A NOVEL RECTIFICATION APPROACH FOR HJ-1A/B IMAGE BASED ON RATIONAL FUNCTION MODEL

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ABSTRACT:

Rational Function Model (RFM) has been widely applied to process high resolution imagery, and most of the modern high-resolution satellite products are distributed with Rational Polynomial Coefficients (RPCs), as RFM enjoys some advantages, including generality, high fitting precision, fast processing speed and confidentiality. The vendor provided RPCs are solved terrain-independently with the rigorous physical sensor models, and it is convenient for users to do precise rectification using bias compensation in image space or object space with the help of DEM and ground control points (GCPs). This approach performs well for high-resolution imageries, which are usually captured by narrow field-of-view cameras. However, the accuracy is limited when it is applied in wide field-of-view cameras. Moreover, it is also problematic to approximate the rigorous sensor models with terrain-independent RFM when the variation of position and attitude of the satellite is violent, such as HJ-1A/B.

Chinese HJ-1A and HJ-1B satellites are equipped with two wide view CCD cameras (the spatial resolution is 30 m), and have a large aspect angle of 31 degree and a swath width of 360 km (for one CCD) and 720 km (for the two CCD cameras combined). The advantages of wide swath width and high return frequency with two days interval help they play an important role in natural disaster monitoring and risk assessment, environment monitoring, and other fields. Nevertheless, HJ-1 images have low geometric precision, and precise geometric correction of HJ-1A/B is difficult due to the wide field of view (about 30 degrees), and the instability of the satellite attitude (inner distortion of the image is more than 10 pixels). Conventional RFM approach cannot be directly applied to HJ-1A/B image. As the variation of satellite attitude is violent and irregular, it is difficult for a smooth RFM to precisely approximate the distortion in cross-track direction. Consequently, over-fitting frequently occurs when solving RPCs from generated virtual ground control points even if ridge estimation is applied. Moreover, it is not likely to perform precise rectification through simple bias compensation in image space or object space.

The existing approaches, such as high order polynomial correction and Delaunay Triangulated Irregular Network (TIN) based local rectification, do not utilize the prior information of rigorous sensor model, and required a large number of well distributed GCPs to achieve high geometric accuracy. Another approach is to directly refine the rigorous sensor model by correcting the ephemeris and attitude data, but the rigorous model of the push-broom sensor is complicate and computationally expensive. Moreover, the rigorous model based approach also requires many well distributed GCPs to avoid singularity.

This paper analyzes the geometric characters of HJ-1A/B images in detail, and introduces a novel approach to generate terrain-independent RFM when the traditional approach fails to provide stable RPCs. The main idea of the new approach is to add a ℓ_1-norm regularization parameter into the normal equation, which will result in sparse estimation of RPCs. Thus only a part of the 78 RPCs are active while the others are inactive (are zeros). Although the sparse RPCs fit the virtual control points a bit worse than the RPCs yielded by ordinary least squares or ridge estimation, they are much more stable. Moreover, a full parameter optimization approach is applied to refine the terrain-independent RPCs (with the help of GCPs), which results higher geometric accuracy than conventional bias compensation approaches. The proposed rectification approach makes full use of the rigorous sensor model of HJ-1A/B, and it is possible for users to efficiently perform precise rectification without establishing the complex rigorous model.

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