Fine Tuning of Stretched-VISSR Image Mapping

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Abstract

Stretched-VISSR image mapping error may increase after satellite orbit control (station-keeping maneuver) or satellite attitude control (attitude maneuver). To solve this problem, a fine tuning technique of the Stretched-VISSR image for user’s computer systems has been developed. This technique can be applied to both full disc images and half disc (northern hemisphere) images. The applicable theory and sample fine tuning programs written in FORTRAN are presented.

1. Introduction

Image mapping is used to process Visible and Infrared Spin Scan Radiometer (VISSR) image data, where each pixel of the VISSR image data must correspond to its respective position on earth. To improve the accuracy of image mapping, the Meteorological Satellite Center (MSC) developed an image mapping fine tuning technique called Distortion Data Determination (DDD) which is based on detection of the earth’s edge from VISSR infrared image. DDD can be used to correct the processes of all products at the MSC, but it can not correct Stretched-VISSR data because of the broadcast time schedule. Therefore, the image mapping error of the Stretched-VISSR data may increase after satellite orbit control (station-keeping maneuver) or satellite attitude control (attitude maneuver). To solve this problem, a fine tuning technique of the Stretched-VISSR image for user’s computer systems was newly developed. The accuracy of the newly-developed technique is within 1 pixel (infrared image). Moreover, this technique can be applied to both full disc images and half disc (northern hemisphere) images. This technique is very simple because it was designed for any small-scale computer system which can utilize the Stretched-VISSR data that is broadcasted via satellite. The applicable theory and sample fine tuning programs written in FORTRAN are presented.

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2 Applicable Theory

2.1 Mapping Parameter Compilation

The following data are extracted from the documentation sector of the Stretched-VISSR data:
(a) Orbit and attitude prediction data block
(b) Constant parameters for simplified mapping block

(c) Parameters for simplified mapping block

2.2 Earth Edge Data Compilation

The earth edge data (actual earth edge) which meets the following conditions is extracted from Spacecraft and CDAS Status blocks in the documentation sector.
(a) SSL ≥ scan line number ≥ SSL-10 (for equator zone)

or

<table>
<thead>
<tr>
<th>PIXEL No.</th>
<th>100</th>
<th>101</th>
<th>102</th>
<th>103</th>
<th>104</th>
<th>105</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGIVSR* RETURN CODE</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SPACE OR EARTH</td>
<td>SPACE</td>
<td>SPACE</td>
<td>SPACE</td>
<td>EARTH</td>
<td>EARTH</td>
<td>EARTH</td>
</tr>
</tbody>
</table>

↑
ESTIMATED EARTH EDGE (WEST)

* MGIVSR: Coordinate Transformation routine

Fig. 1 Estimated earth edge

Fig. 2 Atmosphere width
2.3 Mapping Parameter Correction

(a) Estimated Earth Edge

Estimated east and west earth edges are calculated from orbit and attitude data with the Coordinate Transformation routine (Fig.1).

(b) Atmosphere Width

An atmosphere width, $A$ (Fig.2), is defined as the difference between the actual width of the earth and the estimated width of the earth on a no-deviation image which is given by:

$$A = A_w + A_e = (W_{est.} - W_{act.}) + (E_{act.} - E_{est.})$$

$$= (E_{act.} - E_{est.}) - (E_{est.} - W_{est.})$$

where

$A_w$ : west atmosphere width

$A_e$ : east atmosphere width

$E_{act.}$ : actual east earth edge point

$W_{act.}$ : actual west earth edge point

$E_{est.}$ : estimated east earth edge point

$W_{est.}$ : estimated west earth edge point

(c) Atmosphere Width Change with Earth Image Deviation

The atmosphere width in the equator zone shows little change with deviation of the earth image. On the other hand, the difference of the atmosphere width between the equator zone and the north zone has empirically been shown to be constant. Therefore, the change of the atmosphere width on the north zone, $2\Delta W$, due to the north–south deviation of the earth image from its predicted position is given by (Fig.3):

$$\Delta W = (A_n - A_0)/2 - B$$

where

$A_n$ : atmosphere width in the north zone

$A_0$ : atmosphere width in the equator zone

$$A_{est.} = A_0 + 2B + 2\Delta W$$

$$A_{est.} - A_0 = 2B$$

mile (empirical constant)

$A_0$ (little change with image deviation)
zone (little change with image deviation)

B : empirical constant (+0.769)

