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Abstract - The number of high resolution space imagery have great interest in the photogrammetric and remote sensing communities. This imagery is considered as a basic information source for mapping with various applications in geomantic. By this hybrid both the projection model and polynomial model in geometric correction of satellite imagery, it needs to control points and standardisation data. In the geometric correction of the IRS P-5 LISS III imagery is required whenever the image is to be compared with existing maps or with other imagery. In this paper execute the composition of correction function using Ground Control Points. The results show eligibility of geometric correction of these models for selected imagery. An accuracy analysis is performed, with emphasis being laid on the number and location of Ground Control Points.

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I. Introduction

Preprocessing of satellite images consist of radiometric and geometric characteristics analysis. Preprocessing commonly comprises a series of sequential operations, including geometric correction, atmospheric correction or image registration, normalization, masking (e.g., for clouds, water, irrelevant features), Image Rectification, and Image Re sampling [6]. The geometric correction of high-resolution satellite imagery needs to take into account the instrument characteristics, the satellite motion, earth rotation, terrain effects, and the ground control points (GCP) simultaneously. This is much different with the traditional geometric correction algorithms, which conducts the correction sequentially and uses the ground control points in higher level processing [1].

In the geometric correction transformation the (High Resolution Satellite Image Geometric correction) transforms the imagery, as they are acquired by the sensors, to match certain cartographic projection, free of distortions, and each pixel is assigned with specific coordinates. While the imagery is to provide Earth Surface hyper spectral reflectance data with a wide range of different viewing configurations, and provide Bidirectional Reflectance Distribution Function (BRDF), for atmospheric, land and water studies [12].

Atmospheric analysis mainly to refers the atmosphere effect along with its corresponding territory (land) features reflection (while geometric analysis). While in the correction removes effects of the atmosphere on the radiation from the territory that arrives to the camera as well as other sensor; it also converts the physical values of the image from radiance to ground reflectance. But it needs accurate observation and illumination angles for each pixel [3]. Imagery registration itself is a general problem and arises in many applications such as depth perception, dynamic scene analysis, change detection and landscape classification. Geometric analysis refers to the image geometry with respect to sensor system with the launch of various commercial high-resolution earth observation satellites, such as Indian Remote Sensing Satellite IRS-P5 Liss-III, Digital Globe Quikbird system, the Space Imaging Ikonos system and Spot-5 precise digital maps generated by satellite imagery are expected in the spatial information industry [1].

The main goal of imagery rectification is to facilitate the overlay of supplementary imagery and other geographic data. A TopoSheet (Standard Map) position, with boundaries set with Universal Transverse Mercator (UTM), is recognized for each scene, thus all imagery is for the same region and once rectified will be available in the same map area. The UTM bounds for the scene are established according to the imagery size, the 28.5 x 28.5 m pixels, and the minimum/maximum northing and easting required containing the full scene area. These boundaries, the UTM zone-1 and the ellipsoid are established on each newly created empty file. Usually RS Imagery is being projected to UTM using WG84 datum for IRS [6].

Finally Geometric rectification of the imagery resample is to produce another copy of imagery data as you change either the pixel dimensions or the High resolution of Satellite image. When you compress the image the number of pixels, information is deleted from the image. When you enhance the number of pixels, new pixels are added, in the application [7].

In this paper Geometric corrections in CartoSat-1 IRS –P5 Liss III Imagery have been used in various

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non-rigorous mathematical models used for geometric corrections. Such as polynomial and DLT model that used different number of Ground control points (GCP).

II. Review of Papers

Due to this fact, an additional constrain is needed to define the point in 3D space. Collinearity equations are the rigorous models, which describe this projection relation between 2D image space and 3D object space. Unlike ordinary photogrammetric photography, high-resolution satellites are a line sensing imaging systems where every line is imaged at different time. That may help to understand the need of a special treatment of the sensor model (Makki, 1991). In general, the rigorous time dependent mathematical models are based on the collinearity equations, which relate image coordinates of a point to its corresponding ground coordinates. Published studies reported till date on IKONOS and other satellites focus on two main aspects, the accuracy attainable in ortho-image generation and DTM extraction concerning 3D positioning from stereo spatial intersection using rigorous and non-rigorous sensor orientation models. Due to some limitations, most of the new High Resolution Satellite Imagery (HRSI) vendors hide the satellite orbit information and calibration data from the customer's community such as for IKONOS and QUICKBIRD imagery. This means that other alternative models should be used to solve this problem and calculate the imagery parameters. Therefore, these empirical approaches can be applied to determine the ground point coordinates in either 2D or 3D.

