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[1]M. I. Vasiukhin,
[2]O. M. Tkachenko,
[3]A. M. Kasim,
[4]V. V. Dolinniy

THE AGGREGATION TECHNOLOGY OF APPLIED SOFTWARE FOR AERIAL PHOTOGRAPHY DATA PROCESSING TO BUILDING MAP DATABASES IN PRECISION AGRICULTURE SYSTEM

[1,2]National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
[3,4]Institute of Cybernetics named V. Glushkov, Kyiv, Ukraine
E-mails: [1]vasgeovideo@i.ua, [2]tom_work@ukr.net, [3]aneesa@i.ua, [4]vite05@mail.ru.

Abstract—*The publication dedicated to the problem of crop mapping software integration and generalization of aerial photography processing technology using Digitals package.*

Index terms—Geo-information system; map database; applied software; precision agriculture.

I. Introduction

One of the priorities of improving the efficiency of farming is a precision agriculture [1]–[4]. This technology provides a significant increase in productivity and continual improvement of soil quality and the most environmental technology in the world.

Precision agriculture systems are widely used in developed countries. Such systems can be used subsystems and means of space (GPS-, meteo-, remote sensing, satellites), air (aircraft, unmanned aerial vehicles) and land allocation. Geo-information system (GIS) navigation subsystem is a key component and an intelligent module that provides processing and analysis of remote monitoring, aerial and satellite image processing, agrochemical research data, etc., and also provides precise spatial linkage of all agricultural units. The feature of this module is the presence of general geographic databases, and thematic data that are provided as electronic maps. Models, methods and software tools of commercial foreign systems are not available for domestic developers.

II. Technical Aspects

However, there are a number of domestic and neighboring countries organizations (Table), which are high enough offer tools for building map databases (MDB) containing digital maps of different scales and content component.

Examples of software for precision agriculture

Company, country	Title of main software product	Software for farms	Server software	Integration with enterprise information systems	Additional
Panorama (Russia)	GIS “Map”	GIS “Panorama AGRO”	GIS Web Service; GIS Server	Software for integration with “1C: Management in agricultural enterprise”	Set of maps for “Panorama AGRO”; Databases for “Panorama AGRO”
Institute of modern agrotechnologies (Ukraine)	“AgroClever”	“AgroClever”	–	“AgroClever” can be integrated with systems of customer	–
Kryvbas-Academ-Invest (Ukraine)	GIS “K-MINE”	“AgroMine”	Cross-platform network version	Integrated ERP-module	Scientific support by National University of Life and Environmental Sciences of Ukraine

Software from Table can solve some problems of precision farming, but they are not able to provide adequate space linking the information necessary to create large scale digital maps.

It is known that aero- and topography photographing are the main ways of obtaining geographic information for mapping large areas on the scale of 1:100,000 to 1:500. In such cases, photographing areas performed using a special aerial photographic, installed on an airplane, helicopter, balloon, and etc. The stereo-topographic and combined methods are the main ways [5].

The *combine* method use properties of single image. Getting of outline is possible during creating

photomap, and getting of relief is possible using geodesic works data. This method is better for flat terrain.

Stereo-topographic method is most popular for mapping. It uses stereo-pair, which allow get outline and altitude part of map. This method used for mapping of areas with hills mountains, and for plains in certain cases.

Result of stereo-topographic method is important source of actual information about mapping objects for building main and thematic layers of GIS databases for precision agriculture.

Since spatially distributed diverse information is the main type of data in any GIS of precision agriculture, the software of these systems are quite specific.

III. STATEMENT OF THE PROBLEM

The purpose of this paper is to create of the developed technology of integration of software for aerial photography data processing, which can be used in map databases and precision farming systems.

Using advanced devices and applications, their ability it was given the task of choosing the optimal scheme performance of works on processing results aerial photography. The essence of the problem was to develop the most effective scheme, including time and means cost minimization when applying the modern achievements in science and technology.

IV. APPROACH FOR THE SOLUTIONS

There are different definitions of the concept of map database. We believe that good is: MDB is a set of interrelated map data on a specific subject area that presented in digital form based on common rules of data describing, storing and manipulating. Map databases is available to many users, does not depend on the specific of applications, and it managed by a database management system.

In view of this, information collecting technology (due creating digital maps) is the digital registration spatial coordinates and map topographical characteristics of objects. In this case, the digital map (i.e. data store) is creating "from scratch". For updating – this applies only to objects that appeared or changed. In addition, digital information about objects disappeared by the time since the creation of maps is removing, and geometry and properties of objects that have changed are restoring.

