A STUDY ON THE DETERMINATION OF THE INSTANTANEOUS FIELD OF VIEW FOR 1-M HIGH RESOLUTION SATELLITE IMAGE

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ABSTRACT:

In this paper we present a detail approach of the determination of IFOV (Instantaneous Field of View) of high-resolution (1 m) panchromatic satellite image over test site. IFOV is the representative measurements as the determination of the spatial resolution in remote sensed imaging system. It can be defined as some area on the ground with the particular altitude when the satellite acquires the image at any given time.
Especially, spatial resolution of passive sensors primarily depends on their IFOV. The determination of IFOV goes through simple steps of procedure as followings: Firstly, the GSD (Ground Sample Distance) should be computed at each point on the geometrically corrected image. Then, The GSD is converted into the IFOV. So we are going to explain our test procedures and results.

KEY WORDS: GSD, IFOV, Spatial resolution

1. INTRODUCTION

Digital images are often described in terms of their pixel size, but can also be specified in terms of the instantaneous field of view(IFOV), which if the angle determined by the pixel size and the focal length. As shown in Fig. 1, as the focal length decreases or the pixel size increases, the IFOV increases. A larger IFOV means that one pixel covers a larger portion of the scene or, equivalently, that the image will have lower spatial resolution.

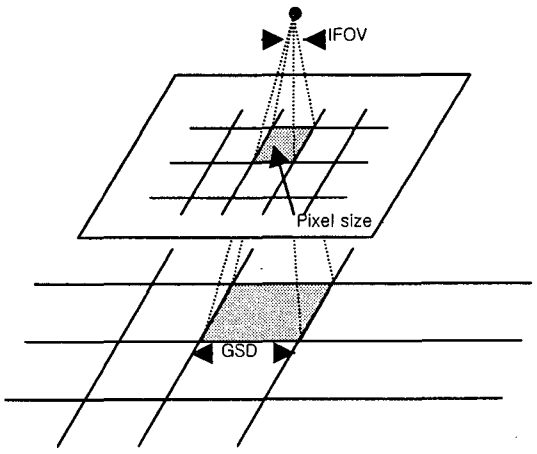

Fig 1. The concept of IFOV and GSD

Another measure related to pixel size is the ground sample distance(GSD), which is the projection of the pixel size onto the ground plane. This is often used erroneously as a synonym for resolution. In fact, the resolution of a digital image is determined by both the sensor geometry and by factors external to the sensor, such as atmospheric conditions, platform motion, etc. The actual resolution may be as good as indicated by the GSD, but in practical applications it is often lower.(Edward M. Mikhail)

In this study, we are going to calculate IFOV and GSD using panchromatic satellite image with 1m high resolution. The Fig. 2 shows the procedure of IFOV determination.

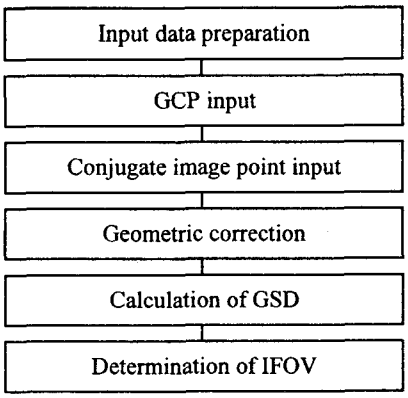

Fig 2. Flow of procedure

2. DATA PREPARATION

The test site is located on the playground of high school in Nonsan. For easy detection of image point, the convex mirrors are put on the ground as ground points. The determination of the IFOV for 1-m high resolution image is needed the high-accurated 3D ground coordinates and image coordinates. So, the 3D ground coordinates can be surveyed by using an instrument such as a differential GPS receiver and Total station. The GPS instrument accuracy was better than 10cm±5ppm which means that the instrument was well calibrated and the maximum error measured for ground coordinate was 10cm±5ppm. Fig. 3 shows the used GPS instrument and GPS survey on the test site.

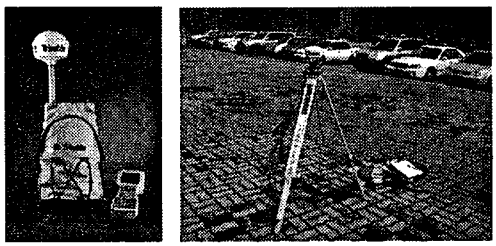

Fig 3. The used GPS instrument and GPS survey

3. GEOMETRIC CORRECTION

3.1 Generation of Ground point

For accurate calculation of GSD, we generate 8 appropriate ground points by GPS survey and Total station triangular survey. Following table indicates the results of GPS and Total station survey.

