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Generation and Evaluation of Cartosat -1 DEM for Hyderabad city

KEYWORDS: Digital Elevation Model, Cartosat-1, 3D, Photogrammetry

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ABSTRACT *A digital elevation model (DEM) is a simple representation of a surface in 3 dimensional way with height as the third dimension along with x and y in rectangular axes. DEM has wide applications in various areas like disaster management, hydrology and water management, geomorphology and in urban development. Valuable information about a terrain can be inferred by exploiting a DEM in proper way. Study of DEM becomes very useful for acquiring heights of 2D image and helps in building 3 dimensional view of 2D data. Cartosat-1 or IRS P5 (Indian Remote Sensing Satellite) is a state-of-the-art remote sensing satellite built by ISRO which is mainly intended for cartographic applications. The satellite carries two panchromatic cameras which are capable of acquiring stereoscopic data along the orbital track. The high resolution stereo data have great potential to produce high-quality DEM. This paper discusses the generation of DEM from Cartosat -1 data for Hyderabad city (Andhra Pradesh, India). The DEM from Cartosat data was generated by using ground control points (GCPs).*

Introduction

A DEM is a representation of Earth surface with latitude, longitude and altitude i.e. X, Y horizontal coordinates and height Z. DEMs play an important tool for the extraction of 3 dimensional models. The launch of ISRO's Cartosat -1 satellite has opened a vast possibility for various areas like disaster management, hydrology and water management, geomorphology, urban development, map creation and resource management. Cartosat-1 is designed for cartography applications (Kocaman, 2008). The satellite is placed in the polar Sun Synchronous Orbit of 618 km from Earth. It has a payload consisting of two cameras - one near nadir looking aft (A) and the other forward looking fore (F) with a tilt of -5 degree and +26 degree providing the real time stereo data along the track. These cameras are mounted with a fixed geometry which helps in collecting stereo coverage of the terrain at a fixed B/H ratio of 0.62. The swath covered by these high resolution PAN cameras is 30 km and their spatial resolution is 2.5 meters. A description of the Cartosat-1 mission is given in Krishnaswamy and Kalyanaraman (2002), Krishnaswamy (2002) (Kocaman et al., 2008). The stereo data from this satellite along with the Rational Polynomial Coefficients (RPC) can be used to generate DEM. The positional and height accuracies of Cartosat data products generated using RPC are in the range of 100m to 250m. The Rational Polynomial Coefficient (RPC) file contains the third degree polynomial coefficients that relate the image to the object space considering the imaging sensor geometry. These RPCs are sensor derived and terrain independent (Rao et al.). Rational Polynomial satellite sensor models are simpler empirical mathematical models relating image space (line and column position) to latitude, longitude, and surface elevation. The name Rational Polynomial derives from the fact that the model is expressed as the ratio of two cubic polynomial expressions (Gopal Krishna et al, 2008).

Objectives

This paper examines the generation of DEM from Cartosat -1 stereo data pair. To generate an accurate DEM from stereo data ground control points are required. In this study DEM has been generated using GCPs.

Data used

Cartosat-1 stereo data pair dated were used to generate the DEM.

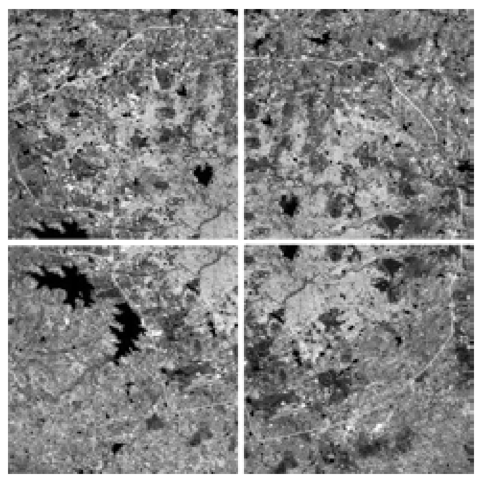

Fig: 1. Cartosat Images of Study Area

Methodology for DEM Generation

Leica Photogrammetry Suite (LPS) version 9.3 Software package was used to generate DEM from Cartosat-1 stereo data pairs. The software can be used to generate DEM, orthorectified image, editing of generated DEM, mosaic and image calibration. The software supports reading of data, manual or automatic GCP/tie points (TP) collection and geometric modeling of different satellites including RPC model and zero order, a first order and second order RPC polynomial adjustments (Gopal Krishna et al,2008). The RPC method based on the block adjustment method developed by Grodecki and Dial was used for DEM generation. A block project file has to be created inside the software for the DEM generation defining the geometric model as RPC model. The block project has assigned the horizontal and vertical coordinates with UTM projection and WGS 84 datum. The stereo pair images band a and band f were added to the frame. The interior and exterior orientations corresponding to the RPC files were carried out in frame editor. Interior orientation defines the internal geometry of a sensor, as it existed at the time of image capture and exterior orientation is the position and angular orientation of the sensor that captured the image. The software extracts sensor information from RPC file and carries out the interior and exterior orientation. The

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pyramid layers were computed and updated. The generation of DEM from stereo data needs geometric model and GCPs. A DEM prepared using GCPs is known as absolute DEM and that without using GCPs is known as relative DEM. In the absolute DEM the horizontal and vertical references systems are tied to geodetic coordinates whereas a relative DEM is a DEM with relative differences in position, scale, and rotation from the geodetic coordinates on the ground (horizontal reference system) and the mean sea level (vertical reference system) (from ENVI tutorial). The DEM was generated using GCPs. The flow chart of complete method is shown in figure 2.

