ZI-AEDAS: A Automatical Elevation Data Acquisition System

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ABSTRACT

A automatical elevation data acquisition system named AEDAS is developed to generate DTM automatically from the aerial stereo pair on MASSCOMP computer in Zhengzhou Institute of Surveying & Mapping(ZISM). This paper describes the hardware configuration and software function. This software system can automatically or interactively recognize and locate fiducial marks with the CHAMFER matching method and finish relative orientation with the feature-based method or hierarchical correlation method. Then epipolar resample and hierarchical relaxation correlation are executed, that is, the system finishes the DTM acquisition automatically. At last, the system gets orthphoto and completes the quality control. This software system was written in C language.

INTRUDUCTION

The use of digital or digitized imagery and VISI technique make possible the fast, efficient, and accurate automatic Digital Terrain Model(DTM) extraction and orthphoto production by stereo digital correlation. However, the approach still has limmitation that leaves some percentage of the points uncollected or in error. So, it is neccessary of interactive editing the data. A automatic elevation data acquisition system named AEDAS is developed to generate DTM and orthphoto automatically from the aerial stereo pair on MASSCOMP computer in Zhengzhou Institute of Surveying & Mapping(ZISM). After describing the system configuration this paper addresses an approach to image orientation, DTM extraction, quality control and orthphoto production.

THE AEDAS SYSTEM

Hardware Configuration
The AEDAS hardware uses a MASSCOMP computer as host computer. The basic configuration and performance of the host computer as follows:
1) Two MC68030 25MHz Virtual Memory CPU (MC68882 20MHz Floating Point Co-processor/CPU, 64 KB Cache Memory/CPU), 3 serial ports (Console, Modem, Printer) (may be 5CPU installed)
2) 16 Mb ECC Memory
3) 30 Multibus slots
4) 11 6U VME slots
5) 32 RS-232 serial ports
6) 650 Kb Floppy Disk Drive
7) two 568 MB Winchester disk (may be 9000MB)
8) 150 MB Cartridge Tape Drive
9) Stream Tape Driver 1/2"
10) Two Graphics Subsystem
11) Two image monitor (1152x910x12x2Bf, 1152x910x4x2Bf)
12) 19" color control monitor
13) 3 buttom mouse system
14) Printronix Line Printer

Software Function
The software in this system can be divided into five basic (fuunctional) components:
(1) Database management;
(2) Photogrammetry;
(3) DTM extraction;
(4) Quality control;
(5) Orthphoto production;
All the software within the system was written in ANSI C language.

FUNCTION DESCRIPTION OF THE AEDAS

The five basic components of the AEDAS software function are described in detail as follows:

Data Management
This software allows the operator to input any kinds of parameters used within the system and forms a relational database for next steps. Each of the steps can track the details and add respectively information to the database. The major inputs to the AEDAS are:
1) digital or digitized imageries and scanning parameter
2) camera calibration reports
3) flight information
4) DTM gridding resolution
5) name or code of the interesting area
6) ground control points

Photogrammetry

This procedure is for generating the Transformation parameters based on rigorous photogrammetric principles.

1) Inner orientation

The system can recognize fiducial marks automatically or interactively and find the accurate position. For automatically getting the coarse position of fiducial marks, the CHAMFER matching method[1] is used. And the relationship between scaner system and photo system has been got.

2) Relative orientation

The system also can complete the relative orientation automatically based on feature based method (B&T, Barnard and Thompson method[2]) or hierarchical (pyramid) relaxation correlation (HRC) method. The processe of the two methods are in the following:

For the B&T method
. operator choicing approximate positions of Gruber points
. getting several pieces of Gruber image
. feature points extraction and non-maximum compression
. make the initial estimate of the probability of each possible disparity based on the similarity of subimage surrounding the points
. iteratively improving the estimates by a relaxation labeling technique making use of the local continuity property of disparity
. normalized cross correlation for initial position
. least square matching for accurate position
. relative orientation computing

For the HRC method
. getting Gruber image without interfere
. forming pyramid data
. gradually matching from the lowest to the hightest resolution level
. least square matching for accrate position
. relative orientation conputing

3) Absolute orientation

Unlike the inner and relative orientation, the absolute orientation is driven manually using mouse for getting position.