III. Geometric Corrections

The use of standard pixel sizes and coordinates permit suitable layering of images from different sensors and maps into a GIS. The final level is ortho rectification. This level focuses on pixel by pixel correction of the image for topographic distortion. Every pixel in the resulting image appear as if the earth is viewed from directly above, the image is a strict orthographic projection.

Geometric correction is needed to preprocess remotely sensed data and to remove geometric distortion such as Internal and External distortion, so that individual image pixels are in their appropriate plan metric (*x, y*) map locations. This allows remote sensing derived information to be related to other thematic information in Geographical Information System. Geometrically corrected imagery can be used to extract exact direction, distance and polygon area information. Geometric corrections in IRS P6 Liss-III Imagery have been used in these steps of geometric correction in satellite imagery and used in different number of Ground control points[8].

Now a days, utilization of satellite images as a substitute for small scale airborne photograph to produce new maps and accurate old maps much faster than before eliminates shortage of geo information and need to update these information. Immediate access to information and needed geometry accuracy of photogrammetry for maps of different scales leads to a demand for accurate mathematical model from accuracy and speed point of examination. This paper presents a suitable solution to solve the two dimensional problem.

Generally, used mathematical model for geometrical correction of satellite images are divided in two types of physical or general models [5].

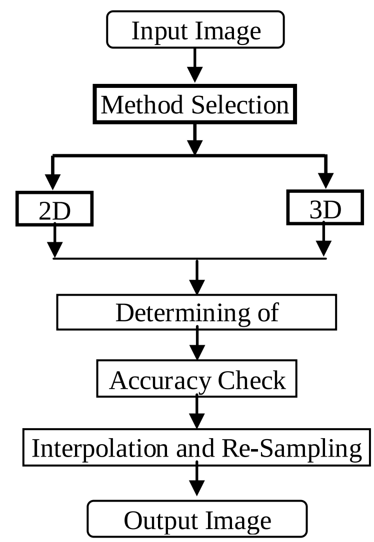


Figure 1 : Geometric correction

IV. Mathematical Moduls

Physical Model

This model explains the procedure of imagery physically and the parameters used show the position and angle of sensor in object space. This model such as co-linearity equation is suitable for adjustment of analytical aerial triangulation and has high accuracy.

General Models

In this model the type of sensor has no importance and parameters used in linking object space and image space are not associated to sensor physics. Rational Function Models, polynomials, affine model and so on are of this type.

Appropriate to photogrammetric operation such as image reconstruction, rectification and generation that is to be in real time practice of general models are appropriate and it is done in photogrammetric instruments without any attention to the sensor type and for new sensors it is sufficient to update only the coefficients of models. Substituting the sensor model by a general one should be done by selecting the best fitting physical sensor models.

The following modules are used in geometric Correction and discussed with our study area

a) Polynomial model

Polynomial models usually needed for the transformation between image and object coordinates. In the transformation it is expressed in different orders of the polynomials based on the distortion of the image, the number of Ground Control Points and terrain type. A linear transformation is the first order polynomial transformation, which can change the location, rotation, scale, and skew. In most cases, first order polynomial is used to project raw image to an object for data covering small areas and large areas. A non-linear transformation of higher order Polynomial or second order polynomial transformations that can be used to correct non-linear distortions that convert latitude/longitude to the image such as earth curvature and sensor distortion.

This polynomial equation can calculate new output pixel locations (x, y) and relate image location to the Ground Control Point location. The following 2D and 3D equations are used to commonly for the polynomial model[9].

$$\left.\begin{aligned} X &= a_0 + a_1 x + a_2 y \\ Y &= b_0 + b_1 x + b_2 y \end{aligned}\right\} \qquad (1)$$

Given a coordinate (x, y) in the model parameter, the model coordinates of the corresponding (a,b) are given by the equations

b) Projective Transformation

A projective is an invertible mapping h from P2 to itself such that three points x1, x2, x3 lie on the same line if and only if h(x1),h(x2),h(x3)do. A mapping h:P2 → P2 is a projectivity if and only if there exist a non-singular matrix

H such that for any point in P2 represented by a vector x it is true that h(x)=Hx definition as.

