DIGITAL POINTS TRANSFER FOR AEROTRIANGULATION BY ANALYTICAL PLOTTER

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ABSTRACT:

The paper discusses the main aspects of automatic point transfer in processe of aerotriangulation by analytical stereoplotter. Hardware and software are presented. The developed technology features are an exclusion of artifical tie point marking from photogrammetric bridging and substitution of it for digital points transfer. The new technology permits to improve accuracy of photogrammetric measurements, to automate processes of project designing, point coordinate measuring on aerial photographs, and checking of results obtained from major procedures. The technology leads to productivity increase, and makes the routine work of an operator much easier. As preliminary calculations have shown, gain an annual economical effect of about 50 million roubles per one working station.

1. INTRODUCTION

Relaible and precision identification and marking of tie points are of great importance in photogrammetric bridging. The technology, currently in practice in aerotriangulation, with artificial tie points marking and sterocomparators applied does not allow an efficiency increase of the process and prevents from introducing promising mapping technologies based on analytical plotters. In this connection the developed technology features are an exclusion of artificial tie point marking from photogrammetric bridging and substitution of it for digital points transfer. The new technology based on using of STEREOANAGRAPH analytical plotter permits to improve accuracy of photogrammetric measurements, to automatise processes of block designing, point coordinate measuring on aerial photographs, and checking of results obtained from major procedures.

The technology involves using of the following software and hardware devices:

- an analytical plotter (AP) STEREO-ANAGRAPH;
- a PC compatible with IBM PC/AT 3863/4/120;
- a digitizer of a plotting board-type SMP-6410;
- a sterescope ZLS-4;

- software for the developed technology included as a part into loading modules: PROJ.EXE; NEWANA.EXE; DGN.COM;

- a program package for block adjustment - "Photocom" or "Photo"-block".'

The above set of technical means actually forms a technological working station of the on-line triangulation that makes it possible to accomplish at one working place and by one operator-photogrammetrist all the procedures needed for block adjustment including the formation of a catalogue of bridging point coordinates and parameters of orientation for each stereopair.

Integrated solution of the problem providing for control of measurement results for each stereopair, for elimination of defective points, and than their repeated mesurements permits to increase reliability and precision of block adjustment, to reduce the number of forced additional measurements made by the results of adjustment. An automated way of mark bringing to the chosen points and a graphical interface convinient for use, all this reduces workload on an operator and increase his productivity. The developed technology was tested by using aerial photography materials for the test area and other objects surveyed. The aerial photographs were processed in the framework of research and development program of TsNIIGAiK.

2. GENERAL ASPECTS OF DIGITAL POINT TRANSFER

2.1. Preparation works

Preparation works have few differences from works of traditional technology.But nevertheless a special attention is paid to an image quality of fiducial marks which helps to define their coordinates with accuracy 2-3 mkm.

Projects' designing consists of carring out of two parts of work:

- to choose and mark zones for forward and lateral overlaps;
- to measure coordinates of centres of selected zones on paper photos and compiling data file for driver STEREOANAGRAPH analytical plotter (AP).

Project designing begins with laying down photos on their strips and getting covering assembly . After that go on with choosing of tie and additional (check, control and transformation) points, that need to compute geodetic coordinates. Measuring coordinates of zones selected on aerial photos by a digitizer is a new procedure which allows to automatize following procedures of plotting by STEREO-ANAGRAPH analytical plotter. When choosing a zone it is not necessery to write the number of photo because coordinate measurings of a point automaticly have its unic number inside. Exception to the rule is a necessety of giving the number to check and control points for their identification with a list of coordinates.

Having chosen zones on the first strip they choose points on the second one, here points transferred from upper strip are appreciated. This procedure stops with marking of every second photographs for a block (marking zone points that participate in adjustment) and laying doun of all diapositives and contact paper photographs. Mesuring of zone coordinates is carried out by the digitizer SMP-6410 connected with IBM PC.

According to software package of project designing a screen of computer essential commands of consecutive activities on measuring of zone coordinates is indicated. This Software provides:

- computing measured coordinates of zones from digitizer coordinate system to coordinate system of photographs;
- computing of coordinates of zones'centres relatively the principal point of photographs ;
- computing and transfer of homologeous points coordinates from common photo to next photos for forward and lateral overlaps.

When the work with a digitizer is finished, the following files in chosen directory are open: HEADLINE (*.prJ) and NUMBERS OF COORDINATES (beg.*), containing numbers of photos , quantity and numbers of points and their coordinates. When project designing is finished these files are removed to the directory, where works on STEREOANAGRAPH analytical plotter will be carried out.

