Geometric and Information Potential of IRS-1C PAN-Images

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ABSTRACT

Up to the availability of the announced very high resolution satellite images, the IRS-1C and IRS-1D PAN-camera creates with 5.8m pixel size, digital space images with the highest resolution which are not classified. The swath width of 70km in the nadir view is covered by a combination of 3 CCD-line sensors, each with 4096 pixels. There is a time delay in imaging with the center line against both other CCD-lines, causing geometric problems of joining the 3 CCD-lines together.

Based on ground points, visible in the overlapping area of 2 neighbored CCD-lines, the image parts can be transformed together. But a simple shift is not sufficient because the scale of the CCD-lines is different and there is also a rotation of the sub-scenes. This only can be determined by self-calibration with additional parameters in a bundle solution using a rigorous mathematical model.

With precise control and check points a ground accuracy of SX=+/-7.1m, SY=+/-5.0m and SZ=+/-9.7m has been reached corresponding to +/-1.1 pixel. This is possible without pre-knowledge of the sensor geometry just with 8 control points for the covered area of 86km * 84km. The achieved accuracy is mainly representing the point identification, not the sensor accuracy itself.

A comparison of mapping the same area with IRS-1C-PAN-images and with multispectral and panchromatic SPOT-images has shown the advantage of the higher resolution IRS-1C-images. Nearly all objects required for mapping in the scale 1 : 50 000 could be identified, which was not the case for the SPOT-images. Only with the very high resolution Russian KVR1000-photos, better object information could be achieved.

INTRODUCTION

According to publications of the United Nations, only 2.3% of the maps in the scale range of 1 : 50 000 are updated per year. The corresponding poor map information cannot be accepted, it is causing a loss in the national economics. One of the reason for this is the restriction in the use of aerial photos in several countries. The Open Sky agreement of the United Nations has opened the field for the commercial use of very high resolution satellite images. Former classified data are now available for civilian use and the launch of commercial earth observation satellites is possible and announced.

In addition no risk with the photo flights is existing and only the required images must be ordered. The today highest resolution space images available for commercial use are still the Russian photos. The distribution problem has been solved by cooperation's with Western companies, but the photos never can be so actual like digital data. With a pixel size of 5.8m for IRS-1C /1D PAN, higher resolution digital space images than before are available.

GEOMETRIC PROBLEMS AND POTENTIAL

The Indian Remote Sensing Satellite IRS-1C, launched in December 1995 and the identical IRS-1D, launched in September 1997 do have 3 sensors on board, the high resolution PAN-camera with a pixel size of 5.8m, the Linear Self Scanning camera LISS-III with 4 spectral bands and the Wide Field Sensor WiFS with a pixel size of 188m. A stereoscopic coverage is possible with the PAN-camera by a rotation up to +/-26° across track, corresponding to SPOT.
The PAN-camera has 3 CCD-lines, each with 4096 pixels. There is a small overlap of the 3 lines, so the effective size of the combination corresponds to approximately 12 000 pixel.
The separation of the CCD-sensors in the orbit direction can cause a change in the connection of the 3 parts up to 0.5 pixel. A ground point will be displaced by 10m in the orbit direction, if the point is located 1000m above the control

