

AGRICULTURE 4.0 - THE USE OF SMART TECHNOLOGIES FOR HIGH-PERFORMANCE AGRICULTURE

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AGRICULTURA 4.0 – UTILIZAREA TEHNOLOGIILOR INTELIGENTE PENTRU AGRICULTURA DE ÎNALTĂ PERFORMANȚĂ

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ABSTRACT

Given that the labor market in Romania has an acute shortage of labor (about 1 million people), in agriculture this lack is felt even more acutely because the population in the villages is declining and aging, thus it is increasingly difficult for Romanian farmers to find labor, let alone skilled labor.

One solution can be the digitization of agriculture, ie the introduction of the latest management concepts, sensors, automation, robots, etc. in the modernization of work processes in agriculture, thus reducing the need for labor, while increasing productivity and efficiency in agriculture.

REZUMAT

Agricultura este una din ramurile de bază în România, atât din punct de vedere al numărului de persoane care sunt implicate în aceasta dar și din punct de vedere economic, al aportului pe care aceasta îl are la PIB-ul României dar mai ales al potențialului de creștere pe care aceasta îl poate avea în viitorul apropiat.

Acest lucru se datorează dezvoltării tehnologiilor informaționale din ultimii ani (introducerea 5G, IoT, soluțiilor de management, inteligența artificială, etc.), care prin implementarea pe echipamentele, respectiv în tehnologiile agricole, pot conduce la obținerea unor producții ridicate cu costuri de exploatare și forță de muncă reduse.

INTRODUCTION

Precision agriculture is the area where it can be used to effectively manage agriculture by understanding the temporal and spatial changes of soil, crops, production and management through innovative techniques. [16]

Intelligent agriculture, based on the incorporation of information and communication technologies into machinery, equipment and sensors into agricultural production systems, enables the generation of a large amount of data and information by progressively introducing automation into the process.

Smart farming relies on the transmission of data and its concentration in remote storage systems to enable the combination and analysis of different agricultural data for decision-making. [4]

In a Romanian context, technology serves both as a threat and as an opportunity. Given that the Romanian agricultural system brings only 4.5% of GDP, compared to 25% for the IT industry, there seems to be an extraordinary opportunity for growth. But the associated problems are complex. On the one hand, the predominant structure of the country's small farms, fragmented land ownership and low levels of mechanization are the main tangible barriers to rapid system change. On the other hand, farmers have referred to the growing lack of available labour as the main obstacle they face to stay in business, a challenge in which digitization and automation are obvious solutions. [12]

Artificial intelligence (AI) has become an area of strategic importance and a key factor in economic development. This can bring solutions to many societal challenges, from treating diseases to minimizing the environmental impact of agriculture.

Artificial intelligence (AI) equips systems with the ability to analyze their environment and make decisions with a certain degree of autonomy to achieve their objectives. Automatic learning denotes the ability of a software/computer to learn from its environment or a very large set of representative data, allowing systems to adapt their behavior to changing circumstances or perform tasks for which they have not been explicitly programmed.

Romania has a huge potential in agriculture, 2017 has been an exceptional year with high agricultural figures, however Romania needs to capitalize its potential in a smart and sustainable way. There is a need for greater focus on productivity and efficiency in the Romanian agriculture, so as to bridge up the gap between Romania and the other EU Member States and improve the external competitiveness on the medium and long term. For this purpose, it is necessary to diversify the

economic activities in the rural areas, to better integrate the rural economy into the market economy, by supporting local investment and job creation, as well as by the application of technical innovation and modernization of agriculture.[1]

Agriculture is industry No. 1 in Romania. Modern information technologies, such as 5G, IoT, cloud computing and artificial intelligence, can be deeply integrated into traditional agriculture to implement information awareness, accurate management and intelligent control throughout the agricultural production process. Smart agriculture is based on digital agriculture, and 5G is the prerequisite for the development of agricultural IoT (Internet of Things). Science and technology are the conditions that enable agriculture to be achieved, and 5G digitizes physical land. IoT and satellite teledetection technologies are used to build a digital system of agricultural land, transforming the farmer's activities into looking at the screen and understanding the data. Large data technologies and cloud computing can be used to build an intelligent management and decision-making system to test and score the entire planting process of seed material.

