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Contents

Volume 93
Issue 6
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Editorial

Research Articles

Sensors & Transducers Journal, Vol. 93, Issue 6, June 2008, pp. 37-49

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A Generic Model for Relative Adjustment between Optical Sensors Using Rigorous Orbit Mechanics

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Abstract: The classical calibration or space resection is the fundamental task in photogrammetry. The lack of sufficient knowledge of interior and exterior orientation parameters lead to unreliable results in the photogrammetric process. One of the earliest in approaches using in photogrammetry was the plumb line calibration method. This method is suitable to recover the radial and decentering lens distortion coefficients, while the remaining interior (focal length and principal point coordinates) and exterior orientation parameters have to be determined by a complimentary method. As the lens distortion remains very less it not considered as the interior orientation parameters, in the present rigorous sensor model. There are several other available methods based on the photogrammetric collinearity equations, which consider the determination of exterior orientation parameters, with no mention to the simultaneous determination of inner orientation parameters. Normal space resection methods solve the problem using control points, whose coordinates are known both in image and object reference systems. The non-linearity of the model and the problems, in point location in digital images and identifying the maximum GPS measured control points are the main drawbacks of the classical approaches. This paper addresses mathematical model based on the fundamental assumption of collineary of three points of two Along-Track Stereo imagery sensors and independent object point. Assuming this condition it is possible to extract the exterior orientation (EO) parameters for a long strip and single image together, without and with using the control points. Moreover, after extracting the EO parameters the accuracy for satellite data products are compared in with using single and with no control points. *Copyright © 2008 IFSA.*

Keywords: Cartosat-1, Ground control points (GCPs), Coplanarity condition, Along-track stereo sensors, Imaging geometry, Taylor's series

1. Introduction

Cartosat-1 (IRS-P5) is one of the Indian remote sensing satellites, which provides high resolution stereo imagery of earth surface for Cartographic application, launched into polar sun-synchronous circular orbit at the altitude of 618 km. The satellite carries two identical panchromatic cameras with nominal resolution of ~2.5 m and swath of ~30 km. Both the cameras are tilted with respect to the nadir direction in order to get two views in along the track, one at an angle of +26 deg and the other at -5 deg. The camera looking ahead is called Fore camera and the other one looking near nadir is Aft camera. The PAN cameras are significant for photogrammetry and cartographic application due to its fine resolution and stereo acquisition capability. The primary goal and advantage of Cartosat-1 mission is generation of Digital Elevation Model (DEM) for orthoimage production and 3D terrain visualization on a global basis. Push-broom scanning technique is used in Cartosat-1 for acquiring images like in the other IRS satellite. The Data Product Generation System (DPGS) software employs photogrammetric collinearity condition for modeling the imaging geometry of Cartosat-1. This approach takes care of modeling time varying Exterior Orientation (EO) parameters (Orbit & Attitude).

With the dual cameras onboard Cartosat-1 (separated by 52 seconds), the advantage of simultaneous imaging of the objects at different times is well handled by *Coplanarity condition* (Mikhail 2001& Ghosh 1988). For improving Cartosat-1 data products accuracy, various approaches have been tried to model orbit & attitude parameters using either Physical Sensor Model or Rational Polynomial Coefficients (RPC) model. Photogrammetric space resection and Kalman filter approaches have been tried using Cartosat-1 data (Singh et al. 2002). These physical sensor model approaches considerably improved the geometric accuracy of precision/ortho products for Cartosat-1 with the help of a few ground control points (GCPs) identified over a scene (30 km) or a longer strip (500 km) from a single or stereo cameras. Further study & research carried out in this direction have led to an alternate approach to treat Cartosat-1 stereo imaging sensors as attitude sensors using photogrammetric *Coplanarity condition* for improving geometric accuracy.

This methodology adopted for refining platform parameters for Cartosat-1 performing the relative orientation between optical sensors of remote sensing satellite (Cartosat-1) using *Coplanarity model*. Also, the approach addressed are the study and experiments conducted with this approach for Cartosat-1 with different data sets, results obtained and summary of observations and analysis.

2. Coplanarity Condition

If the photographs are relatively oriented with respect to each other, then object space rays defined by two image points and their respective perspective centers will intersect exactly. The two rays and the base vector connecting the two perspective centers constitute the three sides of a triangle and thus implicitly define a plane.

The *Coplanarity* condition implies that two perspective centre coordinate, any object point and the corresponding image points on the two photographs of the stereo pair, must all lie in a common plane. This condition is fundamental to relative orientation or *space intersection*, i.e. the scalar triple product is zero. Also the possible scalar triple product is always cyclic. The process of fixing single camera is said to be the *dependent* method of relative orientation, otherwise it is *independent*. This condition is said to be the necessary and sufficient condition for scalar triple product of three vectors. Moreover, for the intersection of pair of rays there is a requirement for the relative orientation. Since the coordinate points of object space do not appear in model (problem formulation), the image points are sufficient for complete solution of the phototriangulation problem.

In this approach, it is assumed that the knowledge of interior orientation and spacecraft position is sufficiently accurate while error in attitude is modeled linearly for estimating attitude bias and rate bias which helps to recover the uncertainties present while acquiring the imagery (Caron et al. 1975). *Since the object coordinates do not appear in Coplanarity equations, this method may also be considered for in-flight calibration of geometric parameters during initial phase mission qualification operations.*

3. Mathematical Formulations

If two images are not relatively oriented w.r.t each other object space rays will not intersect exactly, therefore, there will be shortest distance between two lines. Here assuming that the rays intersect at an object point forms a triangle for three vectors (Fig. 1).

