Umanskiy M.O.
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail:
umanskiy@nubip.edu.ua

FEATURES OF USE OF AGRICULTURAL DRONES IN CROP PRODUCTION TECHNOLOGIES

https://doi. **10.5281/zenodo.15427773**

УДК 631.4.001

Umanskiy M.O. ***Features of use of agricultural drones in crop production technologies.***

Abstract. *The article presents a generalization of the production cycle regarding the features of the machine use of agricultural drones in crop production technologies. Applied methods and initial data of agricultural drone technologies in agriculture have been developed taking into account the diversity of technological operations. In the course of the research, fourteen tasks are presented that modern agricultural drone technologies solve. The author outlines a six-level full cycle of agricultural drone monitoring of crops. At the same time, accounting for the initial data allows for the process of forming a visualization of field surveys from agricultural drones. The author recreates the features of video and photography from a height, the functionality of thermal imaging cameras of agricultural drones for agriculture, which allows monitoring to be brought as close as possible to the real cycle of crop production.*

Key words: *agricultural drone, technology, machine use, method.*

Уманський М.О. ***Особливості машиновикористання агродронів у технологіях виробництва сільськогосподарських культур.***

Анотація. *У статті представлено узазагльнення виробничого циклу щодо особливостей машиновикористання агродронів в технологіях виробництва сільськогосподарських культур. Розроблено прикладні методи та вихідні дані агродронових технологій в сільському господарстві з огляду на різноманітність технологічних операцій. У ході досліджень представлені чотирнадцять завдань, які вирішують сучасні агродронові технології. Автором окреслено шестирівневий повний цикл агродронового моніторингу посівів. При цьому облік вихідних даних дозволяє провести процес формування візуалізації обстеження полів з агродронів. Автором відтворено особливості відео та фотозйомка з висоти, функціонал тепловізійних камер агродронів для сільського господарства, що дозволяє моніторинг максимально наблизити до реального циклу виробництва сільськогосподарських культур.*

Ключові слова: *агродрон, технологія, машиновикорстання, метод.*

Introduction

While precision farming technologies have revolutionized agriculture in recent years, the use of drones has made it possible to further increase efficiency. They take aerial photos, monitor fields, create 3D maps, sow seeds, apply fertilizers and chemicals, monitor crops, assist with irrigation, and help control animals in agriculture.

Analysis of recent researches

Unmanned technologies in agriculture can perform a variety of operations:

- aerial photography – to detect bald spots, crop losses after exposure to natural factors, and other defects that require timely elimination. Aerial photography from a drone is much better than satellite photography in terms of detail, due to the low flight altitude;
- video filming – the performance of the aircraft during video filming reaches 30 km per hour, which significantly reduces time and financial costs compared to using ground equipment;
- 3D modeling – allows you to identify overmoistened or arid areas, soil excavation, and expertly create plans and maps for soil moistening or draining, site reclamation, or land reclamation;
- thermal imaging – is carried out using the entire spectrum of infrared radiation: near, medium and far range. The study makes it possible to determine the timing of differentiation of growth points, which directly affects the yield and preservation of productive properties of plants while preserving the hereditary capabilities of the variety;
- laser scanning – used for terrain analysis in hard-to-reach or inaccessible areas. This method provides an accurate high-density model with detailed relief even when working in conditions of high density of plantings;
- Spraying – thanks to the possibility of retrofitting, drones are used for spot spraying of plants and fruit trees. This approach allowed farmers to treat only diseased plants, eliminating the possibility of chemicals getting on the rest of the crop;
- Seed planting – is a relatively recent practice and has not yet become widespread, but some companies are experimenting with planting seeds using drones. In essence, manufacturers are experimenting with specific systems that are programmed to scatter seeds into prepared soil;
- This technology helps minimize the need for personal presence to plant plants in a selected area, which can sometimes be a costly and energy-consuming task. The same drone technology can be adapted and applied to many types of farms, reducing planting time and labor costs.

