.advanced information technologies in precision farming

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Abstract: Presented in this paper is the authors’ research of the different applications of the newest information technologies in agriculture. Provided in this article is information concerning the use and application of GPS receivers and GIS software, which are valuable for the up-to-date agriculture. These technologies and their applications provide numerous possibilities, as for example mapping of the nature’s resources, evaluation of the environmental impact, mapping of different soil types, etc. The different applications of the available hardware and software, which affects the efficacy and productivity of the agricultural activities, were analysed. Low-cost RTK-GPS receiver is represented. A technology for the data processing of the digital mapping information is provided as well.

KEYWORDS: PRECISION FARMING, GIS, DATA PROCESSING

1. Introduction

Implementation of new information and communication technologies in agriculture is relatively slow compared to the use of digital technologies in other industrial sectors. Key to improving the competitiveness of agricultural production is the spread of information technology in this area.

Geographic information systems (GIS) are advanced information technologies for mapping and analysis of real-world objects [8, 9]. Geo-information systems are a natural and necessary component of information systems which stored spatial data. Such a structure have information systems in agricultural field [1,2,6]. The main areas of application of GIS in agriculture are increasing of agricultural production, optimization of transport and distribution.

One of the most promising directions in agriculture is a precision farming. It uses different types of data:

- Results of soil samples and their geographical location;
- Processing of remote sensing data;
- Digital thematic maps.

Development and application of precision farming methods open up new possibilities for the management of processes in plant and animal production through the use of modern information technologies [5].

Some of the advanced technologies have been developed as standard applications such as the Global Positioning System GPS used for mapping and processing of agricultural lands and the management of agricultural machinery.

Particularly important is the information of digital maps for factors such as:

- Yield and type of crops;
- The type of mechanical and chemical treatment of the soil;
- Spatial distribution of the diseases of the crop;
- The dynamics of the spread of harmful insects.

With this information there are real opportunities for in-depth analysis, forecasting and optimization of the agricultural farms. Especially important is the application of geo-information technologies to remote sensing by aerial photographs, satellite photos for complex thematic deciphering of the area.

Complex GIS incorporate these digital maps for mineral content in the soil types and their characteristics, a map of the slopes with a digital model of the terrain and exposed slopes, temperature, climatic and hydrological conditions [3].

Particularly very important is the information of the digital map to the sequence of factors such as type and yield of crops such as the chemical and the chemical treatment of the soil, the spatial distribution of the diseases of crops, and the dynamics of the distribution of the harmful insect. With this information, there are real opportunities for in-depth analysis, forecasting and optimization of the agricultural farms.

2. GIS software

ArcGIS is a family of software products of new generation. They were developed by company ESRI [12] that is recognized as a leader in the creation and distribution of leading GIS, taking into account the latest developments in IT and the growing demands of multiple users. The platform is the optimal solution for the creation of a corporate GIS, which can be a foundation for managing large-scale organizations.

ArcGIS is built on the basis of standards in software, namely Object Architectures COM, NET, Java, XML and SOAP. It provides extensive support for common standards, flexibility of the proposed solutions and opportunities for interaction. ArcGIS 9 can be used on personal computers, servers, over the Web or in the "field."

There are many software products that are compatible with ArcGIS through which experts solve problems of different nature. Leica Photogrammetry Suite (LPS) works with images of various formats derived from a wide range of sensing devices, including black and white, color, high resolution multi-spectral capacity. This process serves a wide range of formats, ground control data from the GPS systems and orientations, vector data and processed images.

Figure 1. Structure of GIS

Current developments in the field of precision agriculture has focused on building sensors by producing information about the condition of the soil and plants grown from a distance in real time including image processing and remote sensing [7].

