GEOGRAPHICAL INFORMATION SYSTEMS AND DIGITAL MODELS

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ABSTRACT

This paper discusses problems, connected with description of technological processes in manipulating and using of existing data within the GIS. In this context, I will also deal with the accompanying stages of creating Digital Building Models (DBM).Furthermore, I will also discuss problems and errors faced due to the natures of the automation processes. Finally, I will also highlight the role which the contemporary Digital Photogrammetric Technologies play in the information systems for urban planning and management.

Introduction

The automation of the generation of 3D city models as required by many users of Geographic Information Systems has become a major focus of photogrammetric research in the past few years. Starting with 2D image processing techniques, researchers did soon turn towards 3D approaches like grouping features matched in multiple images. The automatic extraction of parametric and prismatic building models from digital elevation models generated by photogrammetric techniques or airborne laser scanning .

The best and must complete cartographic products can be obtained by photogrammetric survey at a proper scale, a correct scanning of existing cartography submitted to a robust georeferencing process, can give acceptable cartographic products for GIS applications.

Problems of manually managins 3D objects representation

Digital orthophotos in combination with GIS are a suitable instrument for input data for changes in mapping rapidly growing cities. It is expected that in the 21st century, more than 70% of earth inhabitants will live in cities.Therefore accurate mapping of cities in digital orthophotos is very important. There are systems for digital orthophoto, which are not present as objects until now such as buildings, bridges or highways as a 3D. Therefore middle scale (1:5000 -1:10000) orthophotos of urban areas show disturbing geometric errors in the form of displacement and double mapping [1].

Erroneous pixels in common digital orthophotos exist in excess of 8%, depending mainly on building density and height .This causes serious problems for further applications such as data overlay, 2D coordinate measurement or 3D visualization. This paper presents a method for accurate mapping of 3D objects in digital orthophotos. It is based on image separation and independent rectification of terrain and building areas.

The proposed solution for accurately mapped orthophotos calls for requires the following processes :

- Digital building model.
- Building orthophoto computation.
- Terrain orthophoto computation.

The digital building model determine the shape of each building and is required for the subsequent process of building orthophoto. Since conventional orthophotos system can hardly model building surfaces and is not concerned with hidden surfaces, an algorithm has been developed for this purpose. The result of this process is an orthophoto of all buildings.

Digital Building Model (DBM)

There are many types of 3D-objects visible in aerial images. Natural objects such as trees will not be considered in this work .An overview of buildings and their representations is given in Fig.1.

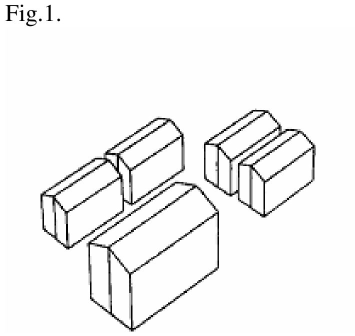

Fig.1. Overview of buildings and their representations

A flexible solution to model this types of objects is boundary representation. This technique uses geometric to describe objects boundaries. It is sufficient to choose triangles and quadrangles as geometric . Beside the geometric shape which the building model represent, it also attribute information for each geometric primitive. The digital building model distinguishes between primitives that are
visible in the orthophoto (e.g. roof) and invisible(e.g. wall, vertical element, etc).

Methods of data acquisition for building digital model (DBM)

Currently data capturing for building models usually is done manually on analytical or digital photogrammetric stereodigitizers. In procedures, sufficient to automated data acquisition, applying digital techniques are still under development. Therefore simple procedures for manual acquisition on a stereoplotter integrated into a CAD are of great importance [4]. Capturing of DTM and 3D object data will be done simultaneously.

The usage of existing data generally captured for other purposes (e.g. maps, etc.) is very difficult. In most cases those data are stored in two dimensional GIS. Therefore additional information such as 3D topology, elevation, etc. is required. Inconsistency of those data sets presents other big problem. This is caused by data acquisition using different methods at different epochs for different purposes.

Modelling

Many buildings (especially in suburban areas) are of simple shapes. In this case it is sufficient to digitise roofs only. Walls can be computed from data for roofs (eaves) and DTM .