Modern unmanned systems solve the following tasks [1]:

1. Assessing crop quality and identifying damage or death of crops.
2. Determining the exact area of lost crops.
3. Land audit and inventory.
4. Identification of sowing defects and problem areas.
5. Analysis of the effectiveness of measures aimed at plant protection.
6. Monitoring compliance with crop rotation structure and plans.
7. Identification of deviations and violations made during agricultural work.
8. Relief analysis and creation of a map of vegetation indices PVI, NDVI.
9. Gathering information for the security service, including identifying the fact of illegal grazing of livestock in the fields.
10. Support for the construction of land reclamation systems.
11. Monitoring the storage of root crops in cagatas.
12. Introducing Trichogramma.
13. Creating maps for differentiated fertilizer and field spraying.
14. Calculation of seedlings and biological yield.

The aim and objectives of research

The aim is to generalize the production cycle regarding the features of the machine use of agricultural drones in crop production technologies.

Research results

Let's considerabout the possibilities and advantages of drones for agriculture.

Obtaining an orthophoto plan, which allows you to accurately measure the geometric dimensions of the field and determine its geometric area in projection (Fig. 1). This will be the area for which the farmer pays land tax and rent. In addition, the orthophoto plan obtained with the help of a drone will provide a lot of additional information for an experienced agronomist: you can see areas of sifting, reseeding, where plants died, traces of trampling the field by people and machinery.

