THESES

MODERN GEOINFORMATION METHODS IN FORESTRY

Scientific Achievements of a Geoinformation System's Development

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6. Important publications and proceedings

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ABSTRACT

Modern Geoinformation Methods in Forestry

Scientific Achievements of a Geoinformation System's Development

This paper describes the scientific achievements, modern algorithms and technologies of a Geoinformation System's Development. The achievements are built on the Raster and Vector data. The Raster procedures present an algorithm based Image Processor, a new raster format, a new interpolation method, and improved viewshed, hydrological and raster-to-vector procedures. In the raster part more chapters deal with Digital Photogrammetry, such as bundle block adjustment, new possibilities of Ortophoto generation, software version of spatial data acquisition, and automatic Digital Elevation Model extraction. The Vector procedures describe a main-memory based database manager, a brand-new spatial indexing method, and a real-time topological mapping tool. An independent chapter investigates the Hungarian digital forest maps. The last part of this paper introduces new methods of the triangle network based surface modeling.

KIVONAT

Korszerű geoinformatikai módszerek az erdészetben

Egy geoinformációs rendszer fejlesztésének tudományos eredményei

A dolgozat egy földrajzi információs rendszer fejlesztésének tudományos eredményeit, korszerű eljárásait és technológiáit ismerteti. Az eredmények a raszteres és a vektoros adatok köré épülnek. A raszteres eljárások bemutatnak egy algoritmikus képfeldolgozót, egy új raszter formátumot, egy új interpolációs módszert, illetve javított láthatósági, hidrológiai és vektorizálási algoritmusokat. A raszteres részben több fejezet foglalkozik a digitális fotogrammetria témaköreivel, úgymint a sugárnyaláb kiegyenlítéssel, az ortofotó készítés új lehetőségeivel, a térbeli kiértékelés szoftveres változatával, valamint az automatikus felületmodell előállítással. A vektoros eljárások ismertetnek egy memória alapú adatbázis-kezelőt, egy teljesen új térbeli indexelési módszert, és egy hatékony valós idejű topológikus térképezőt. Önálló fejezet foglalkozik az erdészeti digitális térképekkel. Az utolsó rész a háromszög alapú felületmodellezés új módszereit mutatja be.

3.5. Surface Modeling

There is a frequent task in Geoinformatics to fit a continuous surface to spatial points. The author has elaborated new methods to triangulated irregular network based surface modeling. The paper describes the constrained triangulation and the boundary conditions of fitting of the elementary surfaces, which is suitable for reconstruction of surfaces defined by spatial points, breaklines and contour lines. The author presents the recursive triangle decomposition algorithm, which is able to create contour, slope, aspect and illumination maps in real-time. The paper describes the possibilities of the 3D visualization, volume calculation and section generation.

4. Theses

1. A real-time algorithmic image processor has been completed, a new raster format is connected with it. The image processor includes a new interpolation method, a new spreading model, and improved viewshed, hydrological and raster-to-vector algorithms.

2. The orientation of digital images and image block is discussed in a new approach. Considering the image processing new solutions have been established in the field of Ortophoto generation, spatial data acquisition and automatic surface model extraction.

3. A main memory based database manager has been elaborated, which applies object relational model. The database management includes a new spatial indexing method as well.

4. The paper describes a new real-time topological mapping tool. The Hungarian Digital forest maps are created with this tool.

5. In the field of surface modeling the advance is the coordination of the triangulation and the boundary conditions, moreover the recursive triangle decomposition algorithm, which provides real-time processing.

5. Practical results, Future Works

The scientific work has resulted in a large number of practical results. The practical aim of the development is the DigiTerra Map software, which is suitable for professional application. The author's future aim is a further development and publication of the procedures and technologies. There are numerous research challenges in the field of Raster Procedures, Digital Photogrammetry and Surface Modeling.

The development of database management systems and the computer networks, such as the Internet, determine the recent improvement of geoinformation systems. The next geoinformation system is about to be a client browser-analyzer program. The components, the data, likely the results are to be downloaded over the Internet. These trends should be taken into account by further research.

3.3. Database management, spatial indexing

The other general model of the geoinformation systems is the vector model. In this model the geographic objects are described by geometric figures and attached attributes. In case of the vector model the spatial relationship of the objects, the topology requires extra treatment.

The database design and management is a very complex task. This paper presents a visual data-modeling tool, which is suitable for application planning too. The author has elaborated a main-memory based database manager. The object relation model serves as a basis for data management. In the immediate future the main-memory based database management will play larger and larger role.

A geoinformation system must handle the spatial data too besides the descriptive data. The efficient processing of the spatial data is possible with the spatial indexing methods. This essay describes a new spatial indexing procedure. The index is usable in case of geometric objects with any kind of coordinate dimension and spatial extension. The further advantage of the procedure, that the implementation is database independent, because the indexes are stored within the records and not separated index files.

3.4. Topology, digital maps

In case of vector data the creation of topology is a primary importance task. Taking topology into consideration, the vector operations are simple and fast. The spatial relationship contributes to the creation of consistent and correct vector maps.

The author presents a mapping tool, that creates the topology in real-time. The node and editing errors come into light immediately. The correction, the area building, the maintenance speeds up. Real-time topology is useful for network analysis, map generalization, polygon overlay and buffer zone generation too.

