

DETERMINATION OF THE EXTRACT BASIN PARAMETER USING COMPSAT

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Abstract

Digital elevation models (DEMs) are generally used to automatically map the channel network and to delineate subbasins. The most common approach to extract a channel network from DEMs consists of specifying a threshold area, which is the minimum area, required draining to a point for a channel to form. The accuracy of a DEM is dependent on the spatial resolution, quality of the source data, collection and processing procedures, and digitizing systems. An important aspect of technique that seeks to extract hydrologically connected structures from DEMs is the manner in which data errors, particularly artificial depressions, are handled. Dividing ridgeline and hydrosphere from source data is essential to abstract geometric elements in hydrological analysis, and most hydrological factors are the function of area and length in geometric elements. Authors investigated the potential impact of error in DEMs on Kompsat (Korea Multi-Purpose Satellite) at extract basin. Korea Aerospace Research Institute (KARI) base on Korea National Space Program is developing a Korea Multi-Purpose Satellite that accommodates Electro-Optical Camera (EOC), Ocean Scanning Multi-spectral Imager (OSMI), and Space Physics Sensor (SPS). The main mission of EOC is the cartography to provide the images from a remote earth view for the production of 1/25000-scale maps of Korean territory. The purpose of this paper is first to study effect of the extract basin parameter on DEMs using Kompsat. The second objective is to get general laws describing the architecture of the drainage network independent of the scale observation.

1. Introduction

A DEM is a digital representation of sampled terrain, providing a measurement of elevation at specific ground coordinates. These measurements are sampled at regularly spaced intervals.

In recent years, Digital elevation models (DEMs) are currently one of the most important data used for mapping, urban planning, facility management, geological and agricultural research and many purposes. Unfortunately, DEMs of sufficient point density are still not available for many parts of the Earth, and when available, they do not always have sufficient accuracy. Since a DEM enables easy derivation of subsequent information for various applications, elevation modeling has become an important part of the international research and development programs related to geo-spatial data. Data used for generation DEMs is normally obtained by field surveys, GPS surveys, Photogrammetry, Satellite Remote Sensing, Airborne Laser Altimetry and digitizing of existing maps and plans. However, in most cases elevations are interpolated from digitized contour lines on pre-existing maps. Typically the contour lines on these maps are created from aerial photographs using photogrammetry. At present, most DEM data are derived from three alternative sources which are ground survey, photogrammetric data, digital map. Other methods occasionally used include RADAR, laser altimetry, and sonar. Especially, DEMs extraction from satellite radar data has been an active research topic of more than 20 years. The techniques to produce DEMs have been used in many fields along the rapid development of image acquiring techniques. It has been playing more important role in GIS and remote sensing field.

DEMs are generally used to automatically map the channel network and to delineate subbasin. The construction and application of distributed hydrologic model requires information over a spectrum of spatial scales. Generation of runoff within the subcatchment is influenced by the local hillslope profile. The hillslopes control the production of storm water runoff that is transported through the channel network towards the basin outlet. In short and intensive rainfall storms most of the runoff which, in turn, is transported through the channel network towards the basin outlet. In short and intensive rainfall storms most of the runoff is generally contributed by either Hortonian overland flow or by direct precipitation into the saturated areas around the channels. In large catchments, routing of the distributed subbasin runoff through the channel network may dominate the form and timing of the outflow hydrograph and play an important role

in determining the geomorphologic unit hydrograph of a basin; the main parameters are the length and the slope of each stream and the area drained at each point. The geomorphologic instantaneous unit hydrograph(GIUH), which is the impulse response of a basin to a unit pulse of precipitation excess, may be viewed as the provability density function of travel times to the outlet of water particles injected uniformly in space. Rosso(1984) showed that Horton's and Strahler's scaling ratios could be used to parameterize the GIUH. More recently, physically based topographically driven hydrologic models, which use topographic features from digital elevation model, have found increased applicability for runoff prediction (Beven and Kirlby, 1979; Moore et al., 1991; Quinn et al., 1991). The purpose of this paper is first to study effect of the extract basin parameter on DEMs using Kompsat. The second objective is to get general laws describing the architecture of the drainage network independent of the scale observation.