Table 1. The results of GPS survey

	No 1(GPS)	No 2(GPS)
Height of antenna	1.517 m	1.441 m
WGS 84 Latitude	36-10-58.708478	36-11-00.238256
WGS84 Longitude	127-04-37.601671	127-04-42.006180
WGS84 Height	43.099m	43.851m

Table 2. The results of TS triangular survey

The Surveyed Result from TS				3-D Ground coordinates on Bessel TM Middle Origin		
NO	Horizontal Angle (D.MS)	Vertical Angle (D.MS)	Distance (m)	X (East-West,m)	Y (North-South,m)	Height (m)
B6	336.0946	89.5917	39.9603	206995.495	298058.132	18.028
B5	38.4926	90.0724	40.4706	206953.684	298057.083	18.124
B3	139.5753	90.0122	26.2690	206954.584	298109.409	18.047
B1	168.4253	90.0110	53.3863	206956.293	298142.244	18.055
B2	217.1457	89.5258	44.9626	206995.959	298131.315	17.945
B4	267.0917	89.5554	21.7767	206995.582	298096.179	18.011

3.2 Determination of Image point

The convex mirrors are used for accurate pointing while the satellite takes the image over the test site.

Fig 4. The convex mirror

The corresponding image coordinates on the 1-m high resolution image were determined from magnified image of cubic spline interpolation using ERDAS IMAGIME software system and surface fitting of Renka I algorithm using TableCurve 3D software and centroid method. Fig. 5 shows the example of result by each method.

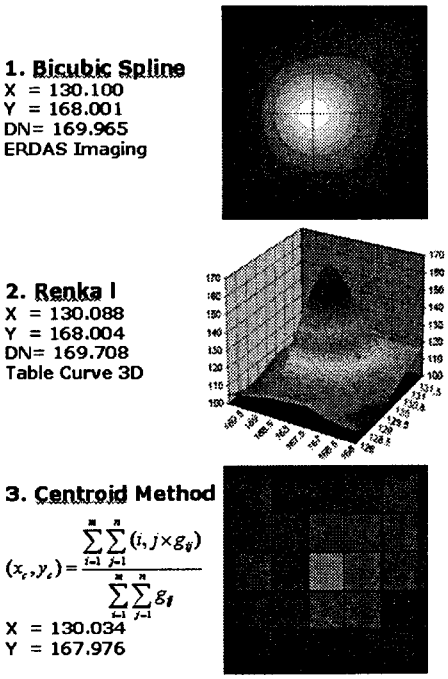

Fig 5. Determination method of image point

3.3 Geometric correction

Geometric correction, sometimes called ground registration, is a technique whereby a digital image is processed so that the columns and rows of the resulting product are aligned with north and east in a ground coordinate system.(Paul R. Wolf)

Following equation is used for geometric correction in this study.

$$X = ax - by + T_X$$
$$Y = ay + bx + T_Y \quad (1)$$

In Eqs. (1), x and y are coordinates of points in the ground system. X and Y are coordinates of points in the image that have been obtained by converting form their column and row numbers.

The accuracy by each method of image point determination is following as:

Table 3. RMSE of each method

Determination Methods for corresponding image center point	Column	Line	Total
	RMSE	RMSE	RMSE
Bicubic Spline	0.298	0.452	0.541
TableCurve 3D Renka 1	0.308	0.451	0.546
Centroid Method	0.393	0.513	0.646

4. CALCULATION OF GSD AND IFOV

4.1 Measurement of GSD

The procedure of measuring ground and image points is accomplished to calculate GSD. Fig. 6 indicates the location of total eight convex mirrors in the satellite image. As following, table 4 shows ground points and corresponding image points of convex mirrors.

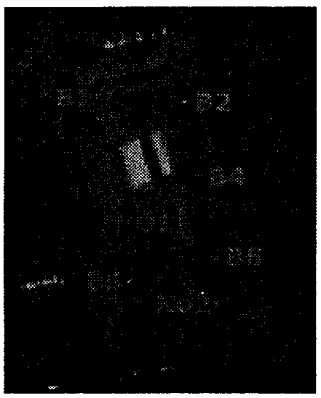

Fig 6. Location of convex mirrors

Table 4. Ground and image coordinates of convex mirrors

Name	X	Y	Z	Column	Line
B1	206956.293	298142.244	18.055	130.1	168.00
B2	206995.959	298131.315	17.945	170.06	171.2
B4	206995.582	298096.179	18.011	177.75	204.98
B5	206953.684	298057.083	18.124	145.18	251.94
B6	206995.495	298058.132	18.028	185.00	241.44
No1	206974.218	298091.957	17.954	157.35	213.25
No2	206991.107	298038.655	18.001	184.92	261.83