The preparation of the Digital forest maps is based on real-time topology as well. The author worked out the first specification of Digital forest maps in 1996. In 1998 the Hungarian Forestry Service had started the standardization, in which the author joined as well. The Specification of Digital Forest Maps was completed in 1999. This paper outlines the construction of the Digital forest maps and the layer structure. The new projection system of the Digital forest maps is the Hungarian Unified Projection System. The DigiTerra Map program contributes to the projection conversion. The software is able to display and print the Digital forest maps, that satisfies every cartographic demand.

1. Antecedents, aims

Geoinformatics, the science of geographic information management, plays larger and larger role in the field of research and economy. Its importance is that 80 percent of the information has spatial relation. Geoinformation systems are an efficient tool in natural resource mapping, so are forest mapping and management. Geoinformatics makes connection between the various fields of science and profession, which unifies data handling. Geoinformatics is an integral part of the information sciences, present day it is a dynamically developing branch of industry.

The forestry application of Geoinformatics in Hungary started in the beginning of 1990s. The researches took place in the Hungarian Forestry Service and the University of West-Hungary. There were unresolved questions in both cases. Neither of the systems has achieved nationwide practical level of application. Forest mapping, forest stand database have increasingly required applied geoinformation solution.

This paper describes the development of a geoinformation system. Birth of this system is associated with the profession of Hungarian Forestry. The system preparation had both practical and scientific aim. During the eight years of development several algorithms and software technologies have been finished, which represent significant scientific results.

The research started form the author’s diploma work in 1994. This work won prize at the 3rd Symposium of Spatial Informatics in Higher Education. In 1996 several algorithms were completed and a Digital Photogrammetry, Digital Image Processing and Mapping software came into being. The author presented the programs and its applications on numerous national and international conferences. In 1997 forest maps digitizing started. The independent programs were connected in 1998, and several modules were added to it in the next years. The specification of the Digital Forest Maps was finished in 1999. The author also took part in this work.

2. Research methods

Determination of the research project meant the selection of a given field of Geoinformatics. Sometimes the practical demands directed the theme selection. The next step was the investigation of the printed and electronic technical literature. The thorough examination of the scientific literature was followed by the algorithm development, programming, test phase and repeated improvement. The author built modules from the algorithms, finally programs form the modules. The module testing took place in particular practical applications.

3. Scientific achievements

The most important result is the finish of DigiTerra Map geoinformation software from the point of view of both science and practice. This meant practically the born of a highly integrated, still easy-to-use Hungarian Geoinformation Software. Numerous forestry applications and 60% readiness of the Digital forest maps demonstrate the success of the software. The Hungarian Forest Service, geodesy and surveying firms, fifteen Forestry joint-stock companies, universities and research institutes use the software. This means about 300 installed programs.

From the viewpoint of science the program contains several new algorithms and technologies. The significant part of the eight years development was the algorithm design and development. The algorithms were born in the field of the newest international researches. The author has presented the results on national and international conferences.

3.1. Raster processing

In geoinformation systems the importance of Raster display and Processing has been growing. During the development of raster module of DigiTerra program several software technologies and new methods were accomplished.

The spine of the Raster Processing is a real-time algorithmic image processor. This is an efficient software technology, which provides real-time display and analysis. This technology is able to substitute a complex image processing software consisting of several menus.

The technology is in close contact with the development of a new raster format, which uses pyramid and block techniques. The author has elaborated the storage-saving pyramid technique and applied the Wavelet compression on the new format.

The essay presents a new pyramid interpolation method to interpolate large-size raster surface models. The author has modernized the visibility and hydrological procedures. The hydrological analyses are based on one algorithm. These analyses are suitable for creation of water flow and accumulation maps, delineation of watersheds, flood and dam modeling.

This paper outlines a spreading model, which has great importance in forestry and environmental protection. It is serviceable to model forest fires, water and air pollution. The part of the raster processing is a raster-to-vector procedure, which contains new conversion, generalization and post-processing functions.

3.2. Orientation and processing of central projected images

Remote sensing provides the considerable part of the raster data. These remotely sensed images are usually central projected. In this case the reconstruction of the taking position, the orientation is essential to process these images.

The essay discusses the orientation of digital images in a new approach. Several chapters deal with the automation of the orientation. The author uses the bundle block adjustment to orient the images. A new solution has been made. After the orientation three parts study the processing of the images.

The first part presents the new procedures of Digital Ortophoto generation. The Ortophoto generation creates perpendicularly projected images from the central projected ones using digital terrain models. The new methods are the joint transformation of the image block, leading in the block technique, working out the competence and color balance maps. The last two mosaic the images during the transformation.

The second processing method is the software version of spatial data acquisition. The author traces back the spatial data acquisition to two acquisitions in plane and automates the second one. This method doesn’t claim spatial visualization, therefore it can be implemented in any computer system, still provides sub-pixel accuracy. The acquisition may be carried out the overlapping parts of the images of the block.

The third process is the automatic surface model generation. The author has elaborated the less researched method the area-based matching in the Ortophoto space. The method provides very dense surface model, global Ortophoto and correlation map of the area of the image block. In this method the block technique, height correction of the entire block, acceleration of the Ortophoto generation and correlation calculation, exclusion of weakly correlated areas, utilization of exist data and the pyramid interpolation are the new solutions.