2. KOMPSAT

KOMPSAT was launched on 21 December 1999 by KARI(Korea Aerospace Research Institute). The satellite has a sun-synchronous and near polar orbit of 685km altitude. The orbit repetition is 28 day. The EOC(Electro Optical Camera), a payload of KOMPSAT provides panchromatic satellite imagery with 6.6m ground resolution and 17 km swath. Image of 800 km are taken in a path, which takes about 2 minutes to scan(satellite Application Group, 1999). EOC has ability to tilt the spacecraft utmost 45 degrees which allows the satellite to take a pair of images of the same ground area in different two paths to take stereo imagery (KOMPSAT Receiving and Processing Station, 1999). At least three days are required to take a pair of stereo image in Korean Territory provided the weather condition permits. With this specification, the cartography to provide the imagery from a remote earth view for the production of maps of Korean territory. However, few stereo images are obtained until now because the satellite is in the early stage and in as been operated according to first mission plan to collect entire image of Korean domestic territory. The input data was KOMPSAT-1 stereo images and the GCPs(Ground Control Points) of the sample areas. The size of KOMPSAT-1 image was 2592×2592 pixel and the fit size of an image was about 7 Mbytes. The sample areas were selected in Busan, place in the South Korea, where city, farming land, river, and mountain were well distributed. Fig. 1 shows sample images acquired from KOMPSAT.

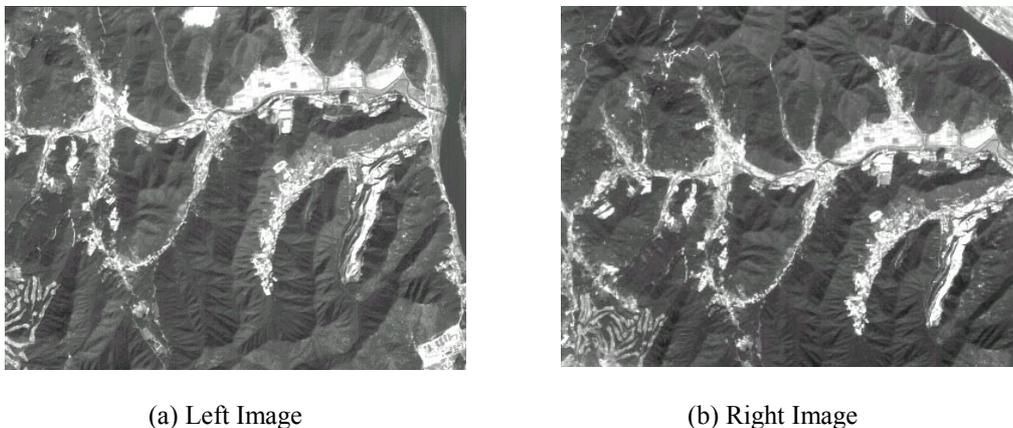


Fig. 1. Study Area in Busan

3. Camera Modeling with GCPs

Not all the status and position data of KOMIPSAT satellite are given by every 1 second interval. For estimating exterior orientation parameters of each image, the collinear condition is used. The collinear condition is that the vector from center of satellite to image plane is same as the vector from center of satellite to ground point corresponding image plane in eq.(1) and the equation of normalizing by Z factors is in eq.(2)

$$\begin{bmatrix} x \\ y \\ -f \end{bmatrix} = SM^T \begin{bmatrix} X-X_s \\ Y-Y_s \\ Z-Z_s \end{bmatrix} \quad (1)$$

$$Fx(\cdot) = x + f \frac{a_{11}(X-X_s) + a_{12}(Y-Y_s) + a_{13}(Z-Z_s)}{a_{31}(X-X_s) + a_{32}(Y-Y_s) + a_{33}(Z-Z_s)} = 0$$

$$Fy(\cdot) = y + f \frac{a_{21}(X-X_s) + a_{22}(Y-Y_s) + a_{23}(Z-Z_s)}{a_{31}(X-X_s) + a_{32}(Y-Y_s) + a_{33}(Z-Z_s)} = 0 \quad (2)$$