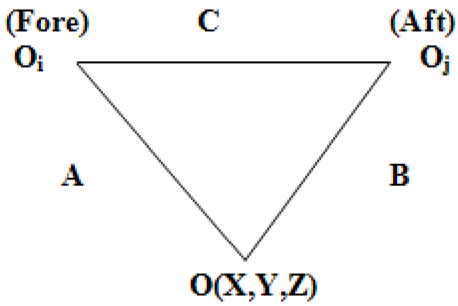


Fig. 1. Coplanarity Condition.

The mathematical formulations for *Coplanarity equations* and its expansion are explained below. The intersection in space is written in *Coplanarity* constraint as:

$$\boldsymbol{F} = (\boldsymbol{A} \times \boldsymbol{B}).\boldsymbol{C} = \boldsymbol{0}, \tag{1}$$

where,

$$\mathbf{C} = (x_{L2} - x_{L1})i + (y_{L2} - y_{L1})j + (z_{L2} - z_{L1})k,$$

i, j, k are the unit vectors along three directions.

The imaging satellite sensor geometry is generally modeled by using photogrammetric collinearity condition (Mikhail et al. 2001). The condition states at any instant of imaging, the image point, corresponding ground point and perspective centre, will all lie in a straight line.

Thus collinearity equation relating image space to object space is given by

$$\begin{bmatrix} X - x_{L1} \\ Y - y_{L1} \\ Z - z_{L1} \end{bmatrix} = \lambda'.M^T.\begin{pmatrix} f \\ -x \\ -y \end{pmatrix} \tag{2}$$

$$= \lambda'.\begin{pmatrix} a_{11} f - a_{21} x - a_{31} y \\ a_{12} f - a_{22} x - a_{32} y \\ a_{13} f - a_{23} x - a_{33} y \end{pmatrix} = \lambda'.\begin{pmatrix} u_i \\ v_i \\ w_i \end{pmatrix}$$

Let (u_i, v_i, w_i) and (u_j, v_j, w_j) be the three components representing image plane for both the cameras Fore and Aft respectively, as per the definition in Eq.(2), where a_{ij} represents the components of the orientation matrix M and λ' is the reciprocal of scale factor and f is the focal length. Also $O(X, Y, Z)$ is the ground coordinate and $O_i\left(x_{L1}, y_{L1}, z_{L1}\right)$ and $O_j\left(x_{L2}, y_{L2}, z_{L2}\right)$ are the two positions of the satellites (i.e. Fore and Aft cameras). Therefore, the orientation matrix can be expressed as

$$M = R_L R_A R_O$$

Taking

$$R_L = \begin{pmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{pmatrix}, \; R_A = \begin{pmatrix} m_{11} & m_{12} & m_{13} \\ m_{21} & m_{22} & m_{23} \\ m_{31} & m_{32} & m_{33} \end{pmatrix}, \; R_O = \begin{pmatrix} y_{11} & y_{12} & y_{13} \\ y_{21} & y_{22} & y_{23} \\ y_{31} & y_{32} & y_{33} \end{pmatrix},$$

where x_{ij} are the elements of Look angle matrix R_L, m_{ij} are the elements of attitude matrix R_A and y_{ij} are the elements of orientation matrix R_O. Therefore,

$$M = \begin{pmatrix} o_{11} & o_{12} & o_{13} \\ o_{21} & o_{22} & o_{23} \\ o_{31} & o_{32} & o_{33} \end{pmatrix},$$

where o_{ij} represents the elements of the orientation matrix.

Also R_A can be expressed as

$$R_A = R_y R_r R_p$$

$$R_A = \begin{pmatrix} c_r c_p & s_r & -c_r s_p \\ -c_y s_r c_p + s_y s_p & c_y c_r & c_y s_r s_p + s_y c_p \\ s_y s_r c_p + c_y s_p & -s_y c_r & -s_y s_r s_p + c_y c_p \end{pmatrix}$$

Comparing the notations with m_{ij} of R_A we get

$$m_{11} = c_r c_p, m_{12} = s_r, m_{13} = -c_r s_p$$
$$m_{21} = -c_y s_r c_p + s_y s_p, m_{22} = c_y c_r, m_{23} = c_y s_r s_p + s_y c_p$$
$$m_{31} = s_y s_r c_p + c_y s_p, m_{32} = -s_y c_r, m_{33} = -s_y s_r s_p + c_y c_p$$

The *Coplanarity* condition in equation (1) can be written as,

$$\begin{vmatrix} x_{L2}-x_{L1} & y_{L2}-y_{L1} & z_{L2}-z_{L1} \\ u_i & v_i & w_i \\ u_j & v_j & w_j \end{vmatrix} = 0 \tag{3}$$

Expanding the Eq. (3) we get,

$$F = (x_{L2}-x_{L1})(v_i.w_j - v_j.w_i) + (y_{L2}-y_{L1})(u_j.w_i - u_i.w_j)\ \{u_i.v_j - u_j.v_i\} = 0 \tag{4}$$

