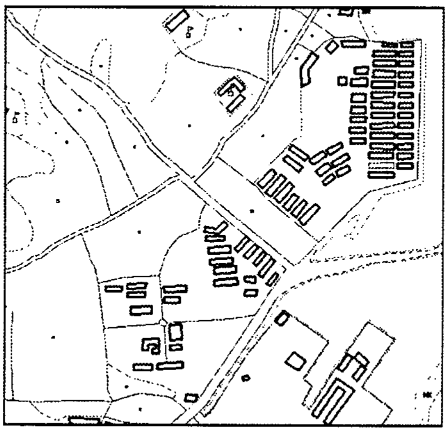


(a) Plotting result

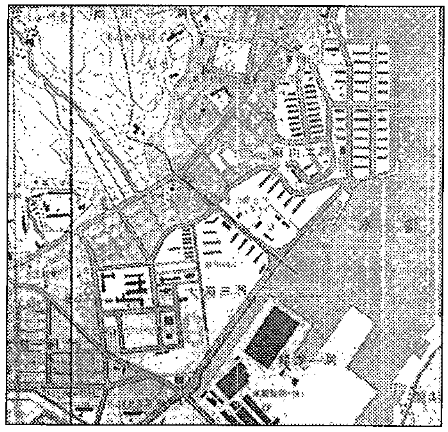


(b) 1:25,000 scale map

Fig. 5. Stereo plotting of tunnel.

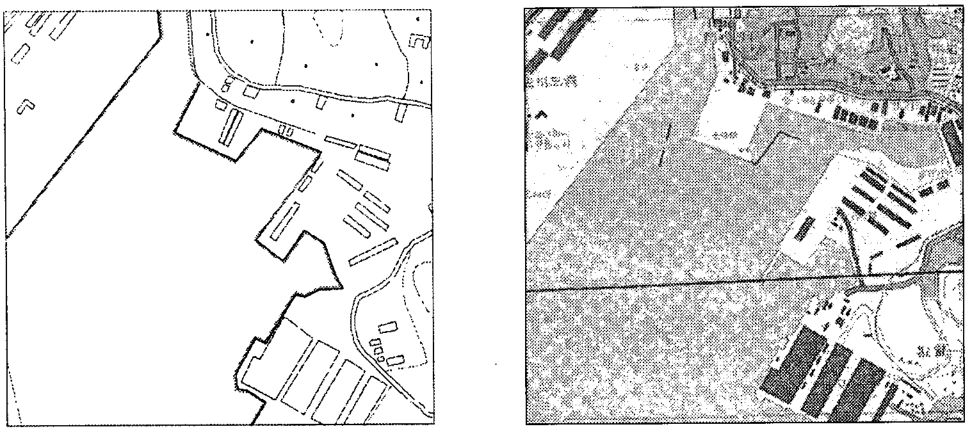


(a) Plotting result



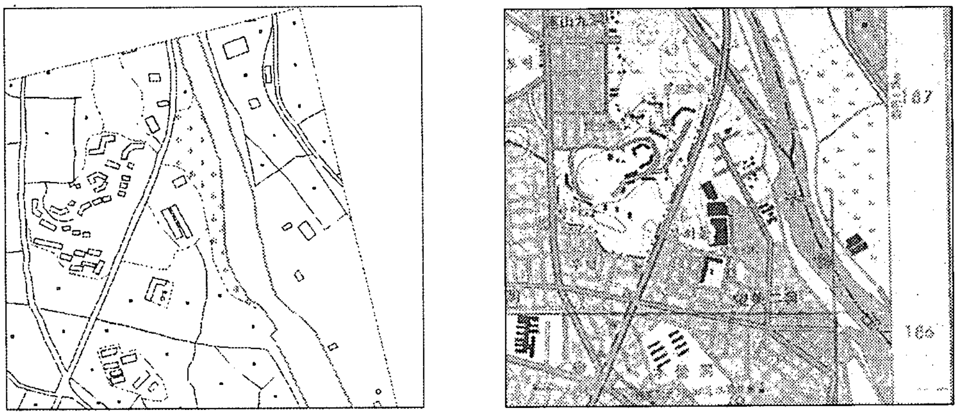
(b) 1:25,000 scale map

Fig. 6. Stereo plotting of buildings.