$$Hx = X' or \begin{pmatrix} x_1' \\ x_2' \\ x_3' \end{pmatrix} = \begin{bmatrix} h_{11} h_{12} h_{13} \\ h_{21} h_{22} h_{23} \\ h_{31} h_{32} h_{33} \end{bmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$$

$$X = \frac{a_0 + a_1 X + a_2 Y}{1 + c_1 X + c_2 Y}$$
$$y = \frac{a_0 + a_1 X + a_2 Y}{1 + c_1 X + c_2 Y} \qquad (2)$$

This model is useful because the linearity of the equations as a function of the coefficients permits least-squares procedure to be used for determining these coefficients. Affine, DLT, Quadratic, and Cubic are polynomials obtained from this model and include the number of coefficients that would be required to utilize the corresponding model. In the analysis of high resolution satellite imagery it is necessary to place these data into registration. To implement this operation the data are divided into sub imagery, and the miss registration between the data subsets is modeled by projection transformation. An Implementation of projection model as contrary to perspective affine model for satellite line scanner imagery is quite robust and stable for image orientation and triangulation. All of a Ground Control Point will give rise to a set of two Projective Transformation equations derived from the relationship between the GCP coordinates and the image coordinates in the geocentric system.

In programming 2D projective Transformation equation in direction and aerial triangulation of High Resolution satellite imagery, all coefficients and coordinates of ground control points synchronously is produced by bundle adjustment. Combining above function with additional parameter, we can model other effective non linear parameters. There are more 2D mathematical models, which has been described in Sadeghian & Valadan (2001).

V. Studied Area and Data Set

Palar is a south Indian river, originating from the Nandidurg hills of Karnataka, it flows through the states of Karnataka (93 km), Andhra Pradesh (33 km) and Tamil Nadu (222 km) before finally draining into the Bay of Bengal at Vayalur. This river is divided in to 8 sub basins. This mostly covers Thiruvannamalai and Kanchipuram districts an area of about 939.91km^2 of which about 92.43% of the total area.

The Kiliar Sub Basin area around the Palar Basin is located at Latitude (12°41'9"N and 12°22'32"N) and Longitude (79°53'26"E and 79°25'10"E). Studied images of Kiliyar Sub basin is a Pan and Liss III merged data panchromatic stereo pair of 5.86m pixel size and proper radiometric quality, a base to height ratio equal to taken on March-2013. Figure 2(a) Viewer#1 Shows the Study area Satellite Terrain data IRS-P6 Liss-III and Figure 2(b) Viewer#2 Shows the Georeferenced data (Toposheet) the above data are collected from Remote Sensing Institute, Taramani, Chennai.

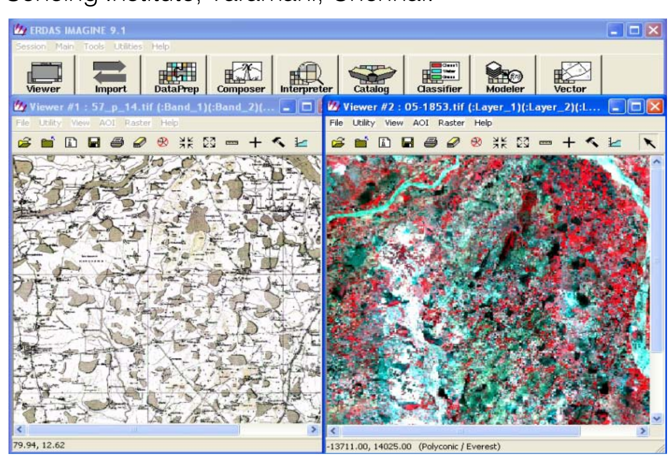


Figure 2 : (a) TopoSheet *Figure 2 : (b) Study Area*

ERAS Image software is used to correct the geometric correction by using the projection type and reference details shown in Table 1, which also presents the main characteristics of the acquired images.

Table 1 : Methodological Specification of IRS P6 Liss III Imagery

Image Type	Pan and Liss III Merged Data
File Format	Geo TIFF
Projection Type	UTM
Spheroid Name	WGS 84
Datum Name	WGS84
UTM Zone	1
North or South	North

a) Ground Control Point Selection

In Kiliyar sub basin areas Geo-reference Data (TopoSheet) 1:50000 Scales and 23.8 meter Satellite Imagery IRS P6 Liss III data date 12 march 2012 to provide by Remote Sensing Institute, Chennai of Tamilnadu. Ground Control point selection is done how as same sparseness in image space especially in corners of geo-referenced image. Control points are selected from crossings of roads, streets and railway stations and so on.

