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NAVIGATION SYSTEMS IN TECHNOLOGICAL PROCESSES OF AGROENGINEERING OF PLANT GROWING

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Abstract
The application of high technologies, and especially navigation technologies, gives a particularly impressive result in those branches of the national economy, which are considered the most backward and depressed. Regarding this, the agriculture of our country is out of competition, but, despite this, the national business is starting a wide implementation of information technologies in agriculture. Complex technologies for the production of agricultural products are a tool that provides solutions to three main problems that determine success in the conditions of the modern market – the availability of timely objective information, the ability to make correct management decisions and the ability to implement these decisions in practice. The solution of these three interdependent problems is possible due to the use of specialized technical means, navigation technologies and software. The user is provided with a wide range of powerful spatial modeling and analysis functions. The analysis is based on the functions of building and transforming vector data into matrix (raster) data and vice versa. Spatial analysis includes: transformation of vector data into matrix data; creation of buffer zones in terms of distance and proximity of objects; creation of object density maps; creation of continuous surfaces by points; construction of isolines (interpolation), calculation of slope angles, exposure of slopes, relief washing; analysis of the matrix map; execution of algebraic operations and logical queries to a series of maps and matrices; execution of overlay operations of entry, intersection, proximity.

Key words:
analyze, effectiveness, process, crop production, agricultural engineering.

Introduction

The application of high technologies, and especially navigation technologies, gives a particularly impressive result in those branches of the national economy (Galland & Pazur, 2015), which are considered the most backward and depressed (Tryhuba *et al.* 2019). Regarding this, the agriculture of our country is out of competition (Cheng-Leong *et al.* 2019), but, despite this, the national business is starting a wide implementation of information technologies in agriculture (Romaniuk *et al.* 2019). Attempts to establish effective and meaningful management in agriculture encounter a lot of obstacles (Nazarenko *et al.* 2021). First of all, this is the lack of reliable information (Zagurskiy *et al.* 2018), both about the area and about the nature of land use and its regime (Pisarenko *et al.* 2019).

Formulation of problem

Managers of large farms often do not even know the exact size of their own cultivated areas (Kuzmich *et al.* 2021), which is due to their constant change due to various natural and administrative processes (Radhakrishnan *et al.* 2012). The restoration of cartographic material (Esitken & Turan, 2020), which was previously carried out at the expense of the state (Ratushny *et al.* 2019), has practically stopped. The work is carried out on the basis of maps from 10-15 years ago (Ang *et al.* 2014), which does not reflect the reality of today (Palamarchuk *et al.* 2021). In addition, the characteristics of soils and vegetation change in different areas of the fields (Kalinichenko & Rogovskii, 2017), as well as from area to area. These data, firstly, should be at the disposal of specialists for forecasting and analysis of yield (Rogovskii *et al.* 2019), and, secondly, they should be the basis of agrotechnical plans for each specific field or plot (Rogovskii, 2020b), otherwise losses and inefficient costs cannot be avoided (Pisarenko *et al.* 2019).

Another source of significant "extra" costs is the inefficient use of agricultural machinery (Rogovskii & Titova, 2021). Reduction of these costs is possible in the following directions:

• automated accounting of all movements of equipment, calculation of mileage and treated areas;

• exclusion of embezzlement of fuel and lubricant materials (PMM) (introduction of a monitoring system for PMM expenses);

• determination of optimal routes for transporting equipment from the base to the cultivated fields;

• determination of optimal crop delivery routes to receiving points;

• control over the speed of movement of equipment during field work.

Complex technologies for the production of agricultural products, which received the name "Precision Farming", began to actively develop abroad in the late 90s, and are recognized by the world agricultural science as quite effective advanced technologies that bring agrarian business to a higher quality level (Rogovskii, 2020a).

Purpose of research

Complex technologies for the production of agricultural products are a tool that provides solutions to three main problems that determine success in the conditions of the modern market – the availability of timely objective information, the ability to make correct management decisions and the ability to implement these decisions in practice. The solution of these three interdependent problems is possible due to the use of specialized technical means, navigation technologies and software.

Research results and discussion

The maximum efficiency is achieved as a result of the construction of a complex of software and technical tools (CPTS), which includes the following subsystems:

Hardware for precision farming:

- parallel driving systems based on GPS navigation;
- samplers and soil analysis;
- systems of differentiated application;
- crop sensors.

Monitoring of agricultural land:

- monitoring of the borders of the working areas of the fields;
- agrochemical field monitoring;
- compilation of yield maps;
- analysis of local conditions.