Analysis of number of GIS show that one of most acceptable domestic technology for creating MDB for precision farming is the technology ***Digitals*** which based on scanned stereo images that obtained from aero-photo-topography using camera 3-DAS from company "Geosystema" (Ukraine). This camera can be used for operational creating ortho-photo maps with scale 1:2000. Another reason is less costs in comparing with satellite images. For creating vector maps in scale 1:1000-1:500 film cameras are better [6].

3-DAS equipment includes:

– *scanning module* with 3 independent channels based on linear a charge-coupled device (CCD) sensors (each have 8000 pixels), with different angels for carrier movement directions (nadir – 0°, forward – 16°, backward – 26°), this is to ensure stereoscopic triple overlap;

– *gyro-stabilizing platform* which compensates angles and spread in the air carrier body, always maintaining the horizontal position of the camera;

– *flight control system* that provides aerial planning, routing, and navigation and flight path control;

– high-speed *positioning GPS system* with intervals of 200 times per second;

– *computer* for high-speed images recording on disk storage capacity at least 2 TB.

Scanning camera gives the output picture, where the image is formed in the central projection just across the flight direction. Along the axis of flight image is an orthogonal projection. This feature requires specially adapted software for photogrammetric processing.

In general, following base modules can be noted [2]:

– data input and verification;

– data storing and manipulating;

– transforming of coordinates and map projections;

– analysis and modeling;

– data output and presenting;

– interaction with user.

The implementation of these functions requires the development of specialized software, because any GIS work with two types of data – spatial and attribute, and for their manipulating software should include system of both data types management, module of input and output, and visualization system to perform spatial analysis.

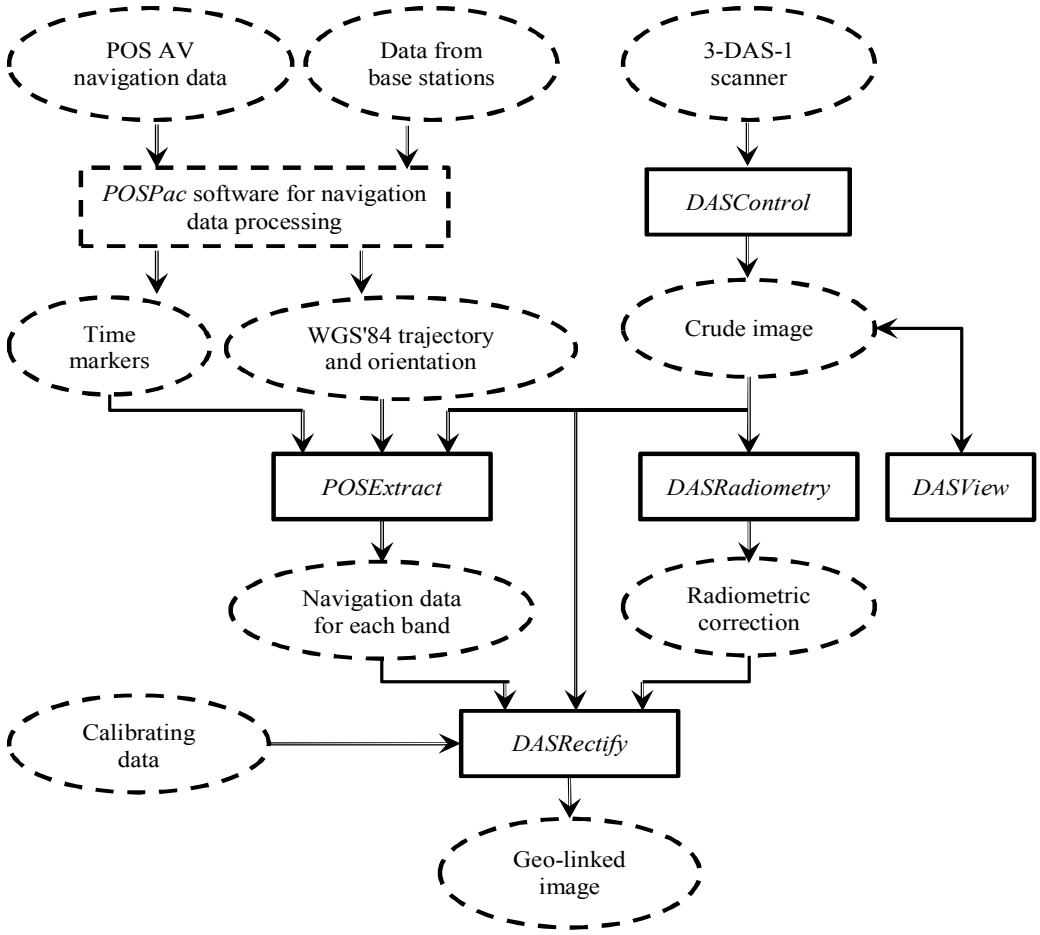
We offer the use of the application package Digitals for creation and maintenance of digital maps and map databases for agricultural purposes. The specific features those are important for precision agriculture is implemented through three additional modules – module of spatial analysis, geo-statistical analysis module and image processing module.