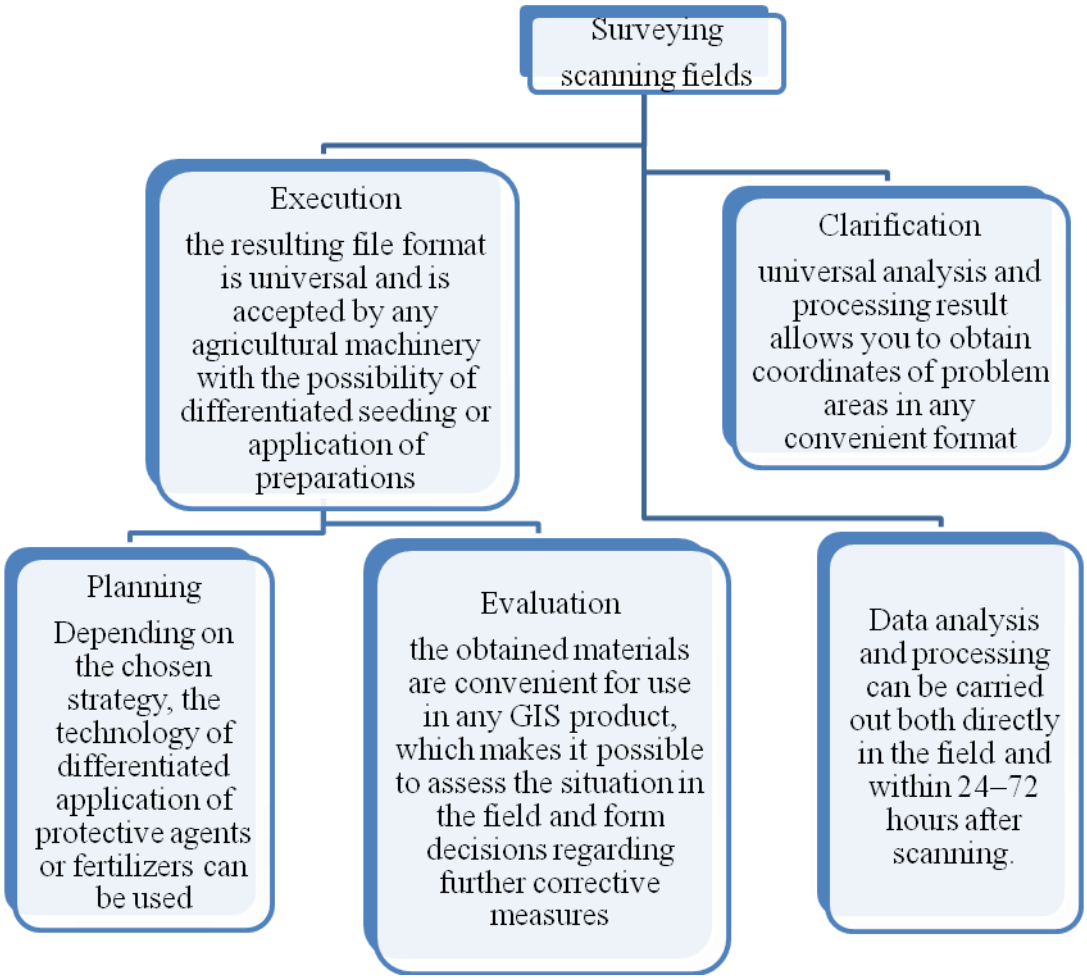

Fig. 1. Full cycle of unmanned crop monitoring.

Moreover, on the orthophoto map, they can be counted, the area measured, and vector contours of interesting and problematic areas can be obtained for further work with them. For example, for compiling tasks for ground-based unmanned aerial vehicles, which also work using vector contours and GPS coordinates (Fig. 2).

Obtaining a height map – a flat map that shows the relief of the field.

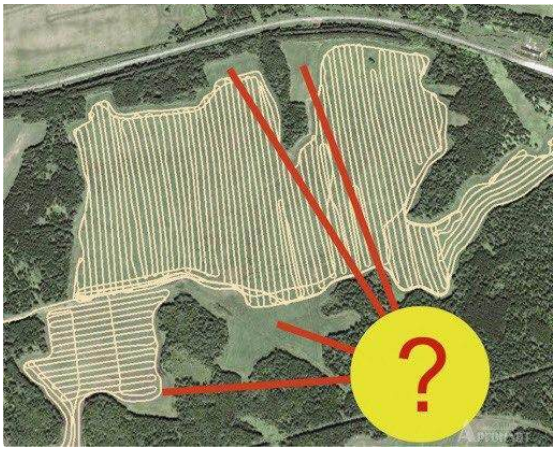

Fig. 2. Vector contour and GPS coordinates.

On this map, the surface level differences are color-coded as on a familiar geophysical school map, where mountains are brown and lowlands are green. In addition to color coding, contour lines are drawn on the relief map connecting points that lie on the same level. For working with relief, it is convenient when heights in meters are plotted together with contour lines. Such marking helps to identify problem areas in the fields.

Multispectral survey (Fig. 3). Fields are different and heterogeneous. Even within one field, there are areas where the yield always differs from the average. In some areas, it is noticeably higher, in others, lower. Moreover, for different crops, these differences can be diametrically opposed. This depends on many factors:

- the relief of the field (some slopes of the hill face the sun more, others are shaded);
- mineral composition;
- different soil moisture;
- various levels of weed contamination;
- susceptibility to pests, etc.