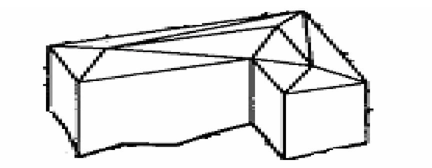

Fig. 2. Building modeling by roof and terrain data

Three dimensional triangulation algorithms with geometric constraints are necessary for automatic generation of geometric primitives.This method is used to model details within roofs. There are similarities in some buildings and it is, therefore possible to prepare standard buildings same topology. Lang et al. (1995) proposed a method for semi-automatic topology building [5]. Digital photogrammetric methods such as edges extracting or matching might be extended to 3D- topology matching [1].

Information Management System

For urban information system in citywide, with several types of building numbers with a many thousands of each type and several thousand digital photos and associated control data, a database system is necessary to manage all these data.

This information system should handle all relevant data and areas, such as :

- Aerial images including image properties (orientation, etc).
- Digital terrain model (DTM).
- Digital building model (DBM).

Implementation of Photogrammetric Digital Workstations in Cadastre

The digital photogrammetric methods for data processing provide retrieval and storage of information in a form protected against ageing decline. These methods provide opportunity for operative efficiency of work, and assist the implementation of new techniques in the organisation of the technological process. I n addition to the foregoing, some capitalise an other advantages, related to the use of computer systems for the facilitation of the connection to GIS, options for easy data editing in case of errors and options for restoring history state of data processing. The main reasons that have hindered the implementation of the digital photogrammetric methods are justified by the necessity of storing and processing large data volume, related to the digital presentation of images which secure acceptable accuracy. The development of computer systems which have to comply with the aforementioned requirements at an acceptable power/price ratio makes it possible for these to be used as a basis for the development of the contemporary photogrammetric workstations, implementing digital processing of images.

Methods for Updating Digital Maps and GIS Databases of Urban Regions

Owing to the continuous developing of the GIS incurs an increased demand of methods for updating maps by means of their implementation. The demand for better and updated map data is considerable. The standard technologies for updating maps are insufficient to satisfy the increased demand [6], incurred both in terms of the contents, and of the database structure. The brief description of the problems which occurs in these types of activities relates to the existing priory developed digital map data that should be converted from the originally compiled data files into special data files, compatible with CAD and/or GIS software environment. Throughout the process of conversion, data may be lost, misrepresented or improperly classified. By means of creating photogrammetric files the opportunity for viewing the map history is increased. Slides of the new topographical survey and then superimposed on the map. In order for the map to be able to comply with the requirements, the data are presented by means of stereoscopic photogrammetric model (in other words data processing is facilitated by means of analytical stereo-plotters), whereto are added subsequently the height values.

The services and/or the companies dealing with map processing encounter the following problems:

- Updating the sources of digital data.
- Converting in a format, which is suitable for the new objectives of the system.
- Creating GIS database, on the grounds of newly developed digital files.

Following the process of gradual change from analogue to digital technologies, typical of the last two decades, the customers and providers of digital data successfully implemental up-to-date computer technologies. The analysis of the processes of digital mapping, typical of the past ten years comprise restrains in the data acquisition in compliance with the data processing capacity of the CAD systems. The large-scale maps of the urban regions (1:2000, 1:4000) are generally presented as "CAD maps", and are used mainly in graphical representations, survey and town-planning, and some other basic engineering tasks [3], [7]. In the last few years they are completed by the implementation of contemporary CAD software and modern GIS. In the development of the present maps, the issues like break lines in relief, congruence of angles are not as important as mentioned parameters are in the present GIS environment for making precise topological database for buildings. The original photogrammetric files had to be subjected to three translations for the achievement of a presentation, suitable for implementation with GIS system. For these mentioned translations various programs are used, and most of them provide options for the so-called translation "one-to-one". However these conversions may cause undesirable changes (deviations) in the structure of the original data, and may cause new errors. In most of the cases the errors that have been made in the graphical elements are not discovered or corrected in maintaining the visual contents of the map. The customers should be acquainted with the additional errors, caused as a result of changes in the graphical components of editing land surveys. The errors that most often occur consist of dislocation of graphical elements in wrong layer or assignment of incorrect attributes [2].