Assuming the linear polynomial fitting with time (t) in attitude components are taking as

$$Roll = Orig\_roll + r_0 + r_1 t$$
$$Pitch = Orig\_pitch + p_0 + p_1 t$$
$$Yaw = Orig\_yaw + y_0 + y_1 t$$

Now putting the above linear correction model in attitude matrix R_A and differentiating partially the equation (3.4) for the Fore camera (assumed) w.r.t $r_0, r_1, p_0, p_1, y_0, y_1$ we get

$$\frac{\partial F}{\partial r_0} = (x_{L2}-x_{L1})\left\{(\frac{\partial v_i}{\partial r_0}.w_j - v_i.\frac{\partial w_j}{\partial r_0}) - (\frac{\partial v_j}{\partial r_0}.w_i + v_j.\frac{\partial w_i}{\partial r_0})\right\} + (y_{L2}-y_{L1})$$
$$\left\{(w_i.\frac{\partial u_j}{\partial r_0} + u_j.\frac{\partial w_i}{\partial r_0}) - (\frac{\partial u_i}{\partial r_0}.w_j + u_i.\frac{\partial w_j}{\partial r_0})\right\} + (z_{L2}-z_{L1})\left\{(\frac{\partial u_i}{\partial r_0}.v_j + u_i.\frac{\partial v_j}{\partial r_0}) - (\frac{\partial v_i}{\partial r_0}.u_j + v_i.\frac{\partial u_j}{\partial r_0})\right\}$$

Same way we can write for $\frac{\partial F}{\partial p_0} and \frac{\partial F}{\partial y_0}$.

Also we can compute simply, $\frac{\partial F}{\partial r_1} = t\ \frac{\partial F}{\partial r_0}$, $\frac{\partial F}{\partial p_1} = t\ \frac{\partial F}{\partial p_0}$, $\frac{\partial F}{\partial y_1} = t\ \frac{\partial F}{\partial y_0}$

Linearizing the equation (4) by Taylor series expansion of several variables and retaining the first order terms we get,

$$F_0 + J\Delta = 0$$
$$\Rightarrow -F_0 = J\Delta \quad , \tag{5}$$

where F_0 is the *Coplanarity* equations with the initial set of measurement and parameters,

$$J = \left[\frac{\partial F}{\partial r_0} \frac{\partial F}{\partial r_1} \frac{\partial F}{\partial p_0} \frac{\partial F}{\partial p_1} \frac{\partial F}{\partial y_0} \frac{\partial F}{\partial y_1}\right]$$

is the Partial derivative matrix and Δ's are the correction factors i.e. the biases of corresponding to each of the coefficients of the linear correction model.

To solve Eq.(5) a simultaneous least square adjustment is used to determine the most probable solution for the unknown deltas of the coefficients which will add to the coefficients corresponding to the each iteration.

4. Methodology

Here, the method is based on relative orientation and as such, both Fore & Aft camera imaging geometry is effectively used to adjust the orientation parameters. Since orbit, attitude information is available in ECI (Earth Centered Inertial) system, the entire approach is adopted in ECI system. Though GCPs are available for different data sets, only the image positions (scan and pixel) are used for adjustment, as the *Coplanarity* formulation does not involve use of ground position. In this sense, all image points are treated as Tie points. However, for checking the accuracy of the model, GCPs are used in the ground to image transformation. Also, the biases seen after adjustment are removed with the help of a single control point. As such, the method works without use of ground control point. The following are the inputs for testing the *Coplanarity* approach viz.

(1) The attitude time series vector.
(2) Ephemeris time series vector in ECI frame of reference.
(3) GCPs position (precise scan & pixel taken from radiometrically corrected Fore & Aft or both) – GCPs are initially used as pure image points or tie points.

Outputs are the set of refined or improved platform orientation parameters.

<u>Step 1</u>: Using GCPs, image positions are estimated at a few points based on rigorous sensor model with the input orbit attitude parameters (taken from Cartosat-1 ancillary data). The system level accuracy is established from the above using actual scan & pixel position.

<u>Step 2</u>: *Coplanarity* model is used based on a set of Tie points (image positions) taken from FORE & AFT camera for the chosen duration to update the attitude.

<u>Step 3</u>: Repeat the procedure as of Step 1 but using the updated attitude from Step 2 corresponding to each of the iterations until the expected accuracy is not observed.

Model level accuracy (Root Mean Square error and Standard deviation) estimated at check points (GCPs) from Step 3 is compared with that of from Step1 to assess the improvement by this approach.

5. Observations and Analysis

Four different Cartosat-1 stereo data sets for shorter & longer strip over different areas having different terrains are considered for testing this approach. The results obtained as per the steps described in Section 4 are tabulated and some of the plots (Figs. 2 and 3) are used for analysis.