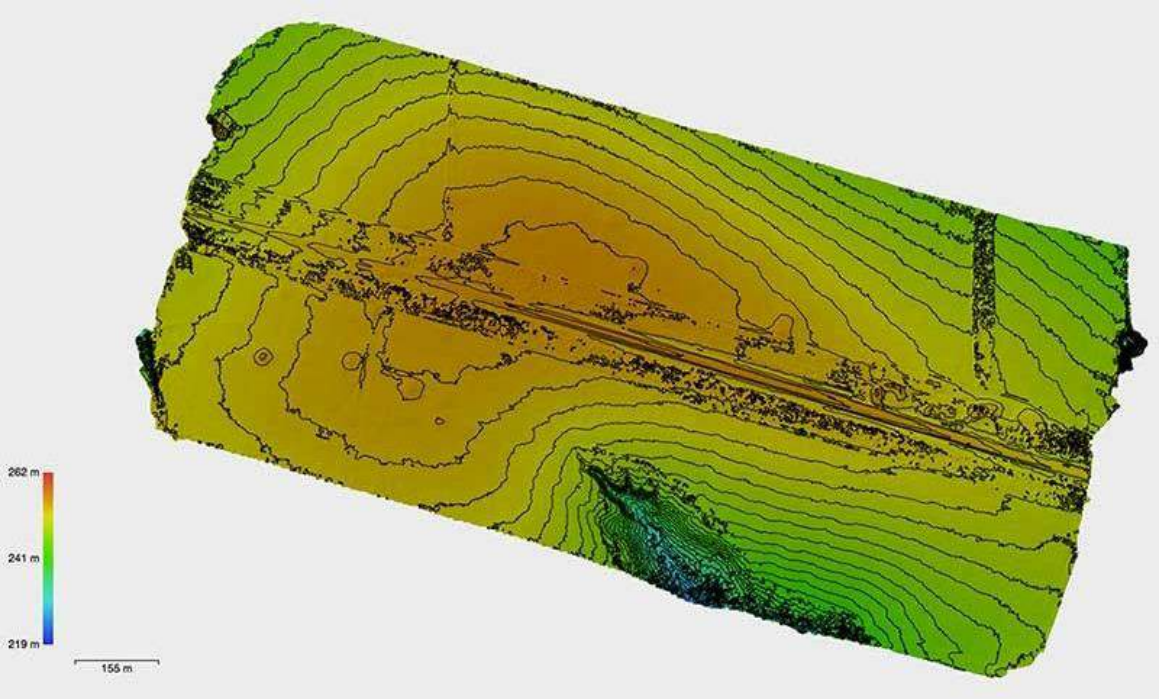

Fig. 3. Multispectral imaging.

There are so many factors that even an experienced agronomist cannot always predict their impact on a specific crop at a certain stage of vegetation, and even take into account the influence of weather.

Even knowing about such mosaicism, the agronomist still has questions about field management. There are also different approaches here. For example, you can ignore mosaicism, hoping for an average harvest. You can additionally feed the plants in weak areas to a greater extent.

You can, on the contrary, spend less expensive fertilizers and seeds on potentially weak and unpromising areas and, at the same time, increase their dosage on potentially strong areas to reduce the total financial costs of the field and increase the overall yield (Fig. 4). And, finally, you can simply re-disc the field in whole or in part if the prospects for the future harvest do not cover the expected investments.

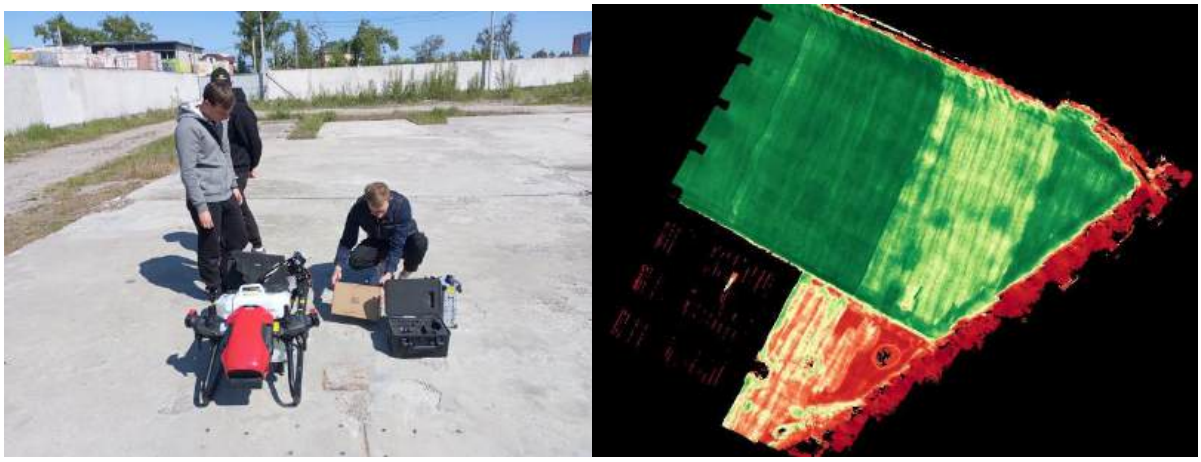

Fig. 4. Field and increase the overall yield.