With the aim of solving the above said multiple tasks a methodology for solving problems has been developed for the cases of incompatibility in data processing, and particularly in case of attributes failure in the existing outline, and of the innovation process as a whole. The end result of the whole process for the innovation is directed to the development of structured database that could be formatted on the grounds of GIS database.

Preparatory Stage

The acquaintance with the exact requirements, the mapping specifications, and the materials required are some of the initial steps of the presented methodology. The preparatory stage is a process of systematic and standard processes that lay up the operator's efforts and minimise the errors in the data analysis. At the initial check up, the whole original database is organised in a system, and is checked for systematic errors.

Before commencing the updating processes of the map, the original files are converted into the corresponding software format. Throughout the translation of the file into each component, in addition to its original attributes, are assigned additional attributes that provide identification of possible corrections and changes. At this stage of preparation, one of the qualitative control check is the so-called representative check for co-ordinating the database of the original survey plan.

Most of the digital graphic files or maps could be converted from the original files into files of the corresponding user GIS software environment. Thus, for example the data of the individual map lists need to be compiled into three separate files:

- DTM-file, containing broken lines and multiple points.
- File with the contour lines.
- File containing the situational mapping elements.

Furthermore the customer has opportunity to modify the original files in their parts containing risk of partial loss and/or complete failure of map data. To the present graphic elements, a fake height value of 0 may be assigned, some other fault height values or any data that may be inconvenient for photogrammetric updating.

The contour lines with missing height values cause displacement and deviation within the existing data for points subjected to stereoscopic survey. This imposes the requirement to enter correct or approximate height values for each of the graphic elements.

One phase of the preparatory stage consists of quality assurance techniques and possibility for optional use of the original DTM. The analysis identifies and categorises the graphic elements of the various groups, like for example:

- Contours without height-end.
- Contours with height-end being out-of-range.
- Contours without end but accompanied by text.

In order to implement user files which contain map data there are files for the azimuths and master file should be made. The supporting files that contain data have impact on the type and the contents of each of the remaining files by establishing and defining their variables. The maintenance files contain the denotation colour, definition, type, conditional signs, models, encoding text details, item number, etc. The data are entered when the operation environment is halted. The current print out of the new data is an operation output that facilitates the editing process and makes distinction between history and updated data.

The number and the situation of the milestones and corrected points are grounded on the points, acquired as a result of the analytical aero-photographic survey process. The registration of new complicated model for integration of the digital map history data could be represented in two options [6].

Creating Digital Model of the relief

DEM is created by means of the corresponding files already transformed. The method implements all possible and successfully identified data, retrieved at the preparatory stage. By means of the implemented software, the data are transferred through various assigned actions, and analysed in terms of compiling photogrammetrically usable files.

DTM represents the relief of the terrain with such forms as they are in the three-dimensional (3D) space representation. In order to represent the 3D image in GIS, both the height and attribute of the graphical element are needed. Other peculiarities like hydrography, type of land-use, cultures, etc. are usually represented in two-dimensional (2D) format. In case when necessary, by means of implementing DEM three-dimensional representation could be added to the two-dimensional representation of the digital map files.

The photogrammetric process of generating DEM is related to the stereoscopic measurement of heights of terrain points by means of analytical stereo-plotters. The point distribution could be normal, roughly normal, or incident to the known average density. In these observations the network is interpolated by means of implementing means for creating DEM. In the general case the average density of the compiled network is 2-3 times greater than the number of the originally measured terrain points.

In order to resolve problems relating to incorrect or missing height data are connected with creating of preliminary DEM implementation of all photogrammetrically defined points of the model, and supplemented by the height values of the existing DTM or file of the contour lines. The first step is to establish the density of the network covered and crossed by two-dimensional indexed contour lines, and also checking of the first DEM iteration. From this point of view the heights are related to the indexed contour lines of the nearest 30 m. Depending on the quality of the original data, the search for correlating index contour lines is allowed up to 60 m, if appropriate.