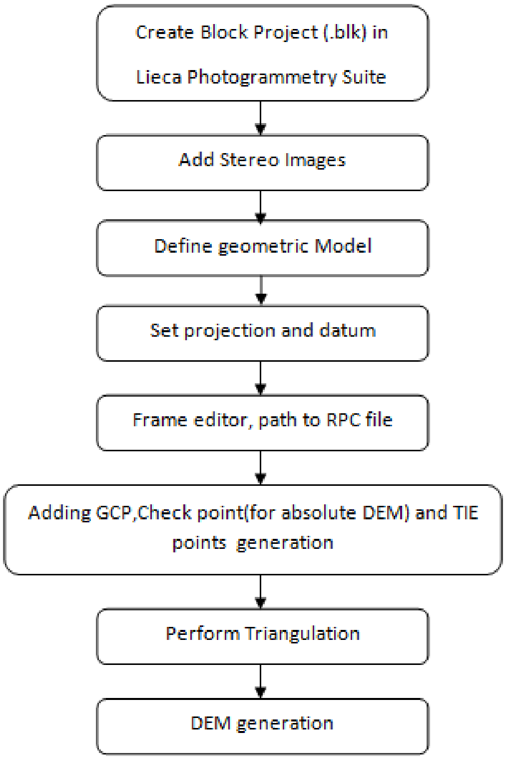

Fig 2: Flow chart describing the methodology DEM generation with GCPs

	A	B	C	D	E
1	point id	latitude	longitude	Height	
2	gcp 23	17.18184	78.54825	493.424	
3	gcp01	17.61587	78.3183	498.236	
4	gcp02c	17.50037	78.28467	479.734	
5	gcp3	17.42368	78.26437	499.47	
6	gcp04b	17.59559	78.40165	542.308	
7	gcp05	17.47455	78.38218	496.351	
8	gcp06	17.4013	78.36533	463.994	
9	gcp07	17.55668	78.53974	521.501	
10	gcp08	17.49715	78.49614	484.29	
11	gcp09	17.38856	78.47652	434.162	
12	gcp10	17.57797	78.60489	501.006	
13	gcp11	17.46964	78.59164	461.74	
14	gcp12	17.37961	78.5773	403.224	
15	gcp13	17.55049	78.69259	509.915	
16	gcp14	17.45441	78.66291	406.205	
17	gcp15	17.35296	78.65684	399.125	
18	gcp16	17.31573	78.25899	531.853	
19	gcp17	17.23399	78.2236	511.062	
20	gcp18	17.30471	78.3678	464.971	
21	gcp20	17.18201	78.32925	511.935	
22	gcp20a	17.28188	78.46466	499.878	
23	gcp21	17.1872	78.4387	540.4	
24	gcp22	17.26356	78.54144	483.626	
25	gcp24	17.25133	78.61912	466.134	
26	gcp25	17.1408	78.59439	484.59	

DEM generation with GCPs

LPS 9.3 was used for DEM generation and orthorectified image generation from Cartosat-1 stereo data. The stereo data Band a and Band f overlap is around 90%.The areas were GCPs has to be taken are identified on the data and they are equally distributed in the study area such that the GCPs are covered entire study area. The points taken were from DGPS(Differential Global Positioning System) Trimble 5700 instrument which is of dual frequency and having an accuracy of approx 0.86cm (as provided by the instrument). A total number of 25 points (figure 3) are collected on entire study area and were used in the refinement of RPC model and DEM generation and 5 points were used as check point to check the accuracy of the DEM generated. The classical point measurement tool was used to add the GCPs and to generate tie points. Ground points were added to the images. Tie points were generated both manually and automatically for even distribution of them. Tie points are points which can be identified in the overlap area of stereo images and whose ground coordinates are not known. Tie points were generated and there location accuracy was checked. The tie points and GCPs distribution in Band a and Band f images. The triangulation was run after adding GCPs and tie points. Triangulation is used to improve the accuracy and refinement of RFM. Triangulation process established relation between images, sensor model and ground points (Krishnamurthy, 2008). The process was run to check the accuracy for GCPs and tie points. After running the triangulation the DSM was extracted with cell size of 10m. GCPs and tie points were used as seed vertices for DEM creation. This input enhances the relative position of the DEM (Krishnamurthy et al, 2008). AFT (Band a) image was used for Orthorectification image because of its near nadir acquisition angle. Figure 4 shows the DEM and orthorectified image generated.

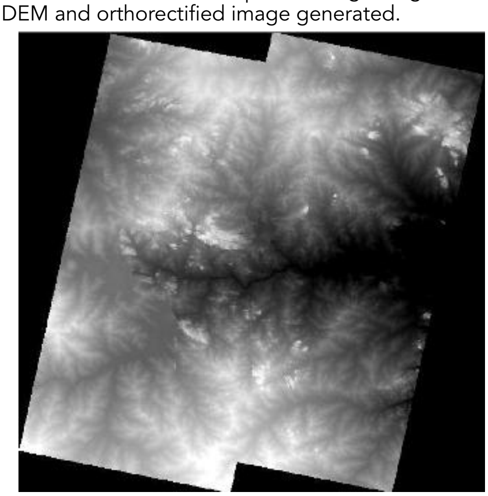

Fig 4: DEM of the study area

Conclusion

The aim of the paper is to generate the DEM with stereo data for Hyderabad. The DEM of Hyderabad can be used for development of 3D city models and its application in Urban Planning. The generated DEM is used for extraction of mean heights of the various features on the ground and later they are enhanced in to Arc Scene software for generation of 3 dimensional features of the study area.