The first two modules to restore the spatial distribution of parameters, such as agrochemical or crop, for metering points, as well as explore the relationship between various indicators that affect produc-

tivity. Feature of geo-statistics (comparing with traditional statistical methods) is spatial aspect of phenomena is considered, which allow to detect not only temporal but also spatial trends, relationships and consider the impact of various factors in the time and spatial context.

Map databases fill during the process of collecting information from photogrammetric digital terrain model. The principal feature of the method is the use of a geodetic coordinate system defined by the coordinates of control points in the external orientation of the model. This approach allows obtain metric information from various aerial images regardless of the orientation of images in one coordinate system.

Processing of the data consists of several stages, each of which uses the appropriate software. For simplicity, this process can be represented by the following block scheme shown in Figure.



Block scheme of data processing using Digitals

The first stage is flight data processing. It performed for getting precise trajectory of Camera 3-DAS, information about changing angles of orientation in space and time marks for synchronization of the image with navigation data. Here the software ***POSPac*** from Applanix Company (Canada) is using.

There are input navigation data for post-processing using POSPac:

1. Crude navigation data from gyro platform POS AV (data from onboard GPS-receiver, IMU (Inertial measurement unit) data, and service information).

2. Crude data from on-land GPS base station, its exact location and height-receiving antenna.

The GPS positioning system provides high-speed and high-precision geodetic linking of images. This system uses kinematical method for determining the location (differential method DGPS) and includes one or more stationary and one mobile receiver installed on the aircraft performing simultaneous observations of artificial satellites constellation of world global system.

The time interval of observation of terrestrial GPS base station should completely cover the time of the flight with at least 15-minute reserve.

Output data are the file with the results of the calculation of the exact flight path and camera spatial orientation angles, and file with the time marks of synchronization used for further processing.

Therefore, after the flight recorded navigation data is processed using software that comes with the system Applanix. The result of this work is two files –navigation file and file with time marks that are

used for further processing. The navigation file contains the position and orientation of the plane in space flight for all time intervals of 0.005 seconds.

The second stage of aerial navigation data processing is linking of navigation data with image that obtained from 3-DAS camera and previously conducted through the program ***DASControl***. It uses software ***POSExtract***, which allows you to find the navigation data for each band based file time marks containing GPS-time of image reference lines exposure. POSExtract using interpolation mines position and orientation of each line and writes them to files strip.att.

Then we have radiometric correction of image, which obtained from a digital aero-scanner 3-DAS. This correction means choice of optimal values of gamma, contrast, brightness, etc. For this reason the program ***DASRadiometry***, which, based on statistical data, suggests appropriate values of these parameters. The "crude" image is always in the same form, the correction apply only to the output image. This is due to the fact that modern processing facilities for remote data characteristic try to keep not processing results, but output data and algorithms as needed to reproduce the target result. Intermediate data obtained in the previous two stages, "crude" image and calibration data will use in the next stage of processing – rectification using software ***DASRectify*** [6].

To generate each image created by the appropriate camera – rearview (Backward-camera) nadir view (Nadir-camera) and front view (Forward-camera), this program use the following data:

a) channel intensities files in RAW format;

b) channel text information files;

c) channel files with radiometric correction of images;

d) channel files of CCD sensors calibration;

e) file Strip.att with orientation elements of each line of the earth's surface scanned band;

f) INI-file with parameters of DAS scanner (<Name of scanner>.cmr).

In the output of each camera program creates the following files:

a) color image file in TIFF 6.0 format, which also recorded all image geo-linking data, that allows to do photogrammetric image processing;

b) image rectification parameters file, which stores information about the state of images rectification, allowing you to continue the interrupted process of rectification;

c) rectification performance log file, which stores information about the progress of image rectification.

The final step in the processing of results aerophotographing is quality control of geodetic linking of images with reaching optimal results through ***DASCorrect*** software. To generate tables of unlinking for each image the program uses such data:

– rectified images;

– control points directory in UTM coordinate system in a given area;

– camera's parameters file.

