Low resolution remote sensing image processing and productions development for earthquake disaster monitoring application

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Abstract. Satellite remote sensing data has the advantages of wide coverage, short imaging cycle, and nocturnal imaging. It has important applications in earthquake disaster monitoring. The built up remote sensing satellite receiving station of our lab could collect the MODIS, NOAA, FY3 Series data. In this paper, we developed a geometric correction algorithm based on conjugate triangles and affine transformation for remote sensing satellite data in the first, and then produce land surface temperature (LST), Vegetation Index (NDVI), and aerosol products for seismic disaster monitoring. In the future work, the products will be applied for earthquake disaster monitoring.

1. Introduction

The satellite remote sensing receiving system built up for earthquake disaster monitoring in national earthquake social service project distributed in Beijing, Xinjiang and Guangdong province could collect MODIS, NOAA and FY3 Series data. Each remote sensing receiving station has a round antenna with a diameter of 4.2 meters and could receive X-band and L-Band image data. The collected image data is in the standard L1B level with relative radiation correction and stored with HDF (Hierarchical Data Format) format. It takes about 1 to 2 hours for one track image to be acquired, transmitted, processed, and mapping. These remote sensing images have the advantages of wide coverage, short imaging cycle, and nocturnal imaging, and are widely used in pre-earthquake anomaly monitoring and post-earthquake disaster extraction, which attracted the attention of scholars at home and abroad. Pre-earthquake anomaly monitoring using meteorological satellite data is mainly focused on the Land surface temperature anomalies[1-6]. Zhang et al and Yang et al employed the sharp MODIS NDVI decline information to extract primary regional landslides[7,8].Since the strong shaking caused by the severe earthquake, atmospheric aerosol parameters have dramatic change[9-11] after the earthquake in a short time. This information could be used to quickly determine the hardest hit area. Since these remote sensing productions couldn’t be acquired timely from the internet, we have to receive these remote sensing images and produce the productions in order to improve the emergency response ability. The remote sensing images processing technique flow is as Figure 1. The experiments shows that we could acquire and process the image data within 2 hours. It greatly improve time efficiency of disaster response and play an important role in emergency and disaster monitoring before and after the earthquake.
2. Image geometric correction

The image data output from remote sensing receiving system is in standard L1B level with HDF format. HDF (Hierarchical Data File) is a new data format that can efficiently store and distribute scientific data developed by the National Center for Supercomputing Application (NCSA) in order to meet the research needs of various fields. HDF can represent many necessary conditions for the storage and distribution of scientific data. We developed geometric correction algorithm which could convert the L1B level image data to L2A level and achieve the image geometric correction.

It divides the remote sensing image into n triangular blocks, and built the conjugate relationship between pre- and post-correction remote sensing images. Since each unit is small, the transformation of the image data in each unit before and after the correction can be expressed in the affine space. Given the vertexes of one triangular block in the raw image data are \( i, j, k \) and their coordinates are \( (x_i, y_i), (x_j, y_j), (x_k, y_k) \). The conjugate vertexes \( I, J, K \) in the post-correction remote sensing image, and their coordinates are \( (X_I, Y_I), (X_J, Y_J), (X_K, Y_K) \). The affine transformation between pre- and post-correction remote sensing images is as formula (1).

\[
\begin{align*}
    a_1 + a_2 \times x_i + a_3 \times y_i &= X_I \\
    b_1 + b_2 \times x_i + b_3 \times y_i &= Y_I \\
    a_1 + a_2 \times x_j + a_3 \times y_j &= X_J \\
    b_1 + b_2 \times x_j + b_3 \times y_j &= Y_J \\
    a_1 + a_2 \times x_k + a_3 \times y_k &= X_K \\
    b_1 + b_2 \times x_k + b_3 \times y_k &= Y_K
\end{align*}
\]  

(1)

In the Eq.(1), We can solve the affine transformation parameters through simultaneous equations. If we get the affine transformation parameters, we could achieve the affine transformation block by
block and finish the image geometric correction. The Figure 2 shows the image georeferencing technique flow.

\[ a_1x_i + b_1y_i + c_1 = X_i \]
\[ a_2x_i + b_2y_i + c_2 = Y_i \]

Figure 2. The diagram of image geometric correction.

Figure 3. The image geometric correction based on IDL program.

In this paper, we adopt 50 \( \times \) 50 control points to divide the remote image into small grids, and establish a conjugate relationship between before and after geometric correction images. We wrote the IDL program and achieved the image geometric correction. The Figure 3 shows the images before and after georeferencing.

3. **Product developing for earthquake disaster monitoring**

There is a certain relationship between the surface infrared radiation anomalies and active faults and earthquakes. Low resolution remote sensing images acquired from Terra/Aqua, NOAA, and FY3 have the thermal infrared band, and could achieve the land surface temperature inversion. It mainly
achieved by band operation. For MODIS data, we use band 29, band 30, band 31 and band 32 employing split-window algorithm to calculate the land surface temperature[12,13,14]. The Figure 4(a) shows the LST inversion result based on the MODIS image. For NOAA-AVHRR, we mainly use the band 4 and band 5 adopting the split-window algorithm to inverse the land surface temperature[15,16].

The NDVI products are also through band operation achieved. We can get the NDVI through formula (2).

\[
\text{NDVI} = \frac{\text{NIR} - R}{\text{NIR} + R}
\]

In the above formula(2), NIR and R respectively indicates bands 2 and band 1 for MODIS image. The Figure 4(b) shows the NDVI inversion result. For NOAA-AVHRR image, NIR and R respectively indicates bands 4 and band 3.

There are multiple methods for aerosol inversion. In this paper, we mainly use the dark target method[17,18,19] to inverse the aerosol optical thickness. The principle of inversion of the AOD value by the dark pixel method is based on the fact that in areas with dense green vegetation, the surface reflectance observed by satellite sensors is relatively low. The blue(0.459~0.479 μm) and red (0.620~0.670 μm) wave bands are particularly effective, and large area forests or dense vegetation pixels can be used as dark pixel targets. The Figure 4(c) shows the aerosol inversion result based on the MODIS image.

![Figure 4. LST, NDVI and aerosol inversion based on the remote sensing image.](image)

4. Conclusion
In this paper, we designed and developed the low resolution image geometric correction algorithm for MODIS, NOAA, FY3 series image based on the IDL language. It is robust enough to achieve the image georeferencing for meteorological satellite data and satisfy the requirements of the receiving system construction. We also developed the earthquake disaster monitoring production based on the low resolution remote sensing images. In the future work, we will achieve the image processing automatically and apply the productions in the earthquake disaster monitoring.

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