Equipment monitoring:

- automated data collection based on GPS navigation;
- visualization of equipment movements;
- operational accounting of agricultural works.

Technological planning and management:

- technical and economic planning;
- operational planning;
- operational accounting of agricultural products.

Budgeting and financial accounting:

- budgeting and financial accounting;
- financial analysis;
- provision of financial reports and data consolidation.

Publication and access to data via the Internet.

So, we are talking about creating a complex of hardware and software tools that allow you to accumulate objective information, analyze it and make quick and effective decisions.

According to forecasts, the global precision agriculture market will reach $10.23 billion by 2025 and will grow by 16% every year. Ukraine is no exception.

Precise technologies cover no more than 15% of Ukrainian agricultural land, taking into account the equipment that comes with the equipment, additional equipment, various canopies for aggregates and equipment, services, software products, drones, the volume of the precision agriculture market in Ukraine is approximately $ 60-70 million Today, Ukrainian farmers are not far behind the rest of the world in terms of technology. In Ukraine, what has been tested in other countries is being implemented. It is no longer necessary to create, test, measure the effectiveness of new technologies, Ukrainian farmers adopt and use the best foreign practices. Therefore, the technological gap in precision agriculture is small and does not prevent it from showing high results.

TOP-10 technologies of precision agriculture in the world, which have already arrived in Ukraine.

GPS systems and GNSS navigation.

Almost every household already has GPS-based tools. Ever since agriculture gained access to positioning satellites in the 1990s, operators and growers have found various ways to link these tools to make field work much easier and more accurate. Today, almost all equipment is equipped with navigation sensors - from tractors and combine harvesters to drones.

Today, the world is increasingly using the larger technology of GNSS navigation satellite systems. It covers various systems including GPS, GLONASS and Galileo.

Mobile accessories for crop monitoring.

The development of precision agriculture today is practically impossible without gadgets. With the help of a smartphone, tablet or even a smart watch, you can monitor the condition of crops, carry out field diagnostics, receive GPS data, literally sitting on the couch.

For this, there are many mobile applications, special programs that allow farmers to save time and money.

Drones, robots and controlled equipment.

Robots have already partially displaced human labor from the fields. They know how to sow, harvest, prune vineyards, water, till the soil, apply fertilizers.

But the greatest progress was achieved in remote control of agricultural machinery. The operator can operate while sitting in the office. There are also so-called smart machines that can follow the tractor. For example, Kinze engineers have created an autonomous grain basket system designed to be connected to any tractor.

Irrigation systems (watering systems).

Innovations in precision irrigation technologies are becoming even more urgent as growers face water shortages due to drought and aquifer depletion. One of the latest achievements in this area is telemetry, thanks to which farmers can remotely control almost the entire irrigation process simply by holding a tablet or smartphone with special software in front of them. The systems save water, time, fuel and spare parts for vehicles.

In the future, growers will be able to integrate soil moisture monitoring, weather and irrigation data into their systems.

Here's one of the latest irrigation developments: a drip line is drawn across the field with a center or line irrigation system, and integrated sprinklers provide a uniform pattern across the length of the irrigated area. Water is delivered immediately (Fig. 1).

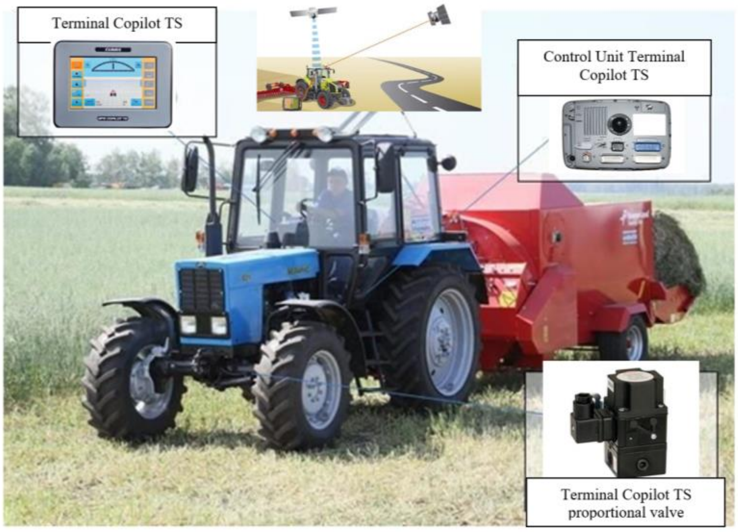

Figure 1. Application of geoinformation systems and computer tools of satellite monitoring in the technology of precision agriculture.