2.2. Measuring of stereopair coordinates

This process is the main one in the new technology. Differently from the technology, used at enterprices it allows to realize a digital transfer of tie points and exclude both the process of artificial marking and essential expensive equipment: point marking instrument PUG (Swiss), Transmark and Interpretaskop (Germany), NT and DSI (Russia).

A STEREOANAGRAPH analytical plotter permits to get higher instrumental precision of measurings till 3 mkm and an automated process for driver of floating marks to zones of stereoviewing (observed) points, process of coordinates point transfer, processes of recording and numbering of points, checking of errors on all steps of photo measurment .

The core of new technology is a procedure of measuring of separate stereopair. To avoid frequent repetition of this procedure data for adjustment of strip network were formed. In turn photogrammetric block includes totality of the strips. There is a special feature for tie points of lateral overlap in the new technology. The points of lateral overlap (that at the same time are tie points in forward overlap) finally were calculated during process of mesuring of a previous strip. To begin the next strip it is necessery to transfer tie points from stereopair of previous strip.

Interior orientation of stereopair (diapositives) is carried out for reformation of coordinate system during digital point transfer and computing of coordinates of the principal point of photos. The procedure is carried out semiautomaticly. Carriages of the analytical plotter are reached automaticly to zones of all fiducial marks.
First, an operator- revolving manual steering-wheel combines the floating mark with a fiducial mark on the left photo, than on the right one . After that he records measuring coordinates as it was said above. Process of fiducial marks mesuring is rather important because all processes suches like digital point transfer and block adjustment's accuracy for spare networks depend on accuracy of their measuring. Choice and measuring of point coordinates are carried out under control of data file of project designing. Software controls succesively approaches floating marks to centres of zones on the left and riglt photos, marked on contact paper photos during the project designing. Viewing the centres of zone, an operator selects points for bridging.

Maybe an operator with some causes will not choose the same point, that was selected in the project and it will situate out of marked zone. It is only possible if there is an additional checking of its image on neighbouring photos on zones of forward and lateral overlaps. Order of measuring of a stereo pair point on the left and right photos with stereo veiwing is

carried out in the same mode that measuring of fiducial marks. Having accomplished the stereo viewing and recording measured coordinates of homologous points on photos, the software package automaticly drives floating mark to the centre of the next zone.

In such a succession coordinates of all the tie points of stereo pair will be measured. It is necessery to say that using a driving of floating mark with manual steering-wheels it is possible to add into measurment points that situate free on stereo pair presented in the project.

2.3. Digital point transfer for forward overlap

Digital point transfer for forward owerlap in the new technology realizes by the following method. On the first stereo pair an operator searches and records coordinates of tie and common points at zones selected during project designing. On the second and following stereopairs an automatic reaching of floating mark to tie points on one of the photos is realized; after that an operator gets possibility to do stereoviewing by moving only the second photo. An error of coordinates point transfer is mainly defined by errors of fiducial marks viewing by the STEREOANAGRAPH analytical plotter and its instrumental precision (with the results of carried out research these precision is 3 mkm).

There are two independent methods of a quality checking of photogrammetric bridging:

- by the results of relative orientation of a stereopair; errors of vertical parallaxes are calculated (this method needs not less than 6 points);

- by the coordinate differences of the homologous points got from two neighbouring stereopairs (it is necessery to have not less than 3 tie points).

Photogrammetric bridging always begins with the upper strip using a data project. The AP software for aerotriangulation in dialoge mode drives to an operator to do laying down of photos N 1 and N 2 and switching over of viewing axis of the analytical plotter.
The last one is necessery for realization of a method which shortens time for photos relaying. Process of strip net modelling is a cyclic repeatition of process of single stereopair modelling, presented earlier, until the last stereopair of a strip will be processed. As a result of this process the common model is formed, it has free scape and orientation relatively of geodetic coordinat system.

If there is essential quantity of control points for strip network, it is possible to use preliminary adjustment with checking of vertical and horizontal coordinate differences of control points. But for block adjustment, when rarefied control, the main part of a strip nets has not essential geodetic points. That is why checking of the net on this part is admissible value of errors on intermodel of tie points and vertical parallaxes.

In case of excess of admissible mean of errors the defective points have been eliminated or remeasured. It is important to measure tie points, participating in block adjustment and fiducial marks, defining accuracy of the method of digital point transfer especially thoroughly.

Results data with measurings of a strip are entered to the STRIP file. Measuring of coordinates on the next strip are carried out only after getting to it tie poins from a previous strip.

2.4. Digital point transfer for lateral overlap

For formation of a block it is necessery to provide a photogrammetric tie between neighbouring strips prepared independently. When artificially marked points are absent, tie of the strips is realized with a method of digital marking by transfer of measured coordinates of points for lateral overlap from one strip to another.