4.2 Calculation of GSD

The process of calculating GSD involves three simple steps: First of all, distance between image points is calculated. Second, distance between ground points is measured. Last, GSD is the value to divide ground distance by image distance. Image distance, ground distance, calculated GSD, statistical data are listed in Table 5. Also, distribution of GSD is illustrated in Fig. 7.

Table 5. Calculated GSD each points

No.	Image Dist.	Ground Dist.	GSD
2	43.935	44.964	1.0234
3	37.175	38.047	1.02346
4	37.175	38.047	1.02346
5	43.935	44.964	1.0234
6	108.674	109.283	1.0056
7	43.935	44.964	1.0234
8	37.175	38.047	1.02346
9	37.175	38.047	1.02346
10	43.935	44.964	1.0234
11	108.674	109.283	1.0056
12	37.175	38.047	1.02346
13	37.175	38.047	1.02346
14	43.935	44.964	1.0234
15	108.674	109.283	1.0056
16	37.175	38.047	1.02346
17	43.935	44.964	1.0234
18	108.674	109.283	1.0056
19	37.175	38.047	1.02346
20	43.935	44.964	1.0234
21	108.674	109.283	1.0056
22	43.935	44.964	1.0234
23	108.674	109.283	1.0056
24	108.674	109.283	1.0056
Average		1.0175	
Median		1.0234	
Mode		1.0056	
Standard deviation		0.0086	
Variation		0.0001	
Minimum value		1.0056	
Maximum value		1.0235	

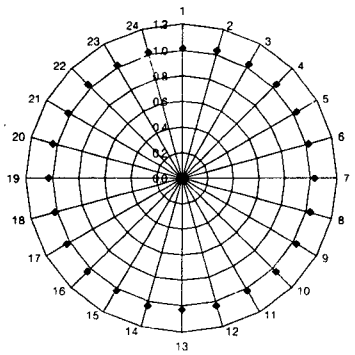

Fig 7. Distribution of GSD

4.3 Determination of IFOV

GSD of the ground area sensed by CCD at any instant in time is loosely referred to as the system's spatial resolution. A small IFOV is obviously desirable to record high spatial detail. And a lager IFOV means a greater quantity of total energy is focused on a detector.(Thomas

M. Lillesand) Here, GSD divided by orbital altitude gives IFOV as Eq (2).

$$IFOV = \frac{GSD}{Orbital\ \ Altitude} \quad (2)$$

As the orbital altitude of satellite used in the test is about 470km which is not computed satellite height from osculating orbit but mean alititude from mean orbit, calculated IFOV by Eq. (2) is listed in table 6.

Table 6. Calculated IFOV

	GSD(m)	IFOV(mrad)
1	1.0056	0.00213957
2	1.0234	0.00217745
3	1.02346	0.00217757
4	1.02346	0.00217757
5	1.0234	0.00217745
6	1.0056	0.00213957
7	1.0234	0.00217745
8	1.02346	0.00217757
9	1.02346	0.00217757
10	1.0234	0.00217745
11	1.0056	0.00213957
12	1.02346	0.00217757
13	1.02346	0.00217757
14	1.0234	0.00217745
15	1.0056	0.00213957
16	1.02346	0.00217757
17	1.0234	0.00217745
18	1.0056	0.00213957
19	1.02346	0.00217757
20	1.0234	0.00217745
21	1.0056	0.00213957
22	1.0234	0.00217745
23	1.0056	0.00213957
24	1.0056	0.00213957
Average		0.00216487
Median		0.00217745
Mode		0.00213957
Standard deviation		0.00001827
Variation		3.33719E-10
Minimum value		0.00213957
Maximum value		0.00217757

5. CONCLUTIONS

The approach of the determination of IFOV of high-resolution satellite image is accomplished over test site. As both IFOV and GSD are the important measurements as the considering the spatial resolution, this kind of approach have been tested.

In this study, the convex mirrors are used for appropriate high resolution satellite image. To determine IFOV, GSD is computed at each point on the geometrically corrected image. Then, The IFOV is calculated by GSD. Further efforts will be made to accommodate the calculating IFOV of high resolution satellite image.

6. REFERENCES

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