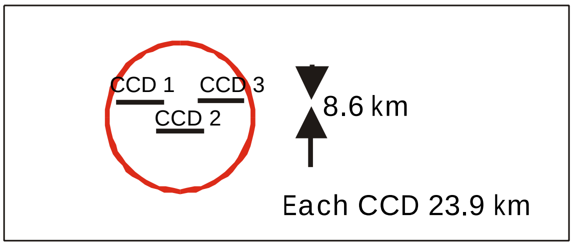


figure 1: separation of the 3 CCD-sensors in the PAN-camera

points. Usually both effects can be neglected. A larger problem has been identified with the not stable connection of the 3 sub-images, based on the 3 sensors. By means of tie points in the overlapping parts of the sub-scenes, the sub-scenes can be shifted together. This was possible with a standard deviation of the observations between ±0.2 up to ±0.6 pixel. With the joined images, bundle adjustments with the Hannover program for the handling of line-sensor-images taken from space, BLASPO, have been made with a data set, shown in fig. 2. Especially the vertical accuracy could not be accepted – the discrepancies at independent check points do show strong systematic effects (see fig. 3). The structure of the deviations can be explained by differences of the 3 sensors in scale and rotation. By this reason, the set of additional parameters in BLASPO has been extended.

```
 1   Y = Y +   P1  * Y
 2   X = X +   P2  * Y          coordinates corresponding
                                to pixel size 7µm
....
11   X = X + P11 * (X-14.)     if x >  14.
12   X = X + P12 * (X+14.)     if x < -14.
13   Y = Y + P13 * (X-14.)     if x >  14.
14   Y = Y + P14 * (X+14.)     if x < -14.
```

table 1: additional parameters of program BLASPO

The additional parameters 1 and 2 (affinity and angular affinity) are in general required for space data, the parameters 3 up to 10 are parameters for the fitting of irregular movements during imaging a scene – they are not so important. The parameters 11 – 14 are the special unknowns for handling the problems of the PAN-camera. Parameter 11 and 12 can determine the scale of the outside located sensors (right and left hand part), 13 and 14 can fit the rotations.

As obvious in table 2, the usual additional parameters 1 and 2, which are satisfying for SPOT and MOMS-data, are not sufficient. The special parameters 11 up to 14 are required, but they cannot be handled for all scenes together (line 2 in tab.2), it is necessary to handle these separately for every full scene. In addition the lines 3 and 4 demonstrate, that the scale effect (parameters 11, 12) is more important than the rotations. Finally line 6 shows that 9 control points are sufficient to reach approximately the same accuracy like with 90 control points.

	add. par.	σo [µm]	SX [m]	SY [m]	SZ [m]
1	1 + 2	28.3	8.6	10.5	82.8
2	1,2,11-14 all	27.7	8.6	7.1	83.2
3	1,2,11,12	17.3	7.0	9.4	10.5
4	1,2,13,14	23.9	9.0	5.7	84.0
5	**1,2,11-14**	**7.9**	**7.1**	**5.0**	**9.7**
6	1.2.11-14 9 control pts.	5.8	8.8	5.4	10.6

table 2: results of the bundle adjustment

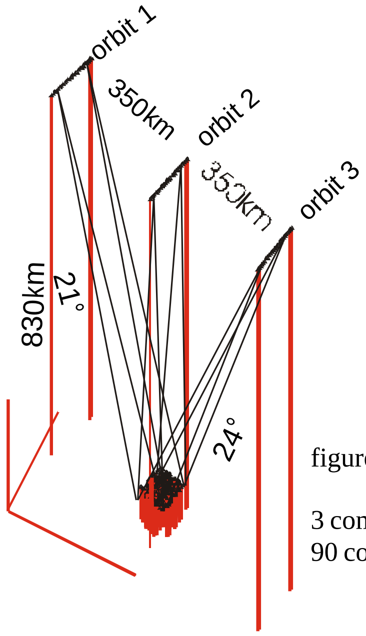
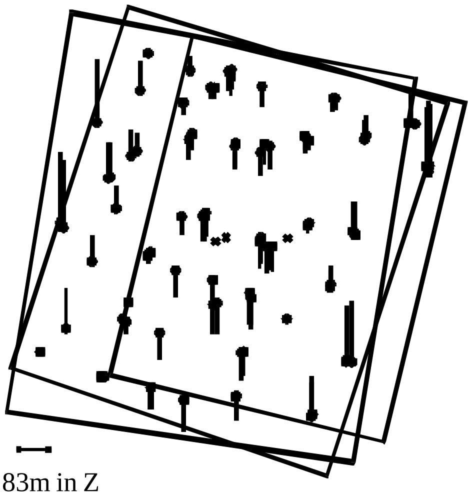