For quality checking, an error analysis is generated listing the residual error on points as well as the Root-Mean-Squared-Error(RMSE) for fiducial transformation, photo-to-ground transformation, photo-to-scaner transformation, space resection, and check point-to-ground point comparison. The individual point residuals are given in ground unit, photo scale, and pixel. The operator can reject points and make the process return to appropriate step to regenerate outputs and recompute errors. So far the AEDAS has built the exact relationship among the scan system, photo system, space model system and ground system. All the relationship parameters are in the database. At last in this part, the image will be resampled align with the epipolar

DTM Extraction

Correlation process is a key procedure in the performance of the AEDAS. we have developed our own algorithm for automatic terrain data colllection which is based on normalized cross correlation. For the pull-in task our correlation method uses several levels of minified images to gradually build an increasing accurate Digital Terrain Model. At the hightest resolution level, the system gets accurate DTM in sub-pixel by analyzing just small neighborhood around the peak in the correlation suface. For the sake of reliability two criterias are selected so that correlations over cloud, water or other structureless area are rejected. The first is to check the peak of the correlation surface. The second is the fall-off rate from the peak of the correlation surface in a small neighborhood around the peak. The two criterias have been found to be effective in identifying false peaks.

The final step for DTM extraction is reformatting, converting the photo data to ground space data and performs the necessary resampling to produce the desired ground space grid.

DTM editing

Extensive tools for editing the elevation data are also provided within AEDAS. Elevation spikes and holes can be edited, as well as regions interactively defined by the mouse. These regions can be interactively filtered, assigned specific values, or given a particular slope. The DTMs are then used in the orthorectific process.

Orthorectification Processing

Images are automatically orthorctified based on the edited DTM. The system will not allow orthorectification to be performed on unprepared data.

Quality Control (QC)

In fact, QC accompanies the process in every steps, such as the two criteries in DTM extraction. Specialities have been researching a good QC approach to the DTM reliability for several years. The AEDAS is using a method to detect and remove the gross error. The following is described in detail:
1) finding the matching point in right image using the left image as target image.
2) getting a patch of image arround the matching

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point in right image.

    3) finding the matching point in left image
using the patch as target image.

    4) differencing the positions of the two left
points.

    5) if the difference does not exceed the given
value the system will accept the matching result.
The QC method has been found to be effective. Soon
the AEDAS will use a new method to detect and remove
the gross error. The following is the details:

    1) orthorectifying with left and right image
respectively. That means the system gets two
orthophotoes that shoudn't have any deformation and
that only have gray difference.

    2) matching the orthophoto in desired grid. In
the theory, the matched point is the same point. If
the ofsset does not equal zero, the orthophoto patch
around the point and the height of the point is
wrong. However, it doesn't matter because the offset
is just the corection. So the system can correct the
height and re-orthorectify the patch.
Outputs

    The outputs consist of precise object space
positions, orientation data, DTM, orthphoto data and
every kind of QC data.

EXAMPLE AND RESULTS

    In the example, a pair of photo will be
processed. The basic information of the data source
is listed as follows:

photo size	23 x 23 cm
photo scale	1:10000
scanning resolution	50 microns
image size	4600 x 4600 pixels
DTM interval	20 m

    The following is the main production time and
accuracy:

Inner orientation	2'30"	
Relative orientation	9'30"	0.0045 mm
Resample	10'00"	
DTM Generation	15'00"	0.2 pixel
(150x120 points)	(20 points per second)	
DTM editing	3'00"	
Ortho	10'00"	

CONCLUSION

    The AEDAS system has been found effective by
experiments. In the future, we wil perfect our
system by adding other functional part to AEDAS such
as photo scanner for scanning, mosaicing to
mapsheet, outputing to film recorder, perspective
scene generation, even better matching method. we
also will make use of the VA-1 vector accelerator to
save processing time greatly.

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