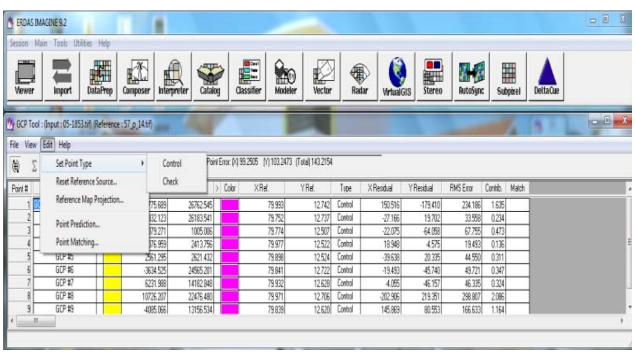


Figure 3 : Ground Control Points

The Figure 4 shows the correspondingly image with ground control and check points distribution, with using GCP Tool in ERDAS Software.

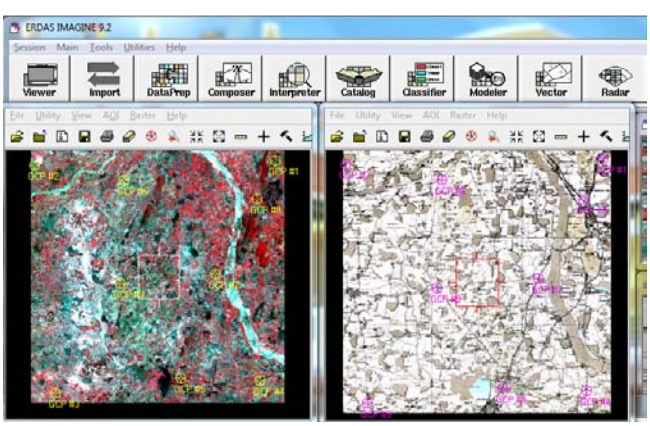


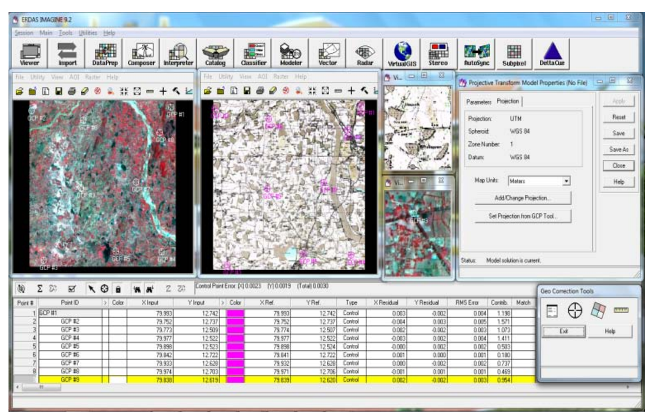
Figure 4 : GCP distribution

The check points and the ground control points (GCPs) in this study were derived from a digital 1:50000 Scale topographic map that produced by Remote Sensing Institute, Taramani in Chennai. It provides approximately planimetric (the word refers to 2D space) accuracy and 50cm vertical accuracy. When compared with the ground resolution of the IRS P6 Liss III image, this digital map provides sufficient control data. The following Practical Test (figure) is to prove the accuracy of the above mathematical model with hybrid model.

b) Experimental Result

The main objective of this approach is based on rectification of result of polynomial using such as polynomial mathematical mode. After geometric correction of satellite imagery using polynomial, the main residual errors are affected from relief displacement, which the polynomial has not been able to model. In order to model relief displacement, projective method is used. This method consists of two main stages. At the first stage, a global polynomial is used for geometric correction of Satellite imagery and the image coordinate of ground control points is recalculated using global polynomial. At the second stage, the calculated coordinates in step 1 and the real image coordinates are used in Projective model.

In order to remove outstanding errors efficiently we should locate a model that maps the calculated coordinates from polynomial to original coordinates. Therefore we can assume that results of polynomial are mapped to an intermediate space close to genuine space of image.



In order the coordinate of each ground control point, at the first, a polynomial is used and then the output of polynomial is overcorrected using Projective model. The above figure is used to calculate both models.

c) Accuracy Result

An IRS P6 Liss III satellite image from a region of Kiliyar Sub Basin is used as experiment area. This image is located near the Kanchipuram and Thiruvannamalai districts.

Result of Polynomial model

There were 9 GCP accessible that we used in three cases with control point. The result is shown in table.

