

The Image of The Entire Moon Based on The CCD Stereo Camera Data of Chang'e-1

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Abstract. In this paper, the 1082 orbits CCD camera data of Chang'e-1 satellite (2c Data) are processed and sorted, using professional remote sensing software such as ENVI、ERDS、NASA PDS Viewer etc. to generate the full moon image map. And the spatial resolution is 120m which lays the foundation for the census of lunar resources.

Introduction

The CCD 2C data is taken by the three line array CCD camera that equipped with Chang'e1 satellite, which is a kind of data product after the radiation correction, geometric correction and photometric correction, it has 1082 orbits. Each orbit has three groups of images, which is consists of forward-looking image, face image and rear image. CCD 2C single orbit image is long strip-shaped distribution from south-north direction, which contains only one band (The lunar exploration project headquarters of Chinese Academy of Sciences in 2008) .

Data File Reading

Remote sensing software can directly read PDS file, such as ENVI、NASA PDS Viewer (Li,X.J. etc., 2007) . ENVI can read the CCD 2C data directly and display image data , but it cannot immediately extract the spatial information from the 2C data. We need to read 2C file directly and extract spatial information according to the rules defined in the header file to facilitate the subsequent correction.

The 2C file can be read through editor such as the Ultra-Edit (a kind of text editor) in the form of binary file. And it can be read by a variety of programming languages. We can open and read the 2C file by using the function in the Binary-Reader class library of C#.net.

Control Point Data Extraction

According to the specified data record format in the header file, the Column 3-6 records of each row respectively correspond to longitude, latitude of the first pixel and the last pixel in 512 pixels in this row.

Now we build a two-dimensional array (row number of image*4) for storing spatial information in a single 2C file, where the row number of images can be obtained directly from the header file "ROWS". Then we use the Binary-Reader class library in C# to fit the data type conversion function in order to extract the spatial information in the data records and store it in a two dimensional array.

PTS file is used for saving the control point file when using ENVI doing image registration. Image registration has two different types: Image to Map and Image to Image. And in this paper, we utilize the spatial control point information instead of the reference image, so Image to Map is more applicable in this paper.

Error Correction

Although the 2c file is framed as the unit of detection time 1 orbit, there are still a number of continuous collection data that are not continuous in fact. These continuous collection data can cause sudden changes in the image. Though the corresponding spatial information of the image is right, but the algorithm the image registration using is applied to the whole image, so discontinuous mosaic will cause errors of image registration and mosaic as shown in Fig.1.

To avoid acquisition time discrete image block joining in a file, we should detect the file to determine the boundaries of different segments so as to facilitate file segmentation or block matching.

We can use the data acquisition interval, the change interval of the latitude and longitude in the original data to check whether the image segmentation occurs. In general, the time interval of collection is less than 0.5s in the two continuous rows, and the same column of the two rows is less than 0.1° . Because of large original data volume and long road traverse, so we take PTS file to check the latitude of the same column in two rows, and to determine that whether image segmentation occurs. Then we create a file named "2C.cut" to record the error points and the segmentation points.

Segmentation point setting

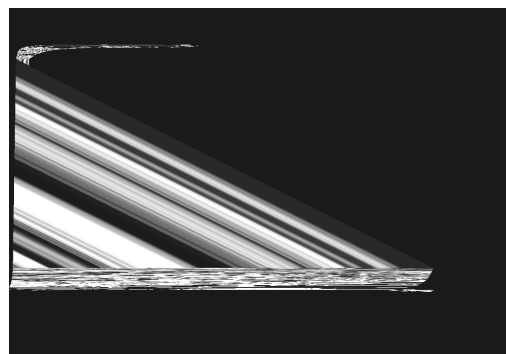


Fig.1. Image mosaic error

Because of the limitation of the registration correction algorithm, most of the correction algorithm adopts the global minimum error algorithm to minimize cumulative error of the whole map, but that cannot guarantee the accuracy of locally known control points. In addition, Chang'e-1 2C data presents a long strip-shape distribution of north-south trend, and the span of latitude and longitude is large. So under the premise of ensuring such a large range of global cumulative error is minimal, it can cause the local data error bigger, and cannot satisfy the requirements of the whole month image mosaic. Therefore, we put forward the idea of file segmentation and subsection correction. This idea is to divide the original image file into 512 x 512 (pixels) or 1024 x 512 (pixels) unit images and correct respectively. In this way, we can ensure each segment of the accumulative error is minimal, and the entire orbits image can be corrected precisely.

On the basis of the detection error point, for there is no error, we should write line number of segmentation in cut file when each interval is 512 (or 1024) pixels.

