Ortho Rectification of Worldview-2 Satellite Image using DGPS Survey for Parcel Level Mapping

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Abstract— The use of very high resolution satellite images in photogrammetric works is increasing continuously, especially in works such as ortho images production or Digital Elevation Models extraction. A large number of new photogrammetric uses of Earth Observation data appear due to improvement of the geometric accuracy of the products. Ortho photo is an image which is being corrected geometrically so each object has to be situated on the corrected place consequently. The present study focus on the Ortho Rectification of Worldview-2 satellite imagery (with spatial resolution of 0.5 meter) for cadastral mapping under national land record modernization programme (NLRMP) for Haryana. The methods applied in this study are a linear polynomial correction using 3 Dimensional ground control points (GCPs), rational polynomial coefficient (RPC) correction without refinement and RPC correction with linear refinement using 3D GCPs. The ground control points (GCPs) were collected by means of differential ground positioning system (D-GPS-Survey). Investigation of the results was performed by examining the RMS error of DGPS points with check point and RMS error for RPC model.

Key words: Ortho Rectification, D-GPS, RPC, NLRMP, RMS Error

I. Introduction

Ortho-rectification is a process of making the geometry of an image planimetric or map accurate, by modelling the nature and magnitude of geometric distortions in the imagery. These distortions are caused by topography, camera geometry, and sensor-related errors. Ortho-rectification is a logical step when precise positional accuracy and uniform scale are required throughout an image. After Ortho-rectifying an image, you can measure or precisely locate features in the image, collect information for a GIS, or combine the image with other Ortho-rectified images for sophisticated analyses.

The Digital Globe's WorldView-2 satellite was launched in October 8, 2009 and has the ability to collect panchromatic and multispectral images (in 8 bands) with pixel size of 0.46m and 1.84 m at nadir respectively. WorldView-2 imagery products are delivered with a set of metadata files called Image Support Data (ISD). The proposed orientation model is applied only to Basic Imagery product, which includes Attitude, Ephemeris and Geometric calibration files. The main technical characteristics of WorldView-2 sensor are: push broom camera with a focal length of 13246.139 mm, image bands on Pan, Coastal Blue, Blue, Yellow, Green, Red, Red Edge, NIR1 & NIR2, 16.4 km swath and stereo capacity with Agile Telescope.

II. Objective

The objective of this study are as follow

1) Consigns a real world coordinate to the satellite image.
2) Remove Geometric distortion from the image as Camera and sensor orientation, satellite errors, Topographic relief displacement, Earth curvatureetc.

III. Study Area

Gurgaon District lies between 27º 39' 15" and 28º 32' 25 North latitudes, and 76º 39' 30" and 77º 20' 45" East longitudes. On its north, Gurgaon District is bounded by the district of Rohtak and Delhi. Faridabad District lies to its east. On its south, Gurgaon District shares boundaries with Uttar Pradesh and Rajasthan. In the west, this district is bounded by Rewari District and Rajasthan.

IV. Data and Methodology

There are many methodology and technique to Ortho-rectify satellite images for different purpose but here is specific purpose of Ortho-rectification for the parcel level mapping which is very large scale mapping. So here a specific methodology and techniques is developed which is as follow.

Digital Stereo Data of World View-2 was acquired through National Remote Sensing Centre, Hyderabad having spatial resolution of 0.5 m for this study with off nadir angle less than 10 degree. After acquiring satellite data it is check the clouds, haze, restricted area, and gaps in area of interest. After than satellite data is mosaic according strips or scene because only first tile has RPC file (Rational Polynomial Coefficient) which is a sensor model commonly used by the Remote sensing industry to determine the ground coordinates of pixels in high Resolution satellite imagery. Single block for the whole study area was created with projection parameters as UTM projection, Spheroid WGS 84, Datum WGS 84 and 43N UTM zone. Very high resolution stereo satellite imagery (world view-2) along with the RPC (Rational Polynomial Coefficient) files was input to the AT block. After that pyramid layer was generated for all image of the block and attached with RPC file.Tie point generation and Block triangulation was carried out by refinement of image geometry model (RPC) supplied with the imagery and ground control point which are generated by DGPS survey of the study area. The objective of block triangulation is to determine the position and orientation of each image in a mapping frame which are known as exterior orientation (EO) parameters.

Digital terrain model was extract of individual images of the block in LTF file format. After that the process of DEM editing was carried out. Ortho-Resampling process with nearest neighbor method using 0.5 meter output cell size, and using the triangulated satellite imageries and DTM (LTF format) as per the defined GSD of sensor was carried out. Projection for output Ortho-rectified images was also define as whole block. Than seem editing and ortho image mosaic for all the study was carried out.