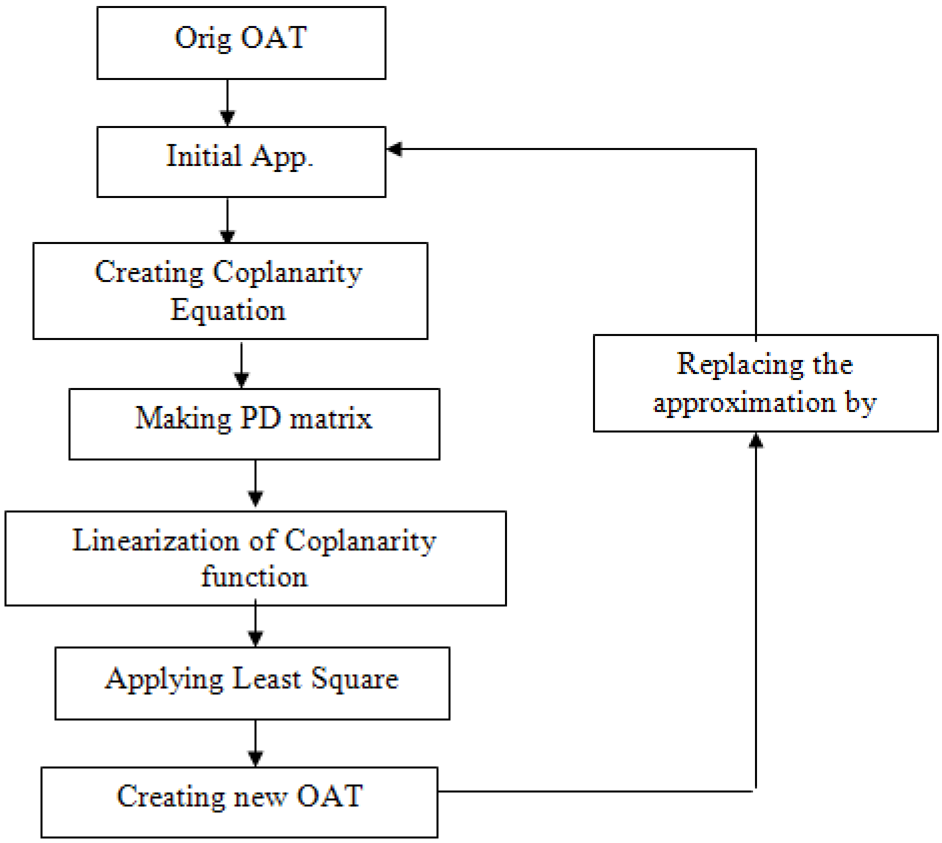


Fig. 2. The flow chart of the proposed algorithm.

Table 1 shows the results for all 4 cases with and without *Coplanarity* model. As can be seen from the table, it is observed that for longer duration the desired accuracy is not met. Here, both pre & post *Coplanarity* results are same except in one case. However, when the strip length is reduced to nearly scene duration the improvement is seen at model level accuracy which can be seen from Table 2 and the consistency is there among the data sets. Further, it can be seen from Table 2, the RMS error in pixel direction has not improved when compared with scan direction. With the help of a single GCP, it is possible to improve the RMS error in both scan and pixel direction.

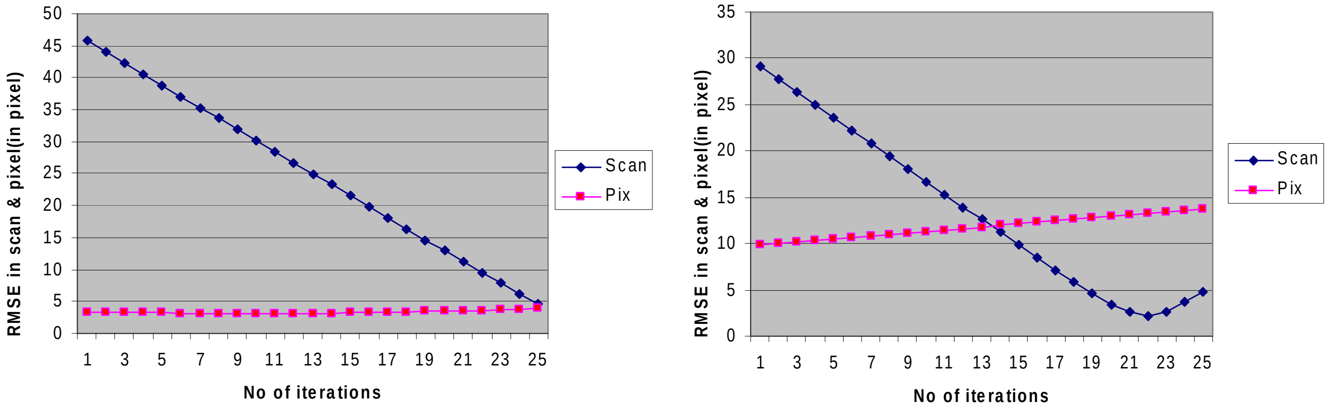
Table 1 presents the location accuracies obtained for 4 data sets of longer strip length. The accuracies are closer to system level accuracy and improvement is not seen. This behaviour is being studied and further testing is on.

Table 2 presents the RMS error corresponding to each data sets having scene size of (30×30) km^2 extending 5 to 7 seconds (slightly more than the Cartosat-1 scene duration of 4.3 seconds), with more number of conjugate/tie points being used. The achieved accuracies are satisfactory. In all cases, RMS error is less than 5 pixels in along-track direction but that is not observed in across-track direction. This may be attributed to poor estimation of roll and yaw angles or the model is not able to adjust the relative geometry of Fore and Aft camera well.