To launch timely early warnings about diseases, pests and herbs and to provide intelligent solutions. At the same time, artificial intelligence and satellite navigation technology can be used to direct drones and field robots. 5G enables the new era of smart farming to achieve automation and full intelligence. [13]

IoT-based smart farms will be built to provide efficient data transmission systems to provide timely information about crop growth, improving their quality and efficiency. This will help to guide agricultural production and planting more effectively, so that the efficiency of the production itself is much improved.

This paper also discusses the implementation of functions such as visual diagnosis, remote control and disaster warning, all of which mean a large increase in agricultural productivity. [13]

MATERIAL AND METHOD

From the beginning, agriculture is a crucial part of human society because of the reality that man and agriculture are directly linked to each other. This leads to the advancement and improvement of the typical, inappropriate and time-consuming methodologies used for agriculture. The fast-moving world, new trends and technological advances have changed people's lifestyles. New emerging technologies are becoming an important part of routine. Smart homes and the network, smart cities [1] smart campus and smart agriculture are

some of all advanced and upgraded information and communications technologies that help people save time and achieve rapid results. [15]

These advanced technologies are now robots and even influence the singularity of people and machines by dramatically reshaping education, business, agriculture - health, science, engineering and other activities in ways we can't yet imagine. In Fig. 1, the different components of precision farming have been indicated and presented [3].



Fig.1. Precision farming components [3]

As intelligent machines and sensors appear on farms and agricultural data increase in quantity and scope, agricultural processes will become more and more data-driven and will be enabled for data. Rapid developments in the Internet of Things and Cloud Computing propel the phenomenon of what is called Smart Farming [17].

While Precision Agriculture only takes into account variability in the field, Smart Agriculture goes beyond this by basing management tasks not only on location, but also on data, improved by context and situation awareness, triggered by real-time events. [19] In order to carry out agile actions, in particular in the case of suddenly altered operational conditions or in other circumstances (e.g. weather alert or sickness alert) real-time assistance features are required to perform agile actions, in

particular in the case of suddenly altered operational conditions or in other circumstances (e.g. weather or sickness alert). These features usually include smart support in the implementation, maintenance and use of technology.

Agriculture has undergone a number of technological transformations in recent decades, becoming more industrialized and technology-based. By using various smart gadgets, farmers have gained better control over the process of livestock and crop farming, making agriculture more predictable and improving its efficiency.

This, together with the growing demand of consumers of agricultural products, has contributed to the increased proliferation of smart agricultural technologies worldwide. In 2020, IoT's market share in agriculture reached \$5.6 billion. [9]

With the increasing adoption of the Internet of Things (IoT), connected devices have permeated every aspect of our lives, from health and fitness, home automation, automotive and logistics, to smart cities and industrial IoT.

Thus, it makes sense for IoT, connected devices and automation to find its application in agriculture and, as such, to greatly improve almost every aspect of it [9].

According to smart technologies, robotics is also introduced so as to take more space

for technological advances in agriculture. The Internet of Things (IoT), the most controversial topic of today's research era, also contributes to the evolution of smart agriculture [10]. Practically agricultural reforms are the sum of three main areas shown in Figure 2.

- Biological technology
- Nanotechnology
- Information and Communication Technology (ICT) [15]

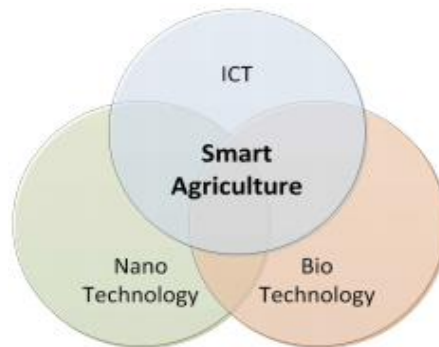


Fig.2. The three main domains of smart agriculture [15]

Technological advances typically include smart support in the implementation, maintenance and use of the technology presented in Fig.3 as the concept of smart farming throughout management as a cyber-physical system, which means that smart devices - connected to the Internet - control the agricultural system. Smart devices expand conventional tools (e.g. rain gauge, tractor, notebook) by autonomous lyccability by all types of sensors, built-in intelligence,

capable of performing autonomous actions or doing so remotely.