Decisions are ambiguous, difficult, and responsible. In these conditions, an objective decision support system will be very useful for the agronomist and farmer. Such a system will provide quantitative indicators on the basis of which it is possible to make a conscious and least risky decision for a given situation.

The input data for the system can be information obtained as a result of processing multispectral drone imagery.

Creating tasks for parallel driving systems. By obtaining information about the zoning of a field based on various indicators – the level of stress in plants, vegetative mass, distribution of specific chlorophyll content in the field, the level of weed infestation and their localization, a farmer or agronomist will be able to develop the right driving strategies as a result of multispectral field surveying.

As a result, using the materials obtained from the drone, the agronomist makes a decision on treating the field with herbicides (Fig. 5). It is possible to apply it to the field evenly with a wheeled sprayer, which is expensive in terms of the cost of the drug and the costs of application. Or you can use a more expensive but "smart" wheeled sprayer to apply the herbicide differentially, which is cheaper in terms of the drug consumption, but more expensive in terms of the cost of application. Or you can use an unmanned agricultural drone, which was not only originally designed for differential application of liquids, but also does not trample the field, does not add stress to the plants from mechanical contact with parts of the sprayer and the heat from its engine.

Drone application of substances. Liquids, granules, trichogramma, fumigation. In the case of tall crops such as sunflower and corn, it is not always possible to send a sprayer to the field. Unlike wheeled sprayers, a sprayer on an agricultural drone can apply substances to the

leaf with great precision, and even with a consumption of only a few liters per hectare. Given the fact that the drone literally blows agrochemicals into the ground with its propellers, applying liquids with drones is becoming perhaps the most effective today.