By using satellite's linear uniform motion during image acquisition period, exterior orientation parameters are approximated to function of time, linearized by Newton's 1st order approximation and transformed into matrix form as eq.(3):

$$V1+B1d1+B2d2=C1 \quad (3)$$

Conformity-ellipse coordinate system which transformed from Bessel ellipse coordinate system is used in geodetic survey and map coordinate system in Korea and GRS 80(Geodetic Reference System 80) coordinate system is used for KOMPSAT coordinate system. The two coordinate systems are transformed into local space rectangular coordinate system. The Z axis used in local space rectangular coordinate system passes the origin point of corresponding area and go through the outer of ellipse, X axis is perpendicular to Z axis and decreased with longitude Y axis is perpendicular with X to Z axes and decreased with latitude.

The observing equation described by approximated value and observed value is as follow:

$$V2 - d1=C2, V3 - d2=C3 \quad (4)$$

The observing equation is derived as eq.(5) from eq.(3) and eq.(4):

$$\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} + \begin{bmatrix} B_1 & B_2 \\ -I & 0 \\ 0 & -I \end{bmatrix} \begin{bmatrix} d_1 \\ d_2 \end{bmatrix} = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \end{bmatrix} \quad (5)$$

Because the physical meaning of d1 and d2 is the offset values to approach the values of exterior orientation parameter and GCP, after finishing a series of calculation each GCP offset vector is iterated by adding estimated value and offset value, until all offset vector d2j are approached to a small value which is negligible. The convergence test of modeling used in this paper is that if the normalized after during the summation of squared error with the number of test points as eq.(6) the value is converged:

$$MSE = \frac{\sum_{i=1}^{nC} R_i^2}{nC} \quad (6)$$

The accuracy of the generated DEM is influenced by stereo matching procedure to find corresponding points from two stereo satellite images. Stereo matching is classified into two categories of feature based and area based matching. Generally, area based matching is used to extract DEMs from stereo. The performance of area based matching depends on the selection of similarity measure to find corresponding points, the decision of window size and shape fitting acquisition images, etc.. In the case of near distance stereo images, the elevation of each point is calculated from simply proportion expression using the exterior orientation obtained from modeling and disparity from matching. Because the projection lines corresponding matched points of two images are exactly crossed at one point. But in the case of stereo satellite images, that of two images are not crossed at one point, due to the errors in influences of the orbit of satellite, the change of attitude and the rotation of the earth, etc. Therefore we select the nearest line of two lines, to decide the middle point of the line having the elevation of given corresponding point. Fig 2. show the location decision by the nearest line of two lines.

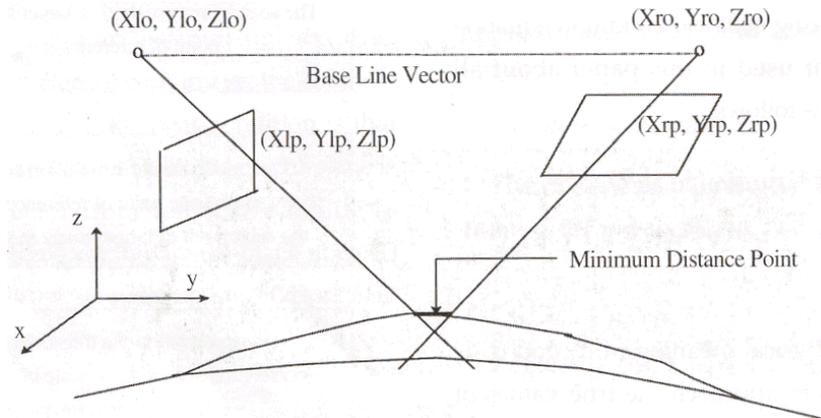


Fig 2. Location decision by the nearest line of two lines.