The new generation of DEM proposes as a milestone basis the combination of survey photography details required for the photogrammetric update. To generate topologically correct contour lines the system implements automatic processes for closing gaps and deleting overlapping linear segments in the Contour lines. Some planimetric displacements of the contour lines that could be caused by the graphical editing or mapping deformation, cause additional errors in the DEM that could not be corrected.

The existing heights may be implemented as an indicator for the accuracy of the contour lines and of the DEM as a whole. The height data could be analysed in order to define whether the acquired data are correct. The co-ordination values of the stipulated planimetric peculiarities, such as hydrological peculiarities, routes of roads, etc., are compared with the DTM file. In case this could be performed the planimetric characteristics will be reclassified as interrupted lines.

Updating Maps

In order to make changes and to perform updating, concurrently with the existing stereoscopic data new aero-photographic survey shall be considered. The updating of the map is performed only in case when the reconsidered corrections could be defined by some stereoscopic method.

The operations on updating the map of the existing vector or point data of the aero-photographic survey, require the following steps:

- Photo-interpretation.
- Establishing the corrections.
- Acquisition of new data.
- Database integration of history and new data.

One of the effective methods for the retrieval the new data is by means of superposing of existing digital data onto the existing new aero-photo survey, and updating the database by means of acquiring new data from the stereo-models. The superposition and acquisition of data could be represented in various ways. The updating of the map or its modification could be regarded to change in the thematic description, to changes in the Z co-ordinate (height), or by means of amending the dislocation of X and Y co-ordinates.

Upon entering the data of the topographic characteristics by implementing the specific technology of superposition, the photogrammetis (operator) visually scans the model in regarding to corrections in the image or additions by means of comparing history maps of the terrain characteristics to the stereo-model. The amendments in the terrain are identified and depicted in order to represent the track between the prior and the new contour. All existing vectors and points within the surrounded region are deleted and replaced by points acquired by means of photogrammetric methods. Besides that the regional amendments could be identified by means of tracking all suspicious peculiarities. The contour lines and the updated regions are generated by means of new sets of points and interrupted lines, implementing triangular asymmetrical network. For editing whole maps a wide-scope processing of data is used. What mentioned above is a stage at which for the purposes of automatic editing and magnification of the data presentation, an extensional software is used to develop the map topology and secure data continuity.

In order to check up whether all data are correctly converted, GIS specialists test the files on graphic workstations.

Conclusion

The points that have been highlighted in this reports have concluded that there can one approach that can be adopted in finding a new, systematic and direct solution in utilizing the appropriate tools which allow far accurate data collection, ease of data accumulation, as well as increases in the efficiency in the semiautomatic 3D data acquisition .

References

1. Amhar, F.,V. Ecker. 1996 a. An Integrated Solution for the Problems of 3D Man-Made Objects in Digital Orthophotos. ISPRS XVIII Congress, Vienna. Intern. Archive of Photogrammetry and Remote Sensing, Vol XXXI, Part B4, Commission IV.
2. Haidoushki, I. 1978. Photogrammetry. Sofia, Tehnika, Bulgaria.
3. Katzarsky, I., L. Koleva. 1996. Revision of the Large-scale Topographic Map in Bulgaria. ISPRS XVIII Congress, Vienna,. Intern. Archive of Photogrammetry and Remote Sensing, Vol XXXI, Part B4, Commission IV.
4. Kraus, K. Photogrammetry, Vol. 2. Bonn, Ferd.Duemmler Verlag, 1997.
5. Lang, F., Locherbach, T., Chickler,W., 1995. A One-Eye Stereo System for Semi-automatic 3D-Building Extraction. GIM, June 1995,pp.6-8.
6. Malla, A. 1999. Photogrammetric methods for creation and renovation of large scale maps. Sofia, Geodesija, Kartografija, Zemeustrojstvo, 1,Bulgaria.
7. Malla, A. 1999. Expedient Photogrammetric methods and technologies for generation of cadastral maps and plane. Sofia, Geodesija, Kartografija, Zemeustrojstvo, 4, Bulgaria.