FAST GEOMETRIC CORRECTION ALGORITHM OF NOAA AVHRR IMAGE

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ABSTRACT

This paper presents a algorithm for the geometric correction of NOAA AVHRR data by using polynomial scan and pixel function. Preprocessings including tangent correction and earth curvature correction can be reduced the order of these functions. Using this method, it was possible to make the geometrically corrected image very fast. Also the precision of geometric correction is discussed.

1. INTRODUCTION

Many researchers have developed digital image processing techniques of NOAA AVHRR images. Several methods were proposed for the geometric correction. However, there are not so many methods whose processing speed is fast and precision is sufficient. A fast geometric correction algorithm for NOAA AVHRR images by using polynomial scan and pixel functions was proposed in the previous study. The order of these polynomials depends on the location of object area. High order polynomials are necessary in high latitude areas. In order to remove this defect, preprocessings including tangent corrections and earth coverture correction were implemented. This preprocessing reduced the computation time largely, especially in high latitude areas. Further images just after preprocessing have sufficient image qualities for archives since most of geometric distortions can be removed in this correction. A method which have high precision and is fast algorithm is developed to fit with the feature of AVHRR images. This paper describes about this method.

2. GEOMETRIC CORRECTION

2.1 The Method of the Geometric Correction

Geometric and geographic correction should be made for remote sensing data in practical application. The distortions in images are resulted from the attitude changes such as the variations of three axes, i.e., roll, pitch and yaw. However, the accuracy of the measurment on bored is not enough to obtain a satisfactory accuracy in the corrected images. Generally, a sufficient number of ground control points with known coordinates should be allocated to establish a transform between image coordinate system (U,V) and geographic coordinate system (X,Y).

However, it is difficult to get the ground control points in this case, because NOAA AVHRR image contains not so many lands. Transform equation should be obtained by use of orbit data. The transform equation calculated by use of orbit data can be written as follows.

$$X = f(U,V)$$
$$Y = g(U,V) \qquad (2.1)$$

In general, inverse transform is necessary in the resampling procedure. But, it is impossible to calculate the inverse transform of the equation (2.1) analytically. It is consider to approximate equation (2.1) by use of polynomials. In this case inverse transform equation can be written as follows.

$$U = F(X,Y)$$
$$V = G(X,Y) \qquad (2.2)$$

There are some problems to apply this method for the AVHRR images. One scene of AVHRR image is about 100 times larger than a landsat MSS image. The distortion of AVHRR images is so large that transform equation can not determined by use of low order polynomials.

If the order of polynomials increase, the number of coefficient increase in proportion as two power of the order. Processing times also increase in proportion as the order of polynomials.

Therefore, in this research, line and pixel function were defined. Geometric correction can be conducted at high precision and in a fast manner by using these functions, because these functions are the polynomials which contain only one valiable.

The procedure of the geometric correction proposed in this paper are as follows. Original CCT of AVHRR data is recorded in BIL format. But it is convenient to use BIP format for the geometric correction. So, at first, format conversion will be conducted. In next step, the orbit parameters which are recorded on the head of this CCT were extracted. The transform equation from geographic coordinate to image coordinate were calculated by use of a least square method.

The scan and pixel functions can be calculated at each line to improve the correcting precision. The precision of the correction were examined for the several points. If the precision of corrected result is not sufficient, scan and pixel functions are calculated again. This repetition are iteratively conducted until sufficient precision was obtained.

2.2 Scan and Pixel Function

As shown in Fig.1 certain points moves on the horizontal line on the image coordinate system (U,V). Corresponding point on the geografic coordinate system (X,Y) also moves on the cuved line. This motion can be devided into two components U and V. The motion of this point on the axis U is expressed as pixel function $U=P_V(X)$. The Vth line on the coordinate system (U,V) describes the geographic coordinate system (X,Y) is called a scan function $Y=Q_V(X)$.

The coefficients of these functions can be calculated easily by a least square method. These function should be calculated for each line of corrected image.

In the resampling procedure, the method which calculated the point (U_1,V_1) corresponding to the (X_1,Y_1) is as follows. At First (X_1,Y_1) are given, scan and pixel function corrspond to Y_1 are selected. Next step is to calculated U_1 and as follows.

$$U_1 = P_{V1}(X_1)$$

Hence, (U_1,V_1) is the corresponding points to the (X_1, Y_1)

2.3 Precision Examination

The processing methods described above have been applied to NOAA AVHRR image. The m-th and n-th order polynomials are taken as the $U=P_V(X)$ and $Y=Q_V(X)$ respectively. Least square method was to calculate the coefficient of P(X) and Q(X). In this calculation 80 points were used . The maximum and mean value of error are calculated for several value of m and n. The result is shown in Fig.2.

As a result, mean value of error for the P(X) does not change so much when m is larger than 7. And for the Q(X), mean value of error are not change so large when n is larger than 3.

Therefore, it is sufficient to select the order of pixel function as a 7-th order polynomials and to select the order of line function as 3-rd order polynomials.