figure 2: test data set Hannover
3 complete scenes,
90 control points



83m in Z

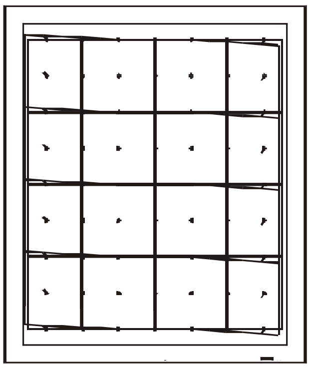


figure 4: systematic image errors

maximal size:
400µm ⇒ 59 pixels

image size: 14 800 x 12 000 pixels ⇒ 104 mm x 84 mm

The geometric quality of IRS-1C-PAN-images allows a mapping in the scale 1:25000 if ±0.2mm in the map are accepted. More important for the creation of maps is the information contents of the available images. It should be possible to identify the details required for the chosen map scale. In no case 100% of the elements can be identified, this is also not possible with aerial photos, but the major contents is required. As a rule of thumb, the pixel size on the ground shall not exceed 0.05 up to 0.1mm in the map scale. Corresponding to this, with IRS-1C-PAN-images, a mapping the range 1 : 50 000 up to 1 : 100 000 should be possible. The range in the map scale is depending upon the quality of the available images, which is influenced by the sun angle and the atmospheric conditions, the national map standard and the area. So a mapping of a city in the USA with wide roads is more easy than a mapping of a city in India with small and unpaved roads.

For the city area of Wunstorf, located close to Hannover, IRS-1C PAN-, SPOT XS and pan-, KFA1000-, KVR1000- and high altitude photo flight images (1:120 000) are available. A mapping of the area was made with all of them. The IRS-1C PAN-images do have a quantization of 6bit or 64 different gray values. The poor contrast of the original images was improved with a not linear look up table resulting in satisfying images (fig.5). Long shadows caused by a very low sun altitude of approximately 13° for the IRS-1C PAN-images are disturbing the object identification, nevertheless most of the important objects, available in the topographic map 1: 50 000, could be identified. There was no doubt with the better results based on the higher resolution images like the KVR1000 (2m pixel size) and the high altitude photos with a photo scale 1 : 120 000 corresponding to a ground resolution of 3m/lp or a pixel size of 1.5m. With these images all details of the topographic map 1:25000 could be seen.

Corresponding to this, the maps created by means of the images with lower resolution like SPOT (PAN with 10m, multispectral with 20m pixel size) do not show the required details.

Not only the pixel size is important, the spectral information supports the object identification. So in spite of a factor 2 for the pixel size, the information contents of the panchromatic and the multispectral SPOT images was not so different.

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fig. 7: SPOT multispectral

fig. 8: SPOT PAN

fig. 5: IRS-1C PAN

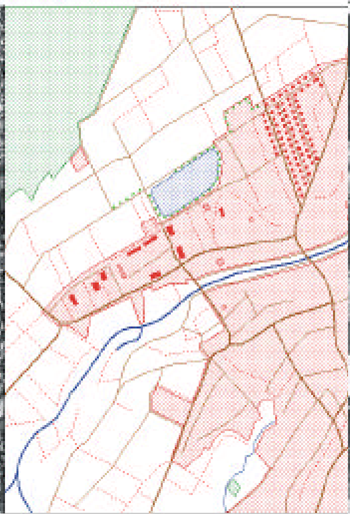

fig. 6: map based on IRS-1C-PAN

fig. 9: KVR1000

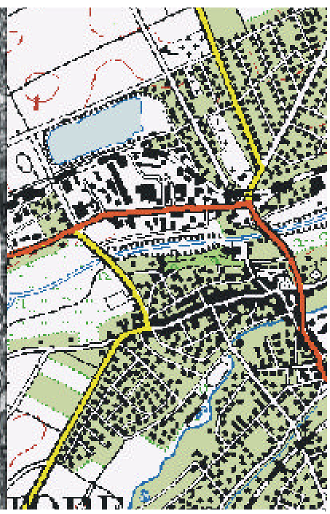

fig 10: topographic map 1 : 50 000