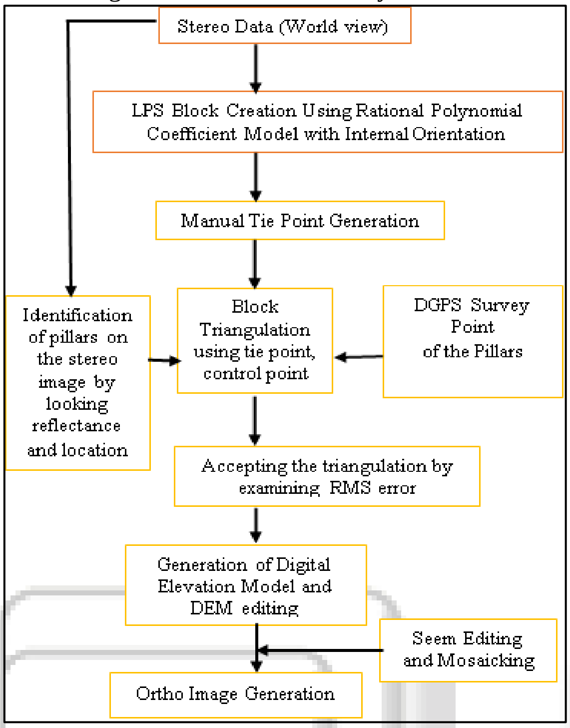

Fig. 1: Flow chart of Research Methodology

V. Result and Conclusion

The evaluation of the Ortho rectified images produced by the fore mentioned methodologies was made by calculating the RMS error, based on eighteen reference DGPS points, the coordinates of which are known with high accuracy. The coordinates of the corresponding pixels in the ortho rectified images represent the input coordinates. The RMS error is expressed as distance (m) in the source coordinate system. The calculated RMSE for whole block is 0.423 which is calculated by software on the following ground control point (DGPS point).

RMS error is calculated with a distance equation:

$$\text{RMS Error} = \sqrt{(x_r - x_i)^2 + (y_r - y_i)^2 + (z_r - z_i)^2}$$

Where:

X b , Y b , Z b are the input source coordinates or image coordinates.

Xg, Y g and Z g are the retransformed coordinates.

Points	Ground control Point			Block coordinate			Difference in Coordinates		
	X_G(m)	Y_G(m)	Z_G(m)	X_B(m)	Y_B(m)	Z_B(m)	X(m)	Y(m)	Z(m)
1	666359.85	3153004.97	214.63	666359.19	3153005.21	215.47	0.66	-0.23	-0.83
2	651761.44	3152163.47	216.76	651761.25	3152163.64	216.39	0.18	-0.17	0.36
3	663565.06	3140809.87	225.13	663561.73	3140810.66	226.04	3.33	-0.78	-0.91
4	662056.12	3132178.44	228.53	662056.25	3132179.38	228.52	-0.12	-0.93	0.01
5	664801.34	3127112.02	234.32	664801.90	3127112.27	234.65	-0.55	-0.24	-0.32
6	650451.16	3127214.52	240.05	650451.51	3127213.99	240.94	-0.35	0.53	-0.89
7	681196.01	3125158.03	251.50	681196.25	3125158.27	250.15	-0.23	-0.24	1.34
8	684588.01	3126884.45	246.68	684588.26	3126884.41	245.03	-0.24	0.03	1.64
9	697277.58	3131882.89	325.26	697277.51	3131883.10	324.83	0.07	-0.21	0.42
10	703829.87	3124256.09	198.36	703829.62	3124256.16	197.88	0.25	-0.07	0.48
13	720777.05	3129370.44	194.90	720777.93	3129370.51	193.54	-0.87	-0.06	1.36
14	710173.65	3147184.69	254.71	710173.04	3147184.26	253.20	0.60	0.42	1.50
15	713748.34	3144283.31	299.79	713748.83	3144283.97	299.09	-0.48	-0.66	0.69
16	697354.95	3158813.79	212.48	697354.06	3158814.60	212.18	0.88	-0.80	0.30
17	684859.63	3155337.60	211.31	684859.48	3155337.58	211.71	0.15	0.02	-0.39
18	680115.40	3154665.31	214.23	680115.21	3154665.26	214.35	0.19	0.04	-0.12
						Average	0.21	-0.21	0.29

Table 1: Comparison between GCPs and Block Coordinates

No.	observation	Ground length (m)	Image Length(m)	differences
1	Tennis court	23.53	23.23	0.30
2	Skate park	18.33	17.97	0.36
3	Basketball court	19.56	19.33	0.22
4	Takraw court	18.87	18.80	0.07
5	Hockey field	24,50	24.70	0.20

Table 2: Distance differences between ground and ERDAS stereo model

Apart from this another method also use for accuracy assessment of the ortho rectification based on ground survey In this method of analysis a set of randomly selected lengths for features such as fields, courts and drains are chosen and their linear qualities measured in ERDAS software from the stereo model. The chosen set of lengths is then determined directly from ground measurements using tape and the results obtained from the field represented along with those obtained from ERDAS for comparison. Some of the points considered include the following. As shown in Table 2, the distance measurement from the ground compared to the distance measurements from ERDAS stereo model is slightly different. The accuracy differences are approximately 0.23 meter and based on the fact that the satellite image were taken about 700 km above the ground surface.

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