3. TANGENT CORRECTION AND EARTH COVERTURE CORRECTION

In the previous result, the order of pixel function is too large for fast calculation. In order to remove this defect, preprocessings including tangent corrections and earth coverture correction were implemented. The result of mean error for several value of m and n are shown in Fig.3.

As the result, mean eror for pixel function does not change so much when m is larger than 3. Therefore, it is sufficient to select the order of pixel function as a 3-rd order polynomials.

4. PROCESSING SPEED

The computer used in this research is HP 9000 system. Resampling time is depend on the order of scan and pixel function. When transform equation (2.2) is used directly, it takes 28 minutes to create 2048 pixels x 1920 lines size image. This processing time could be decreased to 9 minutes by using line and pixel function (m=3,n=3). Moreover, this time could be decrease to 8 minutes by using line and pixel function (m=3,n=2). But in the latter case, error is not so small.

5. CONCLUSION

1) Preprocessings including tangent corrections and earth coverture correction were implemented. After applying the preprocessing, scan and pixel functions were used for the geometric correction of the NOAA AVHRR images. A method which uses the scan and pixel function has high accuracy and is fast algorithm.

2) An experiment was done in order to decide the least order of the polynomials. As the result, it is sufficient to use 3-rd order pixel function and 3-rd order scan function.

3) The processing speed of the method by using line and pixel function can be decreased to 1/3 - 1/5 compared with direct calculation.