Tnis process is very different from a similar in techology with artificial marking of points. In a basic technology all strips become independent after marking. In digital marking, coordinates of points for lateral overlap are defined only after their fixation in previous strip .That is why strips must be prepared consecutively one after another.

There is a difference of materials which is an absence of checking accuracy of photogrammetric modelling on this strip. Checking may be done only at the stage of block adjustment. Laying down of photos with lateral overlaps on the carriages of analytical plotter and measusing of fiducial marks is similar to the written earlier.

Coordinates transfer of homologeous points to the strips is realized by the method of automatic restoration of coordinats meanings of common points got in preparation of previous strip and stereo viewing of floating mark with homologeous points on a photo of neighbouring strip. Programe pacage says that a process of measuring is up, when quantity of processed photos corresponds to quantity of photos that must be processed by the project. After getting all tie points from a previous strip it is necessery to measure next one.

All results with measuring data enter to the STRIP file. Actually forming of data for block adjustment is in consecutive carried out subprocedure of a strips' networks modelling and transfer of tie points to neighbouring strip. Process is stopped when measuring of all strips marked during of project disigning is fulfilled.

2.5. Block adjustment

Quality of block adjustment is valued with everage differences of adjusted photogrammetric coordinates of control points with their geodetic meanings. If there are many errors in tie points that are situated in triple forward or lateral overlaps, it is necessery to correct identification of the point number, accuracy of its stereoviewing and quality of fiducial marks mesurations. It is possible to decide a question about errors in fiducial marks with values permanence of deformation parameters for stereopairs.

Discovery of errors on control points is realized by excluding one after another of points, used in adjustment and their replacement to another ones (if it is possible). Defective point will be discovered, when its replace to anotner one or exclud from a process of adjustment, will be good. Unadmissible errors on control points can spring up after errors of point recognizing, errors of its stereo viewing, erross of catalogue forming or errors got from field geodetic works.

Analysis and adjustment of block are finished with a formation of a bridging points catalogue. Results of a digital point transfer excluding a process of aerotriangulation will be used in future steps during stereoplotting by analytical plotter. Here in a process of stereoplotting for single stereo pairs parameters of their relative and absolute orientation got from results of phototriangulation are also used; it shortens time for their repeat definiton.

3. CONCLUSION

Thus, an experimental working station based on the suggested set of hardware equipment and developed technological software has been formed to accomplish the whole complex of operations for horizontal-vertical control network bridging. The adjustment of blocks can be done by using program package "Photoblock" (TsNIIGAiK) and "Photocom" (Sibgeoinform).

The efficiency of the technology is defined by a number of factors. They are as follows:

- an exclusion of artificial point marking with all necessary expensive instruments from the technological cycle;
- an increase of coordinate pointing precision thanks to the use of digital transfer and to high instrumental precision of the analytical plotter being a basis of the new technology;
- an automatization of processes of project designing and stereoscopic measurements, and control of the results of major procedures.

The efficiency of the technology has been proved, in addition to its efficient theoretical solutions, by the results of experimental studies carried out at TsNIIGAiK on the STEREOANAGRAPH AP by using photographs obtained from 1:5 000 aerial survey of the referenced test area. For this purpose an aerial camera with a view angle of 100 was used. The choice of these test area photographs attributed to the great number of the targets on them determined on the ground with an accuracy of 2 cm. So the use of these aerial photographs has provided reliable results of block adjustment.

According to the developed technology there has been adjusted a block consisted of three strips, each of them having 7 photographs. RMS errors for the check points at X, Y and Z coordinates from the block adjustment by the "Photocom" program are respectively 3, 3, 7 cm. It allows compilation of a 1:500 scaled topographic plan with contour intervals of O.5 m for a flat relief, although due to normative documents the scale of aerial survey for a similar plan to be compiled should be 1:3000.

Time-consumption records have been taken during aerotriangulation procedures based on the suggested technology with automated point coordinate measurements on "Stereoanagraph". The time-study has shown that in comparison with the technologies of artificial point marking currently applied in mapping production the new technology provides a productivity increase in two times for marking and measurement operations, and - in 1.3 for the entire process of aerotriangulation - from project designing till final formation of a catalogue of the adjusted coordinates. A preliminary economical efficiency has been calculated using the data obtained. For this purpose some procedures and processes have been taken into account, in particular, aerial photography, geodetic bridging and aerotriangulation for steretopographic survey at scales of 1:5 000 - 1:500 with contour intervals of 1.0 and 0.5 m.

The developed technology of block aerotriangulation on the STEREO-ANAGRAPH analytical plotter leads to scale reduction of surveys by 1.5 due to a greater precision of block adjustment, as well, as leads to a productivity increase, and makes the routine work of an operator much easier. All these factors, as preliminary calculations have shown, gain an annual economical effect of about 50 million roubles per one working station.