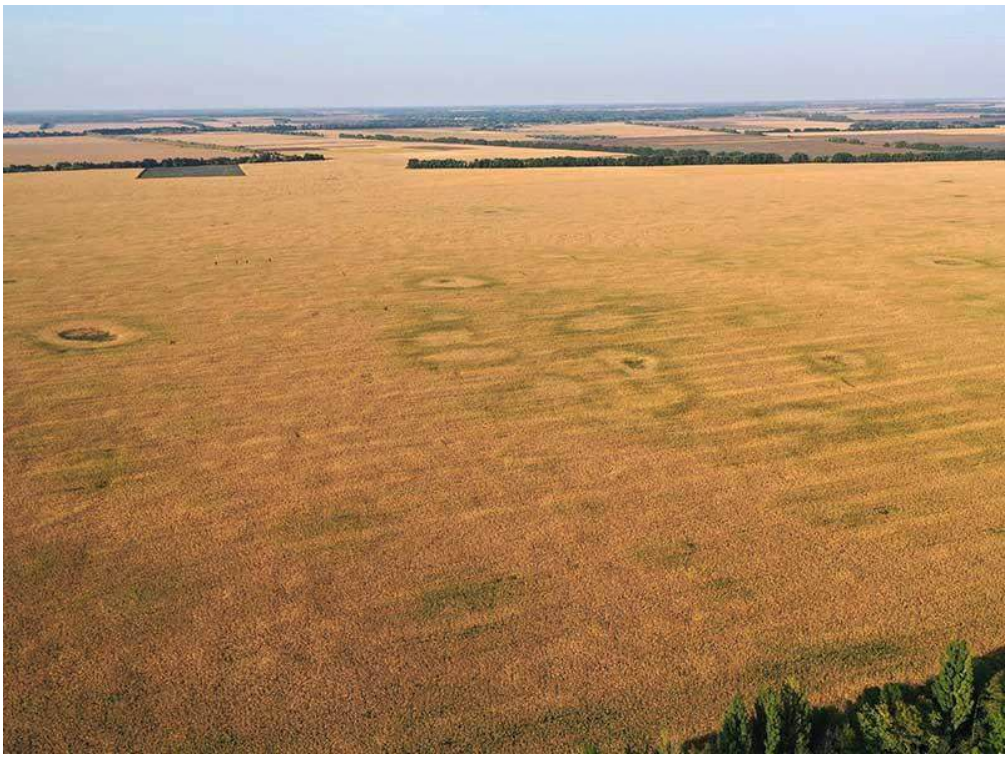

Fig. 5. Visual inspection of fields from drones.

In addition to liquids, the drone is able to disperse granular preparations on the field (Fig. 6). And, of course, a drone can also apply trichogramma as a means of safe biological plant protection.

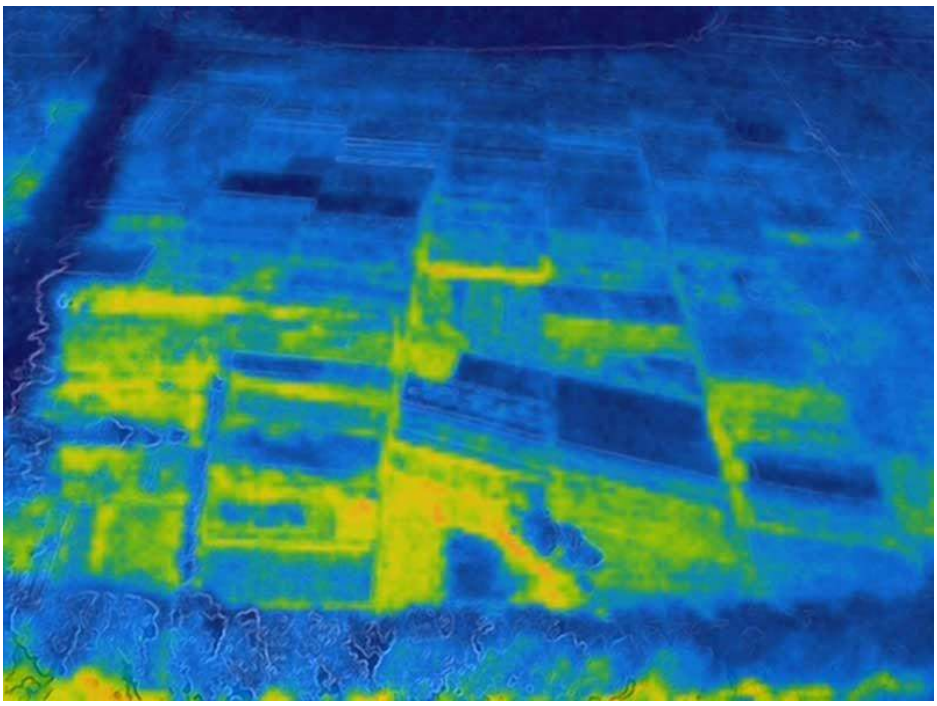

Fig. 6. Thermal imaging cameras on drones for agriculture.

Another unusual type of application of the active substance is fumigation. During fumigation, a special installation on a drone creates a powerful stream of hot air. A mixture of liquid and biologically neutral steam generator and active substance is fed into the hot air. Microdroplets of the active substance (AS) attach to the steam particles, then the biologically active steam is forcefully ejected from the fumigator nozzle.

Drones with thermal imaging cameras can see at night. In addition to being able to detect foreign equipment, people, and animals in the field, a drone with a thermal imaging camera can remotely measure soil temperature and detect fire outbreaks in a timely manner.

Conclusions

Unmanned technologies are increasingly being used in agriculture, as they are very promising for use in precision agriculture. They are becoming common for monitoring the condition of crops, detecting weeds, clarifying the boundaries of land plots, applying plant protection products, especially if this needs to be done on a limited area, etc. In addition, their operation does not require large costs or lengthy personnel training.

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