Table 2 : Error Result using Polynomial model

Control Point Error (X)=9.4975 (Y)=4.0785 Total =10.3361					
GCP	Mean Residual		Result		
Point	X	Y	RMSE	Contrib.	Match
1	15.606	4.483	16.237	1.571	
2	-12.522	5.380	13.629	1.319	
3	12.835	-1.810	12.962	1.254	
4	-13.703	-1.571	13.793	1.334	0.000
5	-1.244	5.171	5.319	0.515	-0.069
6	0.503	-7.431	7.448	0.721	0.124
7	2.313	0.382	2.344	0.227	0.817
8	-6.618	-3.353	7.418	0.718	0.419
9	2.829	-1.252	3.094	0.299	0.279

After getting this final imagery and substitute appropriate polynomial model with same Ground control points and reference points are using Projective model by using the GIS ERDAS application software. The result is shown in the below table.

Result of Projective model

There were 9 GCP accessible that we used in three cases with control point. The result is shown in table.

Table 3 : Error Result using Projective model

Control Point Error (X)=56.4247 (Y)=49.1244 Total = 74.8128					
GCP	Mean Residual		Result		
Point	X	Y	RMSE	Contrib.	Match
1	106.751	-82.936	135.182	1.807	0.274
2	17.335	4.903	18.034	0.241	-0.489
3	24.529	-56.822	61.89	0.827	0.003
4	3.494	-3.277	4.79	0.064	0.571
5	-28.297	25.109	37.831	0.506	0.355
6	-82.566	-11.044	83.301	1.113	0.293
7	-26.111	-19.912	32.837	0.439	-0.083
8	-70.539	77.613	104.879	1.402	0.241
9	55.384	66.365	86.439	1.155	0.715

Result of Hybrid model

There were 9 GCP accessible that we used in all three cases with control point. The result is shown in the table

Table 4 : Error Result using Hybrid model

Control Point Error (X)=0.0023 (Y)= 0.0019 Total = 0.0030					
GCP	Mean Residual		Result		
Point	X	Y	RMSE	Contrib.	Match
1	0.003	-0.002	0.004	1.198	0.000
2	-0.004	0.003	0.005	1.571	-0.000
3	0.002	-0.002	0.003	1.073	0.000
4	-0.003	0.002	0.004	1.411	0.000
5	0.000	0.002	0.002	0.503	-0.000
6	0.001	0.000	0.001	0.180	0.000
7	0.000	-0.002	0.002	0.737	-0.000
8	-0.001	0.001	0.001	0.469	0.000
9	0.002	-0.002	0.003	0.954	0.000

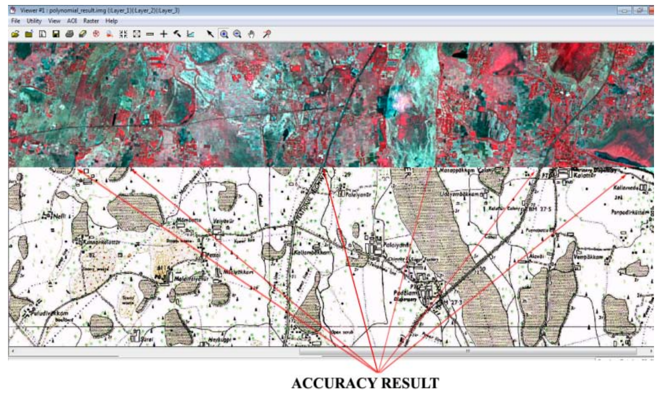


Figure 6 : Hybrid model accuracy result matching points

VI. Result

For examination of the results from the mathematical models in section 2, the unknown coefficients were determined using 9 control points for each model. Then with the determined coefficients, the corrected Image coordinates were calculated for 9 check points. RMS errors were calculated for each model base on the two types of coordinates for check points. Below table shows results for each model.

Table 5 : RMSE Value for IRS P6 LISS-III imagery in Different models

Model	No. of GCP	Control Point	RMS error
Polynomial	9	9	10.3361
Projection	9	9	74.8128
Hybrid	9	9	0.0030

VII. Conclusion

The preprocessing of remotely sensed image is very important to improve the quality and to remove errors. It consists of two types of correction geometric and radiometric correction. In this paper, the results of practical test conclude that above hybrid model gives the best results compared to the mathematical methods especially for high resolution satellite imageries such as IRS-P6 Liss III. The main advantages of this model are increased accuracy, simple calculations and lesser number of ground control points required. Future research work may be selecting effective ground control points in point wise polynomial functions utilizing projective transformation.

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