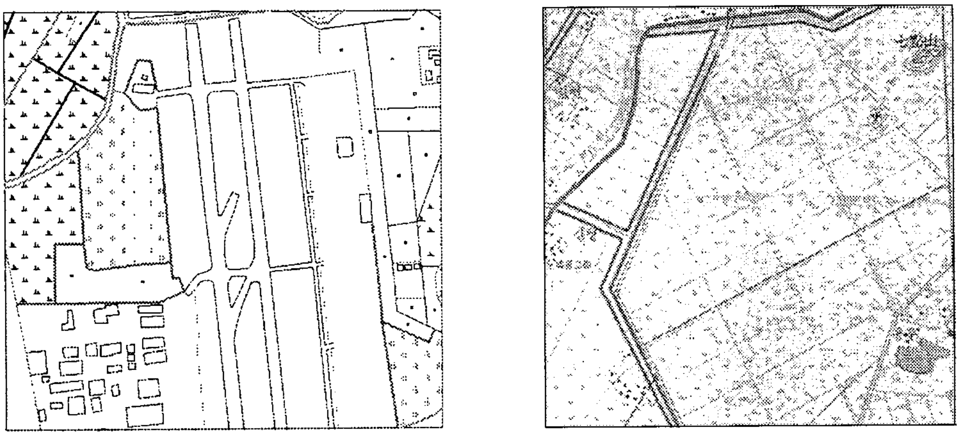
(a) Plotting result (b) 1:25,000 scale map

Fig. 7. Stereo plotting of harbor.



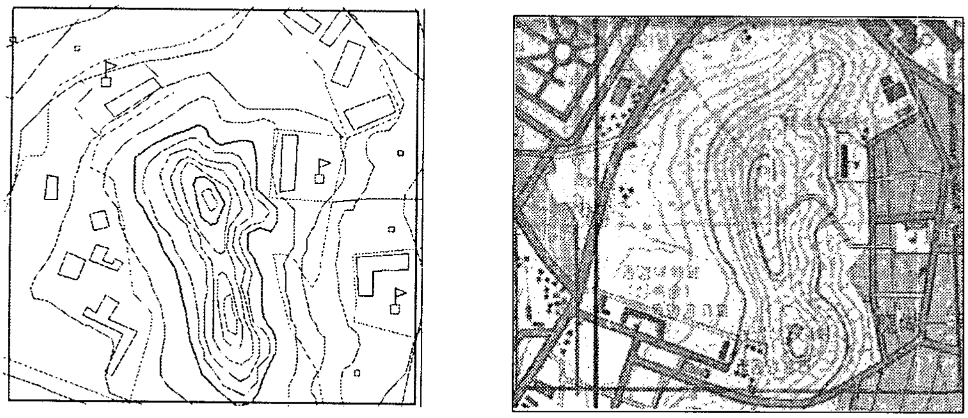
(a) Plotting result (b) 1:25,000 scale map

Fig. 8. Stereo plotting of river.



(a) Plotting result (b) 1:25,000 scale map

Fig. 9. Stereo plotting of farm field.



(a) Plotting result (b) 1:25,000 scale map

Fig. 10. Stereo plotting of contour.

of mountain, etc. In the figure 10, especially, the contours generated by digital plotting were very different from those on the 1:25,000 scale map. In this case, we can identify on the satellite images that the topography has been changed because of the cutting of the mountain. Maybe, the change has been made since the paper map had been produced. It demonstrates that the 1:25,000 scale map can be partially updated or modified by stereo digital plotting using KOMPSAT-1 images.

Some features that exist on the map could not be collected. It is mainly due to the short of interpretability, which is related with image resolution and radiometric quality. So, KOMPSAT-1 would only be possible to be used in small scale map update for some features.

4. Conclusions

In this research, we found that the positional accuracy of KOMPSAT-1 satellite EOC stereo image is well enough to update 1:25,000 scale maps. The interpretability and the possibility of 3D plotting was somewhat short comparing with the case of aerial photo. However, almost all main features could be interpreted and plotted and changes on topography also could be detected. Considering the advantage of periodical image acquisition of satellite, KOMPSAT-1 EOC imagery could be well used for frequent and partial map updating.

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