Another direction of this technology is the use of digital mapgraphic information allowing operationally drawing maps for the state of the crop at current time which are the basis for further decision making. So we can define the areas of the field where you need to be further imported fertilizers.
Definiens [11] specializes in the development of algorithms for image analysis based on its patented Definiens Cognition Network Technology®. It implements object-oriented methodology for image recognition imitating human perception. This technology is the leading technology in the world in today's stage according to the degree of automation and applied finish of the result. This technology is effective in the analysis of all types of images: black and white, color, quality or ambiguous, simple and complex space pictures.

Definiens technology works as a link between data processing for remote sensing and geo-information systems. Information systems applied Knowledge base Definiens Cognition Network which is a set of rules for the analysis of images formed by experts in deciphering the objects. The difference between this Knowledge base and others in this area is that the rules do not apply to individual pixels but to a segment which allows to take into account not only their own signs of these segments but the signs of surrounding objects, i.e. spatial context. Because of this Knowledge base is adaptive and an appreciation of the places the appearance of identical objects in different environments. In Definiens Cognition Network Technology is carried multilevel interactive process of identification, analysis and classification of objects according to rules that are set by the user in the Knowledge base. The resulting objects that can be exported in vector format or transmitted in GIS, accompanied by their attributes describing their properties, which can later be used for spatial analysis in GIS already.

Land Desktop, Autodesk Civil Design and Autodesk Survey [10] are a family of systems for experts in designing and maintaining infrastructure, planning and management areas, surveyors and others. Autodesk Land Desktop that is created on the AutoCAD 2004 and Autodesk Map provides specialized resources for infrastructure design as COGO and mapping, terrain modeling, trails, and lots more. It is characterized by flexible interface and tools for organization and centralized data management in a project.

It extends the capabilities of Autodesk Map with specific functionality for activities related to land. It includes powerful and intuitive tools to create and mark points of geodetic measurements to define and edit parcels and locations of roads, to automate the procedure for plotting to create terrain models and to calculate volumes and surfaces.

3. Applications of GPS units

GPS systems are used to track in real time workflow machinery, tractors and combine harvesters. Besides monitoring the positioning system is also used for:

- Control of tanks and bunkers;
- Control level and fuel consumption;
- Ability to send SMS set configured with different criteria: minimum level of reservoir, maximum level of bunker, hour meter, and others;
- To perform remote diagnostics of the machine (for machines with on-board computer and CAN);
- Ability to connect additional equipment: mini video cameras to capture certain moments at the machine and sending it to the PC.

Field testing of the system for mapping is carried out according to the requirements of hardware and software. They are listed in Table 1 [4].

Measurements were made of arable land in the village Boyanovo, Region of Yambol. Observed agricultural areas are characterized by heterogeneity in their application: pastures, uncultivated arable land which in turn offers different soil conditions, different vegetation and inconsistent relief. This area offers a variety of appropriate banking conditions to test the functionality of the hardware and software of the GPS.

Mobility: Unlike the widespread PDA, tablets and mobile phones devices for field measurements with GPS functionality requires protection by the hull and have to be comfortable to bring in the field and with good design that allows operation by one hand.

Reliability in operation: Field measurement devices can be built based on PC architecture or to be of type PDA. The advantage of the PC based GPS devices consists in fact they can store larger files and well visualize satellite images and bitmap maps. Unlike PC-based GPS systems the others + based on a PDA have some drawbacks - their processors are less scrolling and opening the images takes a few minutes, the little screen monitor allows only certain parts of the image.

Operating System: The software used Arc Pad works well on Windows XP and Pocket PC / Windows CE platform, which is the advantage of this software.

Functionality: Arc Pad software is a basic mapping and requires some settings before starting work. For full preparation and processing project created with this software are necessary additional resources included in the package ArcGIS Desktop. From this perspective Arc Pad is software application directly. For advanced users and Arc GIS Arc Pad allows high settings. Arc Pad provides creating points, polylines and polygons using drafting tools or software with GPS.