(d) North–South Deviation

The rate of change of the earth width in the north zone (45 deg latitude) is almost 2 pixels per line, so 1 line of deviation of the earth image from its predicted position causes a 2-pixel change in the atmosphere width in the north zone. Therefore, the half of change of the atmosphere width in the north zone, $\Delta W$, is almost equal to the deviation of the earth image. The north–south deviation of the earth image, $\Delta i$, is given by:

$$
\Delta i = -\Delta W = \sqrt{(1087^2-(1087/\sqrt{2}+\Delta W)^2)} - \sqrt{(1087^2-(1087/\sqrt{2})^2)}
$$  

where

$\Delta i$ : with north(−) and south(+)

(e) East–West Center

The actual east–west center of the earth image, $C_{act.}$, is given by

$$
C_{act.} = (WE_{act.} + EE_{act.})/2
$$  

and the estimated east–west center of the earth image, $C_{est.}$, is given by

$$
C_{est.} = (WE_{est.} + EE_{est.})/2
$$

(f) East–West Deviation

The east–west deviation of the earth image, $\Delta j$, is given by:

$$
\Delta j = C_{act.} - C_{est.}
$$

where

$\Delta j$ : with east(+) and west(−)

(g) Orbit and Attitude Prediction Data Correction

VISSR misalignment angle around the Y-axis and Z-axis in the orbit and attitude prediction data are corrected with the deviation of the earth image. The corrective angles of the VISSR misalignment angle around the Y-axis and Z-axis are given by:

$$
\Delta Y = -\Delta i \times P \quad (7)
$$

$$
\Delta Z = +\Delta j \times Q \quad (8)
$$

where

$\Delta Y$ : corrective angle around Y-axis (rad)

$\Delta Z$ : corrective angle around Z-axis (rad)

$P$ : IR channel stepping angle along line (rad)

$Q$ : IR channel sampling angle along pixel (rad)

(h) Coordinate Transformation Table Correction

The line number and pixel number in the Coordinate Transformation Table for the simplified mapping are corrected with the deviation of the earth image. The correct line number is obtained by adding the north–south deviation, $\Delta i$, to the line number and the correct pixel number is obtained by adding the east–west deviation, $\Delta j$, to the pixel number.

3. Sample Programs

Sample programs are presented which are written in FORTRAN (FORTRAN 77),
and are applicable for the Stretched-VISSR data that is broadcasted via satellite. After fine tuning, the maximum coordinate transformation error is 140 μradian (infrared image: 1 pixel). The sample program listings are given at the end of this report.

4. Conclusion

The fine tuning technique of the Stretched-VISSR image was newly developed. If this technique is used at a Stretched-VISSR user’s computer system, the increase in image mapping error after satellite orbit or attitude control is reduced to within acceptable limits.

ストレッチドVISSR画像位置合わせの精度向上

木川 誠一郎
気象衛星センターシステム管理課

ストレッチドVISSRデータは、観測と同時にリアルタイムでユーザ局に配信されているため歪補正処理の結果を反映できず、衛星の軌道・姿勢制御の直後に画像ずれ（画素と緯経度の対応を決定する座標变换の誤差が大きくなること）が生じることがある。ストレッチドVISSRの画像ずれを防ぐために、ストレッチドVISSR受信局で処理可能な簡易歪補正プログラムを開発した。このプログラムを使用すると赤外1画素程度の精度で画像位置合わせが可能になる。
気象衛星センター
技術報告  第26号  1993年3月

C. SIMPLIFIED ROUTINE (STATIONARY IMAGE MAPS)

5000 CONTINUE
RME2 = I4DAT/10.D0 IP0S
RME1 = -(RME1
DO 5010 II(1:2)
RME2 = I4DAT/10.D0
RME1 = -(RME1
5100 CONTINUE
C. SIMPLIFIED ROUTINE (STATIONARY IMAGE MAPS)
RME1 = I4DAT/10.D0
RME2 = I4DAT/10.D0
RME1 = -(RME1
RME2 = -(RME2
RME3 = I4DAT/10.D0
WRITE(*,6(PKT='(A16,1P6.2)'))
RMB1 = RHE1
CONTINUE
DO
RMB2 = RHE1
CONTINUE

IF(ABS(RMEl).GT.50.0)

IF(RHE3).LE.RMEl)

IF(RHE3).GT.RMEl)

IF(RHE3).GT.RMEl)

IF(RHE3).LE.RMEl)

ENDIF

ENDIF

ENDIF

ENDIF
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