VRA Seeding (special seed sowing technology with variable speed).

Variable rate seeding technology allows growers to take advantage of all the opportunities to increase yield, paying special attention to the factors that affect seed growth. A similar technology is used to apply fertilizers, setting the required intensity of movement for each culture.

Weather forecaster.

Over the past 25 years, many important technologies in meteorological modeling have appeared. There is a special ClearAg platform that can analyze weather conditions, soil condition and temperature, and simulate the option of growing the most suitable crop for the region.

Modeling of nitrogen.

Fertilizer application with a variable rate has been used for a long time. However, in the situation with the application of nitrogen fertilizers, this system is not always suitable. Therefore, the developers of SST Software, in cooperation with Agronomic Technology Corp, have created a special tool for managing the use of nitrogen, so that the impact on the environment is minimal.

Compatibility of precision farming technologies.

Farmers who deal with the use of various equipment in the fields advocate that the choice of equipment be treated more responsibly and comprehensively. Most often, different technical units are purchased from different manufacturers, and then it turns out that they are incompatible. Farmers are interested in an online system for monitoring the effectiveness of the use of various equipment in the fields. The availability of electronic field maps makes it possible to keep strict records, plan and control all agricultural operations, which are based on accurate information about the size of fields, the length of roads, information about the terrain, etc. On the basis of electronic maps of the fields, a complete analysis of the conditions affecting the growth of plants on a given specific field (or even on plots of 100x100 m or 10x10 m) is carried out. Field maps form the basis for obtaining the structure of crop rotation and optimizing production in order to obtain maximum profit, as well as rational use of all resources involved in production.

The following methods of drawing the borders of the working areas of the fields are used:

- vectorization of field boundaries based on a high spatial resolution image;
- bypassing field boundaries using GPS equipment and special software;
- a combined method, i.e. a weighted combination of

the first two.

As part of the complex management system of an agricultural enterprise, electronic maps of fields are used for accounting for crop rotation, monitoring of moving objects, organization of transportation, compilation of yield maps, for soil research, for statistical and thematic analysis of data, for production process planning, etc. (Fig. 2).

Satellite monitoring of fields

The survey of agricultural areas is carried out using the Global Positioning System (GPS). According to the data of the GPS receiver, the actual boundaries of the fields are determined. The accuracy of measurements is determined by the type of GPS receiver used and additional equipment. Field measurements can be performed by mobile systems – a laptop with a connected GPS receiver and special software or remotely. For remote measurements, it is possible to use a deployed equipment monitoring system with centralized data collection. The choice of the option is determined by the requirements for the accuracy of the measurements and the efficiency of their execution (Fig. 3).

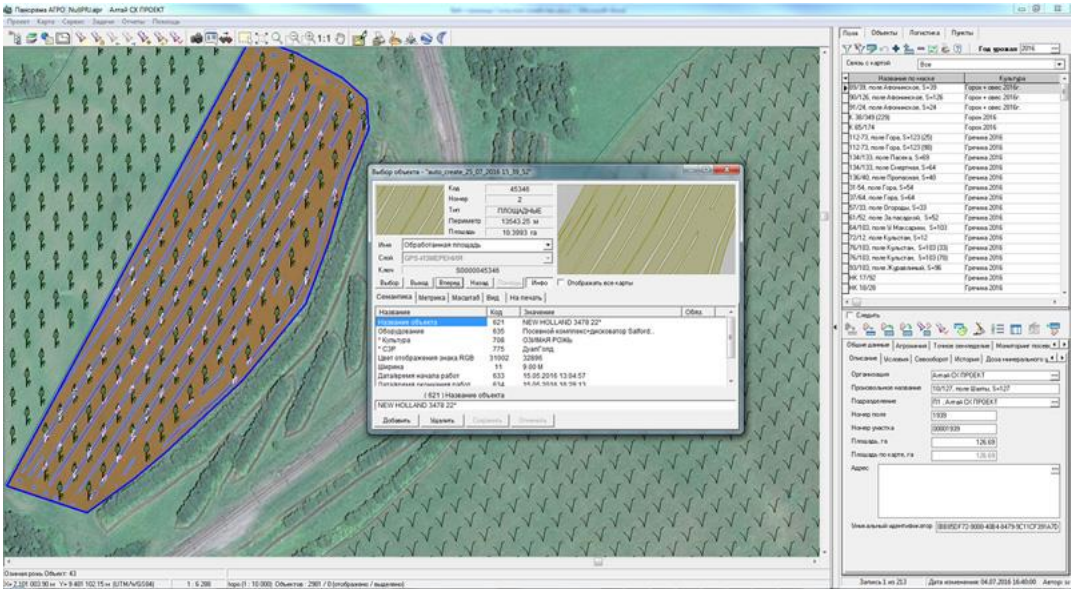

Figure 2. Creation of field passport using Panorama AGRO GIS.