The tops of the lines and polygons can be set one by one or continuously using the GPS features of the device. Software to create maps allows editing cards directly in the field. Project settings: This is an important element of fieldwork mapping. Arc Pad requires the prior establishment of the main elements of the project in ArcGIS. All necessary files for the project are transferred to the GPS device. After completion of field measurements data have to be sent back into Arc GIS for processing and analysis. This method has some drawbacks such as overwriting the old files on the new ones.
File format compatibility: ESRI Shape files are the only vector format that is supported by ArcPad. These file formats that are not supported should be converted to the specified format. There are supported formats JPG, Mr SID, BMP, and CADRG as a part of raster formats. ArcGIS supports functions of converting the files before the files will be transferred to the GPS device.

Reliable performance: During the field test ArcPad works well but in some cases there are tendency to “crash.” This problem occurs due to the limited memory of a PDA-based GPS mechanism. It is necessary to reset the device and therefore the data should be saved more frequently in such situation.

### Table 1: Criteria for selection of GPS system for field measurements

<table>
<thead>
<tr>
<th>GPS system for field measurements</th>
<th>Hardware</th>
<th>Software</th>
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<tbody>
<tr>
<td><strong>Mobility</strong></td>
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<td></td>
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<tr>
<td>Screen size</td>
<td>Functionality</td>
<td>Main functions for mapping</td>
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<tr>
<td>Storage</td>
<td>Off-line &amp; on-line functions for mapping</td>
<td></td>
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<tr>
<td>Processor and RAM</td>
<td>Usability</td>
<td>Fault tolerance and easy to learn</td>
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<tr>
<td>Ergonomics</td>
<td>Project setup</td>
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<tr>
<td><strong>Technical parameters</strong></td>
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<tr>
<td>Processor and RAM</td>
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<td>Fault tolerance and easy to learn</td>
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<td><strong>Reliability</strong></td>
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<tr>
<td>Ruggedness</td>
<td>Compatibility</td>
<td>Fail formats</td>
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<tr>
<td>Average time to failure</td>
<td>Reliability</td>
<td>File transfer</td>
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<tr>
<td>Stability</td>
<td>Stability</td>
<td>Backward compatibility</td>
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<td>Maintenance</td>
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Another approach is to use low cost RTK-GPS receivers (e.g., u-blox NEO-6P) for precise dot placement with the help of Internet RTKLIB corrections.

Characteristics of the RTK-GPS (GSP with kinematics in real time):

- High-precision positioning technology with centimeter precision (100-fold more accurate in comparison with conventional GPS positioning);
- Use the measurement of the phase of the carrier wave signal instead of the information content of the signal, relying on only one reference station in making adjustments in real time, which achieves very high accuracy;
- Need wireless communication link between the antenna and the base station.

Characteristics of RTKLIB:

- RTKLIB programming package open source RTK-GPS. It contains portable application library and several application programs using the library;
- Distributed under license GPLv3;
- Portable C library + some applications positioning: consumer graphical interface and Windows console application under Linux.

Features of the module u-blox NEO-6P GPS:

- Low cost (approx. 140 euros);
- Receiver 50 channels, L1 frequency, C/A code;
- SBAS: WAAS, EGNOS, MSAS;
- Precise point positioning algorithm for static and slow-moving objects (reaches full accuracy in just a few minutes work, unconstrained communication).
Thanks to digital imaging analysis of weeds in arable land can be done several times before and after harvest. Photos do not permit precise identification of individual plants, but clearly present weeded large areas.

5. Conclusion
Based on the study of the application of the most advanced information technologies in agriculture is considered the use and application of GPS and GIS technologies that are valuable in modern agriculture. These technologies and their application reveal many possibilities for use as a mapping of natural resources; evaluate the impact of environment mapping soil types and more. GIS can be considered as a concept for reducing errors in decision-making due to seasonal changes in the characteristics of soils. Technology development in agriculture is mainly due to technical innovation and profits obtained in their application.

6. Литература