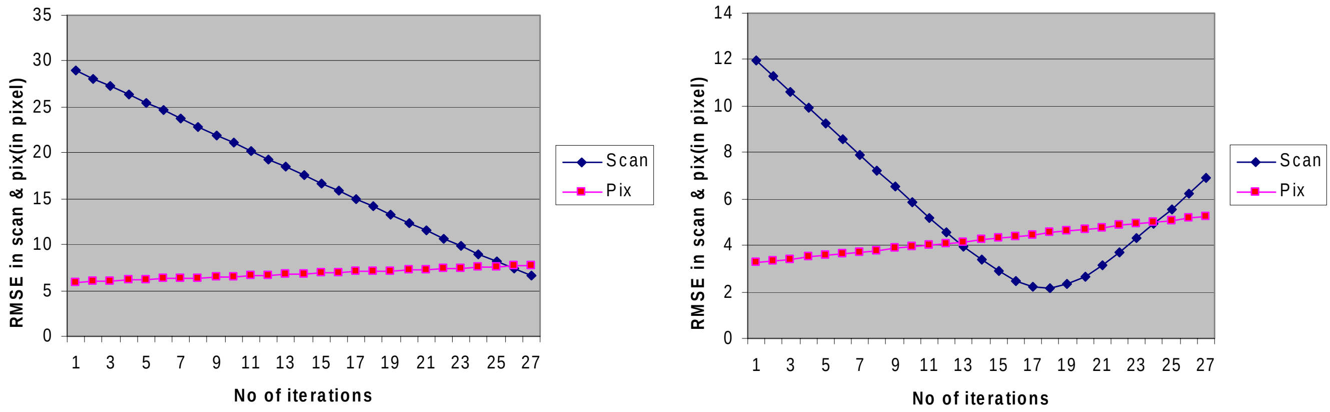
Table 3 shows that it is possible to improve the RMS error after compensating the biases in attitude components with the availability of at least single control point.

From the above observations and analysis, it can be concluded that the *Coplanarity* model is able to refine attitude for shorter duration. Also, with the help of single GCP, the biases are compensated to accurately recover the time-dependent EO (exterior orientation) parameters of the Cartosat-1 platform.

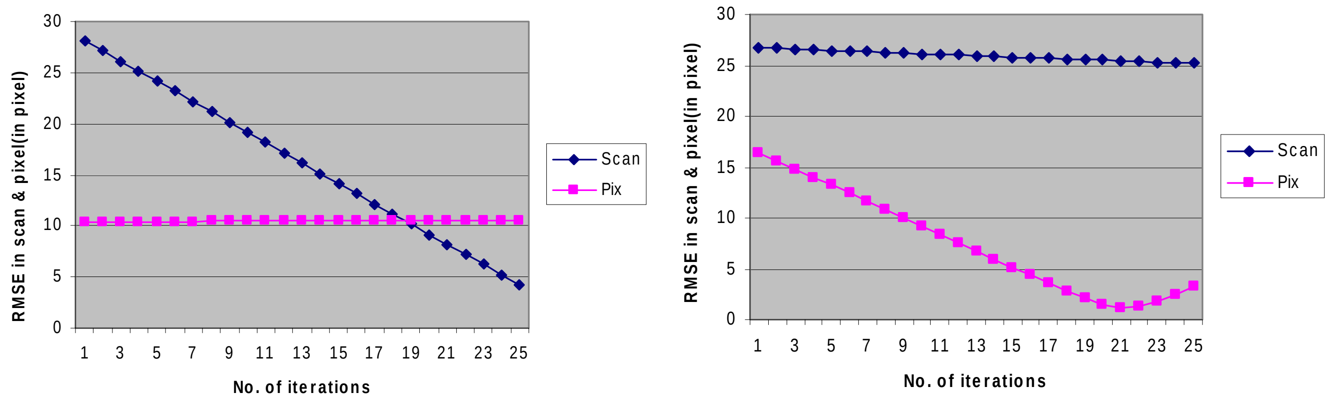
Also a comparative study has been produced together for pre, post and after adjusting biases in attitude components shows in Fig. 3.



28th May Fore and Aft cameras



8th June Fore and Aft cameras



4th Nov Fore and Aft cameras

Fig. 3. The plot shows that the RMSE variations with number of iterations.

Following tables show some of the results of *pre* and *post* application of *Coplanarity model* for Cartosat-1 data.

Table 1. Results on Cartosat-1 data with large strip lengths.

Table 1a. Pre Coplanarity results.

Date	Cameras	Strip Length (in seconds)	RMS scan (in pixels)	RMS pix (in pixels)	Std. scan (in pixels)	Std. pix (in pixels)
28th May 2005 (Bangalore)	Fore	9.87 + 52	47.49	3.47	2.47	3.12
	Aft	9.94 + 52	30.48	9.72	2.22	3.53
8th June 2005 (Hyderabad)	Fore	9.85 + 52	29.86	5.84	3.05	2.30
	Aft	9.97+ 52	12.69	3.21	2.13	1.86
4th Nov. 2005 (Alwar)	Fore	24.45 + 52	29.13	10.39	1.48	1.44
	Aft	24.44 + 52	17.20	26.77	1.06	1.10
14thNov. 2005 (Bangalore)	Fore	17.59 + 52	42.42	18.43	2.76	4.56
	Aft	17.58 + 52	25.78	30.72	2.63	5.48

Table 1b. Post Coplanarity results.