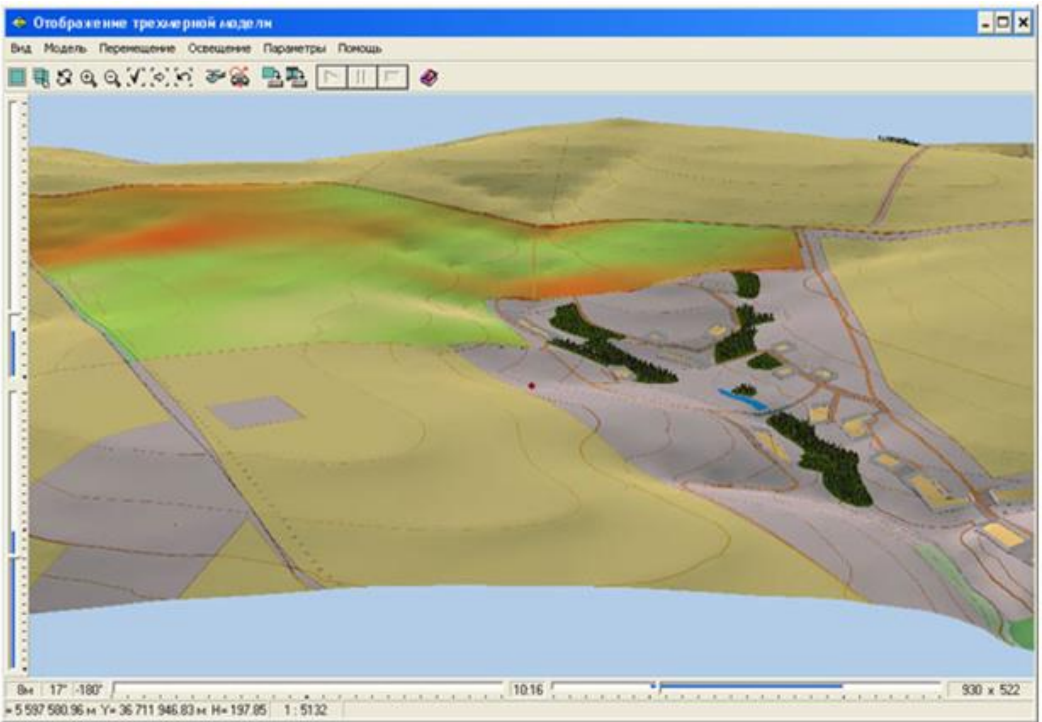

Figure 3. Reproduction of a three-dimensional model of creating a field passport using GIS "Panorama AGRO"

Functional capabilities of the field monitoring subsystem:

• creation of custom field maps in vector format;

• correction of current maps of fields with clarification of their boundaries, breakdown or unification;

• input of GPS data with quality control based on the number of satellites used in work and the geometry of their position, which affects the accuracy of determining the location;

• display on the map in real time the data received from GPS;

• measurement on the map of distances and areas; determination of the part of the field processed by agricultural machinery using a simplified technology;

• correction of accompanying information from each field.

Agrochemical monitoring of fields. The data of agrochemical soil analysis for each working area of the field can be obtained in two ways:

- as a result of agrochemical examinations performed by a specialized organization;

- as a result of own research using samplers and sample analysis laboratories.

In the first case, the data is already distributed by section and must be entered in the appropriate positions. The restoration of information on the agrochemical state of soils should be carried out at least once every 5 years.

In the second case, point measurement.

Conclusions

The user is provided with a wide range of powerful spatial modeling and analysis functions. The analysis is based on the functions of building and transforming vector data into matrix (raster) data and vice versa.

Spatial analysis includes:

- conversion of vector data into matrix data;
- creation of buffer zones in terms of distance and proximity of objects;
- creation of object density maps;
- creation of continuous surfaces by points;
- construction of isolines (interpolation), calculation of slope angles, exposure of slopes, relief washing;
- analysis of the matrix map;
- execution of algebraic operations and logical queries to a series of maps and matrices;
- execution of overlay operations (entry, intersection, proximity).

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