4. Extract DEM from KOMPSAT

A DEM is a digital representation of the continuous variation of relief over space. Fig 3 shows that DEM and from sub-basin from Kompsat imagery. In the past, high-quality DEMs have been generated with traditional photogrammetry in such a way that they were used for many purposes. Watershed analysis is another DEM derivative operation. Drainage modeling identifies cells located along the steepest downfill path extending from a target area. To achieve this, the algorithm always chooses the direction of the maximum relief and the search stops at the location where no more downfill cell can be found. Algorithms to determine the flow direction generally use one of the following cases which is 4 possible directions of flow and 8 possible direction.

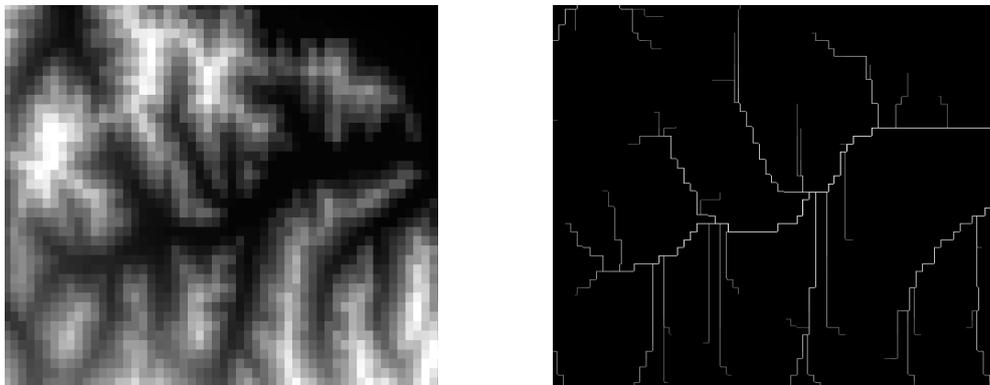


Fig 3. DEM and sub-basin from Kompsat imagery

5. Conclusions and recommendations

This study aims to construct subbasin by using Kompsat imagery in water resources field instead of manual measuring method or digitizing map the hydro-geometric information. Data on terrain, land-use and hydrology of the site was converted to information for storm drainage network planning. Photogrammetry was used to gather data for DEM creation because of the data acquisition of data. Kompsat was used to gather data for DEMs creation because of the fast acquisition of data. Runoff hydrographs can be created for “before” and “after” construction. The change in runoff as a result of a new development can be estimated for the sub-basin or watershed. The combination allowed sitting, location, orientation and modeling of impact on the change in the flow direction of runoff. This can be best done by manually measuring runoff volumes at sub-basin outlet points and then comparing the volume measured against that obtained by using DEMs from Kompsat imagery.

Reference

- C.S. Ye, B.M.Jeon, and K.H. Lee, 1998, A method on digital elevation model extraction using satellite images, Proceeding
- Doorn, B., P. Agouris, R. Al-Tahir, T. Stefanidis, and O. Zilberstein 1991. Digital Stereo Matching in Perspective, Technical Notes in Photogrammetry 10, Department of Geodetic Science and surveying, The Ohio State University Columbus, Ohio, 15 p.
- Hannah, M.J., 1988. Digital stereo image matching techniques, International Archives of Photogrammetry and Remote Sensing, 27(B3): 280-293.
- Wroble, B.P., 1988. Least-squares methods for surface reconstruction from images, International Archives of Photogrammetry and Remote Sensing, 27(B3): 806-821.
- Stefan W. K., 1996, "Using DEMs and GIS to define input variables for hydrological and geomorphological analysis", IAHS Publication number 235, USA.
- Toutin, Th., Amaral, S., 2000. Stereo RADARSAT data for canopy height in Brazilian forest. Canadian Journal for Remote Sensing 26(3).
- Yelozavetin, I.V., 1993. Digital terrain modeling from radar image stereopairs. Mapping Sciences and Remote Sensing 33(1), 1-19.