Date	Cameras	Strip Length (in seconds)	RMS scan (in pixels)	RMS pix (in pixels)	Std. scan (in pixels)	Std. pix (in pixels)
28th May	Fore	9.87 + 52	47.71	3.85	2.17	2.23
	Aft	9.94 + 52	30.92	11.35	2.01	2.31
8th June	Fore	9.85 + 52	33.93	4.50	2.10	0.89
	Aft	9.97 + 52	15.48	2.94	1.19	0.93
4th Nov	Fore	24.45 + 52	19.36	11.51	0.98	1.95
	Aft	24.44 + 52	9.53	26.41	0.97	1.28
14thNov	Fore	17.59 + 52	4.42	19.21	4.11	2.97
	Aft	17.58 + 52	7.66	25.71	5.29	3.89

Table 2. Results on Cartosat-1 data with smaller strip lengths.
(Post Coplanarity results for both the cameras).

Date	Camera	No of points	Strip Length (in seconds)	RMS scan (in pixels)	RMS pix (in pixels)	Std. scan (in pixels)	Std. pix (in pixels)
28th May	Fore	20	2.07 + 52	4.7	3.87	2.44	3.16
	Aft	20	1.91+ 52	4.61	12.76	2.23	3.53
8th June	Fore	20	3.83 + 52	6.58	7.74	3.05	2.32
	Aft	20	3.78 + 52	2.87	4.31	2.13	1.86
4th Nov.	Fore	20	6.06 + 52	4.28	10.58	1.47	1.46
	Aft	20	6.06 + 52	1.08	25.43	1.07	1.11
14thNov	Fore	20	7.71 + 52	2.46	17.32	2.37	4.51
	Aft	20	7.59 + 52	8.37	28.31	1.74	5.4

Table 3. Results on Cartosat-1 data with one GCP.

Table 3a. Case 1: In this case the results are compared with pre and post application of Coplanarity Model for scene level duration (same as Table 2). Date Of Pass: 4th Nov(Alw), No. of Tie points: 20, Scene Duration: 4.38 s.

		Pre Coplanarity model			
Camera	**RMS scan (in pixels)**	**RMS pix (in pixels)**	**Std. scan (in pixels)**	**Std. pix (in pixels)**	**Orbit/attitude Status (OAT)**
Fore	29.12	10.38	1.47	1.44	Original OAT
Aft	17.2	26.77	1.062	1.10	
		Post Coplanarity model			
Fore	4.28	10.58	1.47	1.45	Updated OAT
Aft	3.27	25.17	1.06	1.1	

Table 3b. Case 2: In this case after getting the biases using single GCP, which is added (in attitude component) separately for pre and post application of model. The post biases are collected after initial application of model for compensation. Date Of Pass: 4th Nov(Alw), No. of Tie points: 20, Scene Duration: 4.38 s.

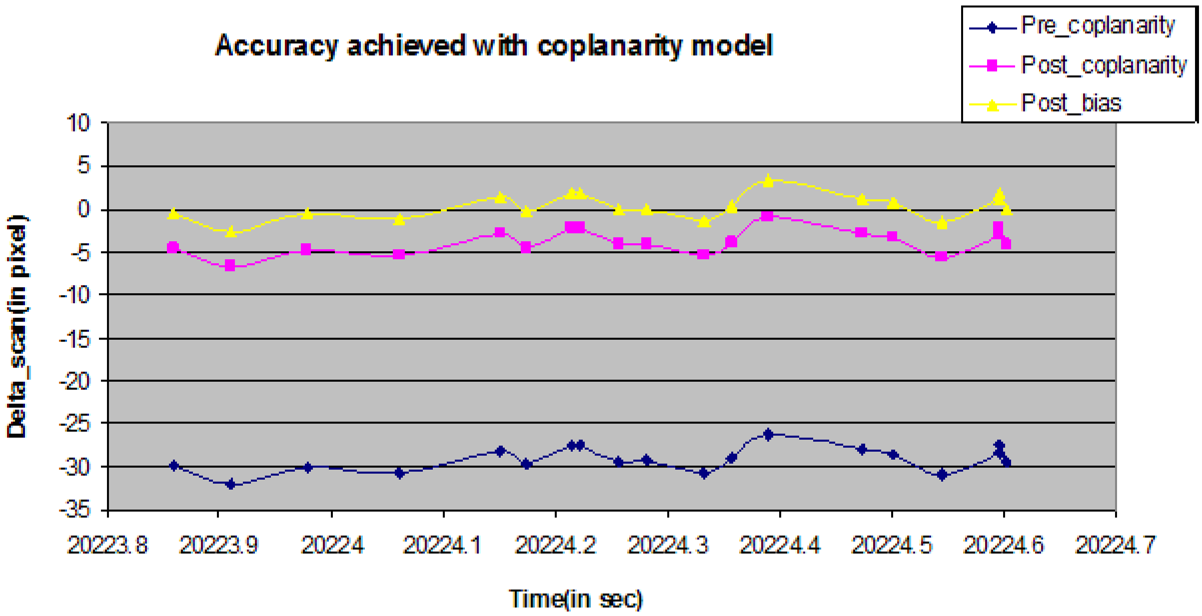
		Pre Coplanarity model			
Camera	**RMS scan (in pixels)**	**RMS pix (in pixels)**	**Std. scan (in pixels)**	**Std. pix (in pixels)**	**Orbit/attitude Status (OAT)**
Fore	7.38	2.08	1.457	1.46	Original OAT+ pre biases
Aft	1.93	3.49	1.05	1.10	
		Post Coplanarity model			
Fore	1.51	1.47	1.45	1.46	Updated OAT+post biases
Aft	1.07	1.83	1.06	1.10	

Table 3c. Case 1: In this case the results are compared with pre and post application of Coplanarity Model for scene level duration (same as Table 2). Date Of Pass: 14th Nov, No. of Tie points: 20, Scene Duration: 5 s.