Framing Correction

Projection parameter setting

The coordinate system is IAU 2000 Cartesian Coordinate System of reference geoid D_MOON_2000: Moon-2000, and it applies to the coordinate system of the moon(The IAU, the

international astronomical union). At present, the general coordinate system of the lunar research in the world is D-moon-2000 which sets up sphere parameters for the coordinate: both semi-major axis and semi-minor axis are 1737400 m, deviation parameters of reference geoid is 0,0,0.

Projection method: According to the latitude and longitude records the Space information using in the original 2C file, and the geographic Lat/Lon is adopted in the whole image mosaic. This projection method can preserve the relationship between the original data and the spatial information as far as possible. And on the premise of preserving the data characteristics accurately, we can redefine the projection.

Map units: Map unit of Geographic Lat/Lon is degree. The spatial resolution of satellite bottom point of Chang'E1 CCD camera is 120m. In this paper, we get the resolution of 120m through the whole month image re-sampling. Besides that, we can get the 0.003957346 Degree/Pix according to 1737400m moon radius.

Correction algorithm

In general, there are mainly three kinds of correction algorithms: RST (Rotation, Scaling, and Translation), polynomial algorithm and triangulation network algorithm.

RST algorithm is only for the image rotation, zoom and other operations, and the accuracy is poorer.

Polynomial algorithm can control the global accuracy. But it is difficult to guarantee the local accuracy of existing control points when ensure accuracy of global. And high order polynomial algorithm can cause serious distortion to the image, so it is not suitable for the use. Triangulation network algorithm is similar to the formation of TIN (Triangulated Irregular Network). We can use the existing control points to build triangulation network, and can calculate spatial location within the triangulation network. The triangulation network algorithm can guarantee the absolute accuracy of existing control points and control the global errors well. In order to ensure the local precision, we split the original file of long strip-shaped distribution into pieces, but we adopt the triangulation network algorithm to ensure accuracy absolutely.

Re-sampling

The spatial resolution of satellite bottom point of Chang'e-1 CCD camera is 120m. We get the resolution of 120m through the whole month image re-sampling. And according to the 1737400m radius of moon, we can calculate the 0.003957346 Degree/Pix. The commonly used re-sampling algorithms are the closest pixel algorithm, the bilinear interpolation algorithm, the cubic convolution algorithm. The closest pixel algorithm has rapid calculation, but the image transition feels angularity after interpolation, and it has obvious effect of mosaic. The cubic convolution algorithm is used to smooth the transition between the pixels, and the effect is good, so we adopt it in this paper.

Batch correction

After determining the correction of various parameters, we can use IDL (Interactive Data Language) to write programs. Then we read PTS (ENVI save GCP (Ground Control Points) in the file) control point file and cut file, then we transfer envi-register-doit function to correct blocks of the image.

Mosaic

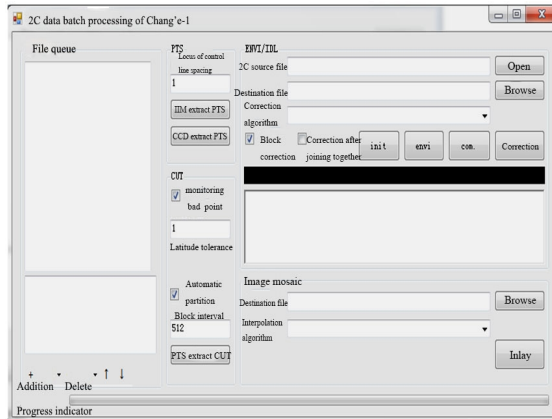


Fig.2. 2C batch data processing system

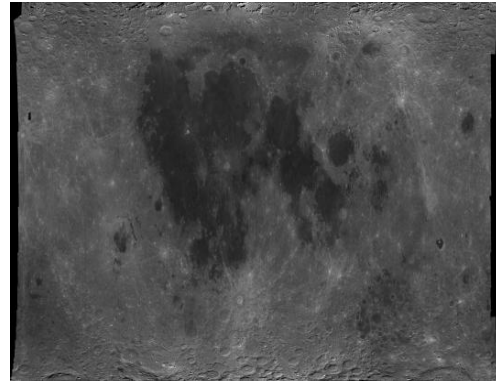


Fig.3. Full moon image

Using mosaic function that based on geographic coordinates of ENVI, we can re-mosaic the data after block correction to the full moon image. Chang'e-1 2C data batch processing system is shown in Fig.2, the full moon image is shown in Fig.3.

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