Formed geo-linked image serves as the basis for map vectoring using Digitals software. To create a new digital map target template and coordinate system are electing. Then on the selected template all geo-linked images opens, and we obtains generated basic layers with triangular boundaries of images. You can map vectoring in Digitals using layers creating and blending. It supports the following types of layers:

– polygon/polyline – shown as a sequence of object points connected by straight lines; this type is used to display most objects;

– smoothed polygon/polyline – displayed as a series of object points, connected by smooth lines that do not necessarily pass through all points of the object; this type is usually prescribed for horizontals;

– SpotHeight is a point; this type is used typically to display the marks of heights, depths, etc.;

– symbol – shown as a point (single simulated signal); used to display, such as wells, single trees, poles, etc.;

– frame and legend – displayed as well as polygon/polyline, but the layers of this type are not clipped to the frame during printing of map; this type is used for out-frame design;

– table – provides a displaying as a table that contains one or more columns of text; "line attributes" determines view of table grid;

– grid of relief digital model (DEM-Grid) – displayed as regular or irregular heights grid; grid of heights creates through relief recovery procedure on raster stereo-pair, or using interpolation from existing contours and spot heights;

– triangulation network (TIN) is a Delaunay triangulation network that can be build on existing spot heights; TIN can use for creating horizontals.

Thus, collecting and updating information on digital contours made not only with scanned maps, but also on the basis of ortho-maps or individual images in stereo-taking mode. Digital information is collected and recorded in layers (number of layers is not limited): the elements of relief, hydrography, vegetation, land ownership boundaries, settlements, industrial facilities, overpasses, communications, pickets, text captions and other elements.

Doing this work we can use templates of various object types: point, line, polygon, etc.

Gathering information about the digital terrain model stereoscopic performed in the following ways:

– manual horizontal tracking;

– creating regular DEM-Grid with given step in manual, auto and interaction mode;

– creating non-regular DEM-Grid as a Spot-Heights for definitive points of relief in manual or auto mode.

Creation of digital ortho-maps for the entire area plane flight carried out by block triangulation results after creating DEM. After entering the information, program automatically creates ortho-transformed fragments of the central areas of each image with automatic cutting, integral improvement of contrast and color removal "unlinked" boundaries. Cropping pictures along the route performed automatically. Between routes circumcision not performed, but cutting lines creates, and after its checking and editing pictures are cut. Editing digital information is intended to form a map tablet sheet with notations, symbols, and getting information on any object.

Editing allows you to perform various functions, such as:

– linking of digital information obtained from different stereo-pairs;

– "slicing" of information on tablets;

– forming of complex polygons based on previously collected objects;

– objects combination and dividing;

– change the order of object collection;

– adding nodes;

– generalization of digital information;

– transformations (line to point, symbol to object, point to circle, line to band, etc.) [5] – [7].

During editing:

– errors are correcting;

– horizontals and contours from different stereo-pairs are arranged;

– symbols, codes etc. can be turned on or changed.

After editing the information is responsible for the composition and quality of the basic requirements for a digital map.

Quality control of digital information provides many features for inspections and control of geometry, content, semantics, and object links. In particular:

– objects metric test to the lack of self-sectional and duplication;

– closed objects contours;

– object contiguity;

– prohibited objects belonging;

– goes beyond nomenclature sheets;

– check the completeness of passport data, object composition, characteristics of objects, etc.

Overall, process of digital information quality control includes the possibility of correction in automatic and in manual and interactive modes with recording results of control operations.

CONCLUSIONS

In this paper, the aggregation technology of applied software for aerial photography data processing to building map databases those are bases for digital large-scale maps, which are basis of precision agriculture GIS.

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Vasiukhin Mykhailo. Professor.
Computer Networks and Telecommunications Department, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine.
Education: Donetsk Polytechnic Institute, Ukraine. (1967).
Research interests: computer systems, GIS.
Publications: 200.
E-mail: vasgeovideo@i.ua

Tkachenko Oleksii. Associate Professor.
Computer Sciences Department, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine.
Education: Kirovograd State Pedagogical University, Ukraine. (1997).
Research interests: programming technologies, intelligent systems.
Publications: 50.
E-mail: tom_work@ukr.net

Kasim Anisa. Researcher.
Institute of Cybernetics named V. Glushkov, Kyiv, Ukraine.
Education: National Aviation University, Kyiv, Ukraine. (2007).
Research interests: computer systems, databases, object-oriented programming.
Publications: 50.
E-mail: aneesa@i.ua