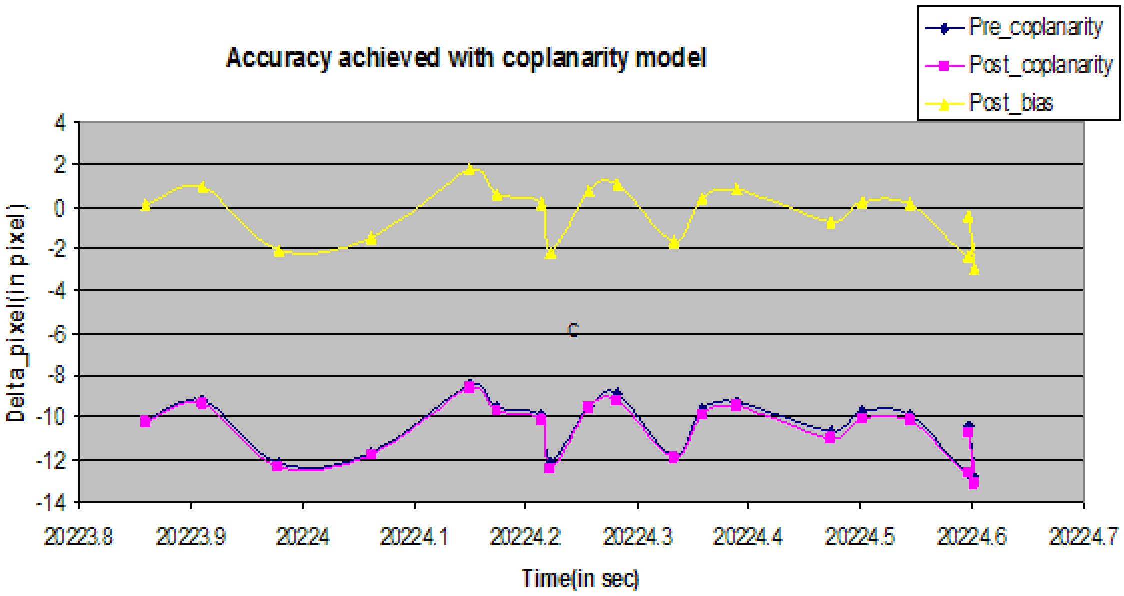
		Pre Coplanarity model			
Camera	**RMS scan (in pixels)**	**RMS pix (in pixels)**	**Std. scan (in pixels)**	**Std. pix (in pixels)**	**Orbit/attitude Status (OAT)**
Fore	42.42	18.35	2.76	4.56	Original OAT
Aft	25.78	30.72	2.63	5.48	
		Post Coplanarity model			
Fore	3.16	12.98	2.8	4.51	Updated OAT
Aft	9.1	27.91	2.67	5.48	

Table 3d. Case 2: In this case after getting the biases using single GCP, which is added (in attitude component) separately for pre and post application of model. The post biases are collected after initial application of model for compensation. Date Of Pass: 14th Nov, No. of Tie points: 20, Scene Duration: 5 s.

		Pre Coplanarity model			
Camera	**RMS scan (in pixels)**	**RMS pix (in pixels)**	**Std. scan (in pixels)**	**Std. pix (in pixels)**	**Orbit/attitude Status (OAT)**
Fore	16.22	8.03	15.92	8.01	Original OAT+ pre biases
Aft	5.96	8.26	3.35	7.28	
		Post Coplanarity model			
Fore	3.40	5.99	3.22	5.92	Updated OAT+ post biases
Aft	4.78	7.14	4.12	6.98	