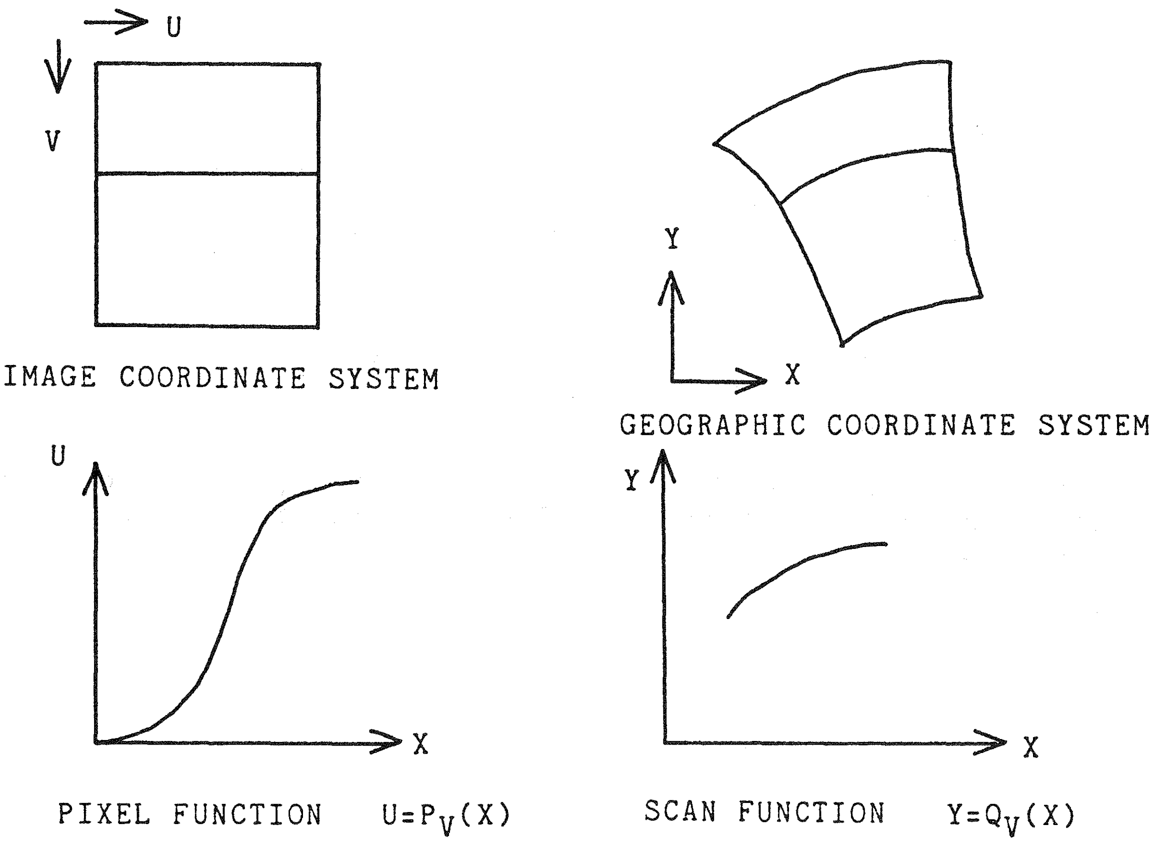

Fig.1 SCAN AND PIXEL FUNCTIONS

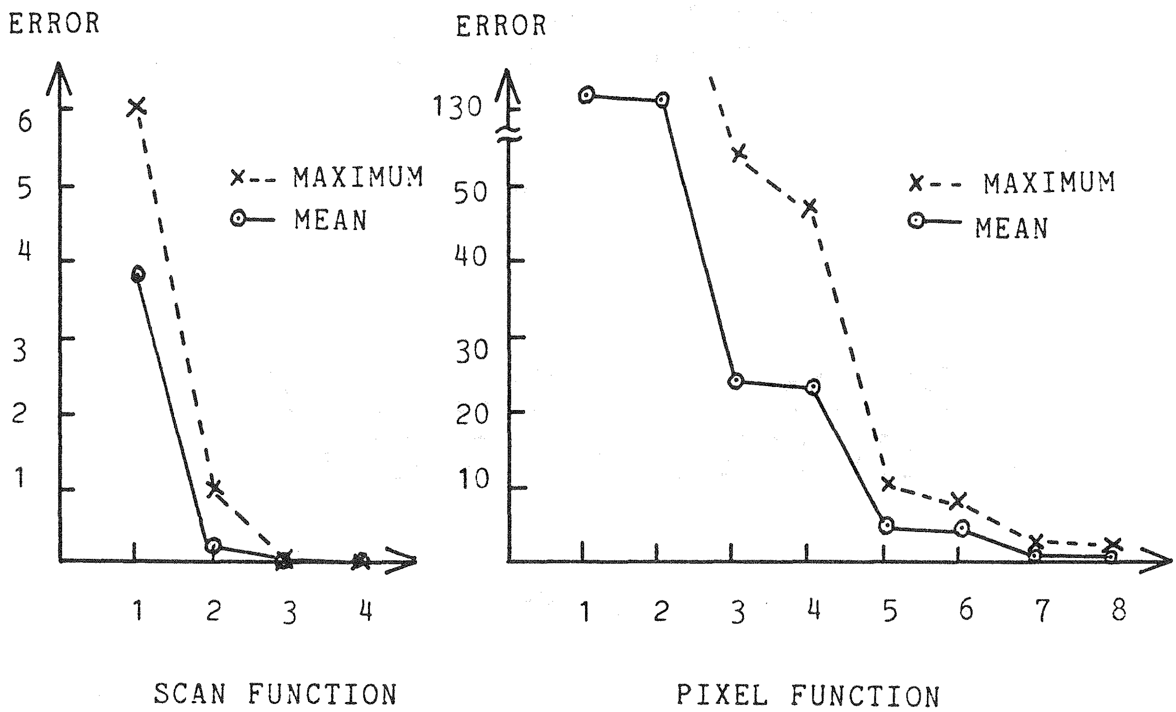

Fig.2 PRECISION OF GEOMETRIC CORRECTION

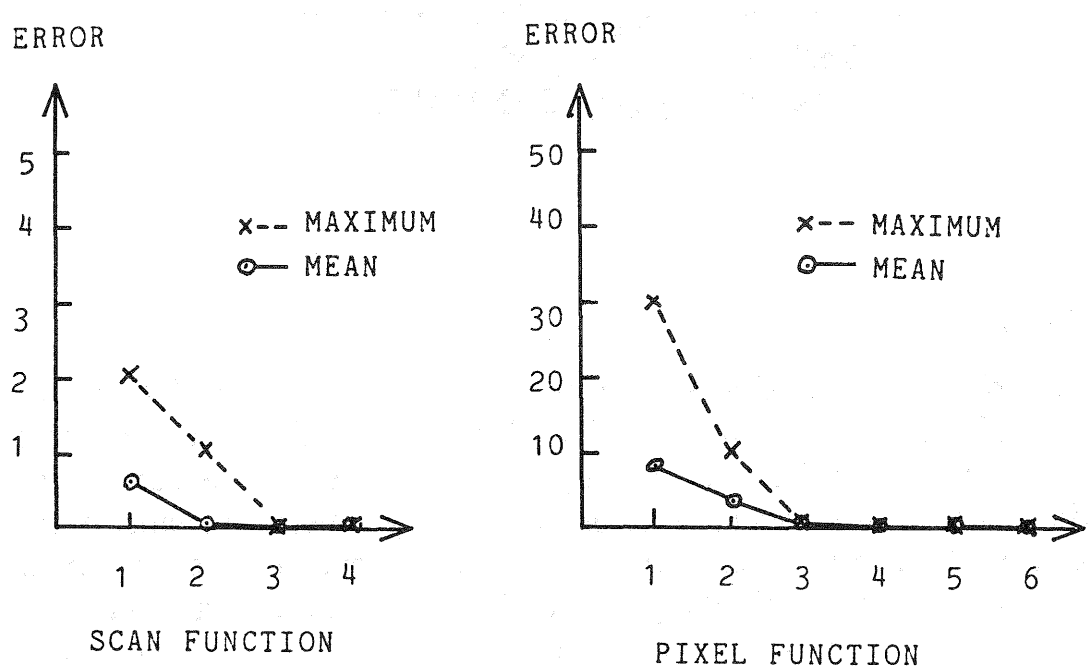

Fig.3 PRECISION OF GEOMETRIC CORRECTION
(AFTER PREPROCESSINGS)