Dolinniy Vasiliy. Post-graduate.
Institute of Cybernetics named V.Glushkov, Kyiv, Ukraine.
Education: Zhytomir Military Institute, Ukraine. (2006).
Research interests: map database, GIS
Publications: 6.
E-mail: vite05@mail.ru

М. І. Васюхін, О. М. Ткаченко, А. М. Касім, В. В. Долинний. Технологія комплексування прикладних програм обробки даних аерофотознімання для створення баз картографічних даних системи прецизійного землеробства

Досліджено проблеми інтеграції картографічного програмного забезпечення у рослинництві та узагальнення технології аерофотографування і обробки зображень з використанням програмного пакету Digitals.

Ключові слова: геоінформаційна система; база картографічних даних; прикладне програмне забезпечення; точне землеробство.

Васюхін Михайло Іванович. Професор.
Кафедра комп'ютерних мереж і телекомунікацій, Національний університет біоресурсів і природокористування України, Київ, Україна.
Освіта: Донецький політехнічний інститут, Донецьк, Україна. (1967).
Наукові інтереси: комп'ютерні системи, ГІС.
Кількість публікацій: 200.
E-mail: vasgeovideo@i.ua

Ткаченко Олексій Миколайович. Доцент.
Кафедра комп'ютерних наук, Національний університет біоресурсів і природокористування України, Київ, Україна.
Освіта: Кіровоградський державний педагогічний університет, Кіровоград, Україна. (1997).
Наукові інтереси: технології програмування, інтелектуальні системи.
Кількість публікацій: 50.
E-mail: tom_work@ukr.net

Касім Аніса Мохаммадівна. Науковий співробітник.
Інститут кібернетики ім. В. М. Глушкова НАН України, Київ, Україна.
Освіта: Національний авіаційний університет, Київ, Україна. (2007).
Наукові інтереси: комп'ютерні системи, бази даних, об'єктно-орієнтоване програмування.
Кількість публікацій: 50.
E-mail: aneesa@i.ua

Долинний Василь Володимирович. Аспірант.
Інститут кібернетики ім. В. М. Глушкова НАН України, Київ, Україна.
Освіта: Житомирський воєнний інститут радіоелектроніки ім. С. П. Корольова, Житомир, Україна. (2006).
Наукові інтереси: бази картографічних даних, ГІС.
Кількість публікацій: 6.
E-mail: vite05@mail.ru

М. И. Васюхин, А. Н. Ткаченко, А. М. Касим, В. В. Долынный. Технология комплексирование прикладных программ обработки данных аэрофотосъемки для создания баз картографических данных системы прецизионного земледелия

Исследовано проблему интеграции картографического программного обеспечения в растениеводстве и обобщение технологии аэрофотосъемки и обработки изображений с использованием программного пакета Digitals.

Ключевые слова: геоинформационная система; база картографических данных; прикладное программное обеспечение; точное земледелие.

Васюхин Михаил Иванович. Профессор.
Кафедра компьютерных сетей и телекоммуникаций, Национальный университет биоресурсов и природопользования Украины, Киев, Украина.
Образование: Донецкий политехнический институт, Донецк, Украина. (1967).
Научные интересы: компьютерные системы, ГИС.
Количество публикаций: 200.
E-mail: vasgeovideo@i.ua

Ткаченко Алексей Николаевич. Доцент.
Кафедра компьютерных наук, Национальный университет биоресурсов и природопользования Украины, Киев, Украина.
Образование: Кировоградский государственный педагогический университет, Кировоград, Украина. (1997).
Научные интересы: технологии программирования, интеллектуальные системы.
Количество публикаций: 50.
E-mail: tom_work@ukr.net

Касим Аниса Мохаммадовна. Научный сотрудник.
Институт кибернетики им. В. М. Глушкова НАН Украины, Киев, Украина.
Образование: Национальный авиационный университет, Киев, Украина. (2007).
Научные интересы: компьютерные системы, базы данных, объектно-ориентированное программирование
Количество публикаций: 50.
E-mail: aneesa@i.ua

Долинный Василий Владимирович. Аспирант.
Институт кибернетики им. В. М. Глушкова НАН Украины, Киев, Украина.
Образование: Житомирский военный институт радиоэлектроники им. С. П. Королева, Житомир, Украина. 2006).
Научные интересы: базы картографических данных, ГИС.
Количество публикаций: 6.
E-mail: vite05@mail.ru