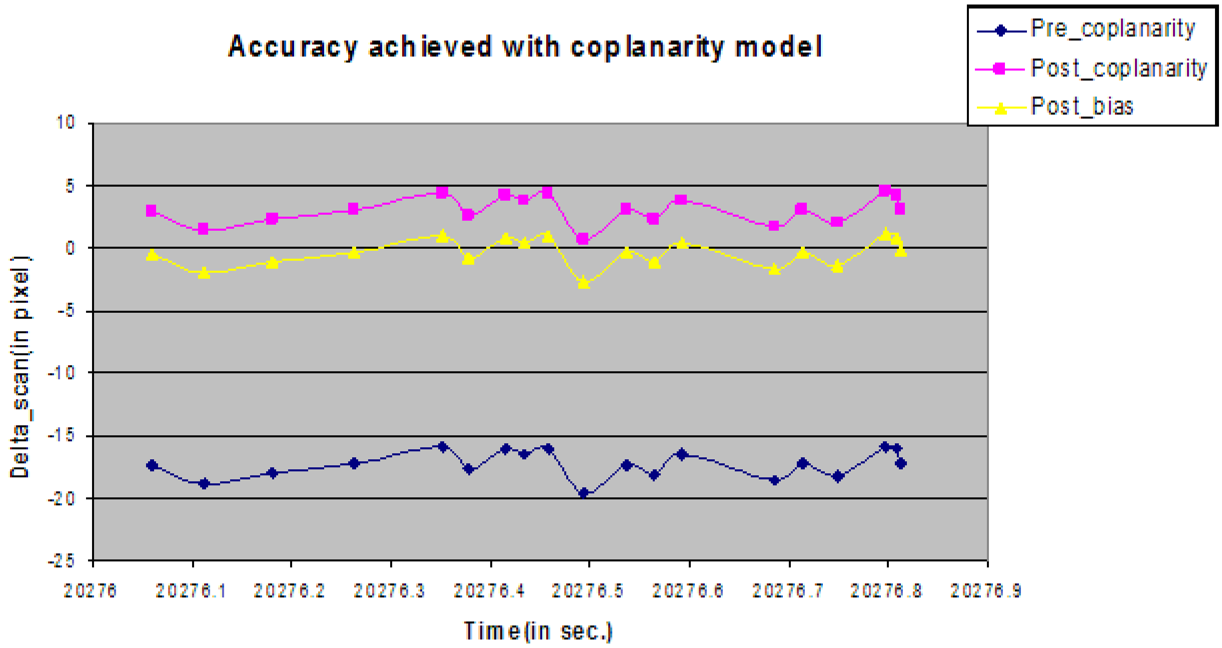


(a)

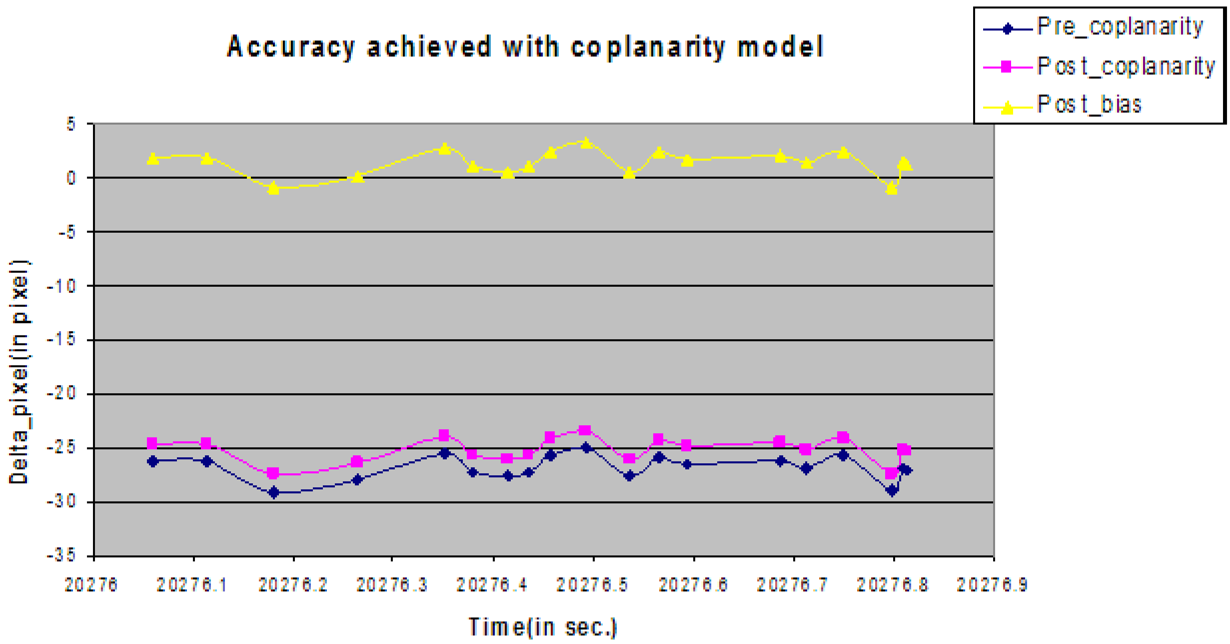


(b)

Fig. 4. (a, b) The plot shows the comparison in pre, post Coplanarity and after adjusting the biases in attitudes: 4th Nov Fore Camera.



(a)



(b)

Fig. 5. (a, b) The plot shows the comparison in pre, post Coplanarity and after adjusting the biases in attitudes: 4th Nov Aft camera.

6. Conclusions

An approach has been studied on using *Coplanarity* model for improvement of Cartosat-1 attitude parameters. The algorithm is developed and the necessary s/w is implemented. This method has been tested for different data sets of Cartosat-1. The exercises carried out with *Coplanarity model* demonstrate that the use of two imaging stereo sensors is able to improve the system level accuracy without control points. However, with one control point further improvement is achieved. Also, it is observed that the methodology works well for shorter duration equivalent to a scene or so refining the Cartosat-1 attitude parameters leading to improvement in location accuracy of the data products. Future scope includes further study, exercises for (i) testing more data sets, (ii) extending to longer strip length and (iii) using triple observation data sets.

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Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In additional, some special sponsored and conference issues published annually.

Topics Covered

Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

- Physical, chemical and biosensors;
- Digital, frequency, period, duty-cycle, time interval, PWM, pulse number output sensors and transducers;
- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
- Frequency (period, duty-cycle)-to-digital converters, ADC;
- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

Submission of papers

Articles should be written in English. Authors are invited to submit by e-mail editor@sensorsportal.com 6-14 pages article (including abstract, illustrations (color or grayscale), photos and references) in both: MS Word (doc) and Acrobat (pdf) formats. Detailed preparation instructions, paper example and template of manuscript are available from the journal's webpage: http://www.sensorsportal.com/HTML/DIGEST/Submition.htm Authors must follow the instructions strictly when submitting their manuscripts.

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