This figure highlights the fact that robots can play an important role in controlling agriculture, but it is expected that the role of humans in its analysis and planning is increasingly assisted by machines, so that the cyberphysical cycle becomes almost autonomous. People will always be involved in the whole process, but at a lower level, leaving most operational activities in place of machines.

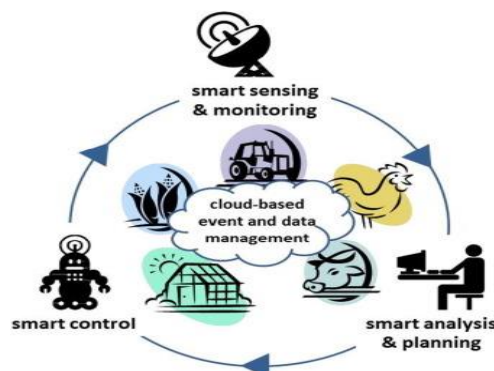


Fig.3. Smart Agriculture Management Cycle [19]

Artificial Intelligence (AI) is a developing technology in the field of agriculture. AI-based equipment and machines have taken today's agricultural system to another level.

This technology has improved crop production and improved real-time monitoring, harvesting, processing and marketing [6].

The latest technologies in automated systems using agricultural robots and drones have made an extraordinary contribution to the agro-based sector. Various systems based on hi-tech computers are designed to determine various important parameters, such as weed and pest detection, yield and crop quality detection and many other techniques [14].

5G has the potential to disrupt a huge number of industries, including one of the

oldest in the world, namely agriculture. State-of-the-art 5G networks can be 100 times faster than 4G, making communication between devices and servers much faster. 5G can also carry much more data than other networks. This makes the technology ideal for transmitting information from remote sensors and drones, key instruments [10].

RESULTS AND DISCUSSIONS

Agriculture plays a significant role in the economic sector. Automation in agriculture is the main concern and emerging topic around the world. The population is growing enormously and, with this increase, demand for food and employment is also increasing. Traditional methods that were used by farmers were not sufficient to meet these requirements.

Thus, new automated methods were introduced. These new methods met food requirements and also provided employment opportunities for billions of people. Artificial intelligence in agriculture has led to an agricultural revelation. This technology has protected crop production from various factors such as climate change, population growth, employment issues and food security issues. [18]

Demographic trends, including ageing population and the continuous migration of people from rural to urban areas, have attracted the attention of researchers, as work-related problems can become a factor of shortages in agriculture. In addition to these trends, the intensification of climate change will continue to alter the conditions

of growth, such as temperature, precipitation and soil moisture, in less predictable ways [2].

Artificial intelligence tools can help reduce these impacts, maintain them consistently or reduce production costs in agricultural activities, and help to minimize environmental constraints [5].

Perhaps one of the most promising agrotech advances is the use of agricultural drones in smart farming. Also known as UAVs (unmanned aerial vehicles), drones are better equipped than airplanes and satellites to collect agricultural data. In addition to surveillance capabilities, drones can also perform a large number of tasks that previously required human labour: crop planting, pest and infection control, agricultural spraying, crop monitoring, etc.

DroneSeed is building drones to plant trees in cleared areas. The use of such drones is 6 times more efficient than human labor. An agricultural drone Sense Fly eBee SQ uses multispectral image analyses to estimate the health of the crops shown in Figure 4. [9]



Fig. 4. Drone [9]

Smart agricultural applications should be adapted for use on the ground. A farmer should be able to access information on the spot or remotely via a smartphone or desktop computer.

In addition, each connected device should be autonomous and have a sufficient wireless range to communicate with the other devices and send data to the central server shown in Figure 5.



Fig. 5. Autonomous wireless device

A more complex approach to IoT products in agriculture can be the so-called agricultural productivity management systems. These usually include a number of agricultural IoT devices and sensors

installed on site, as well as a powerful dashboard with analytical capabilities and embedded accounting/reporting characteristics shown in Figure 6.

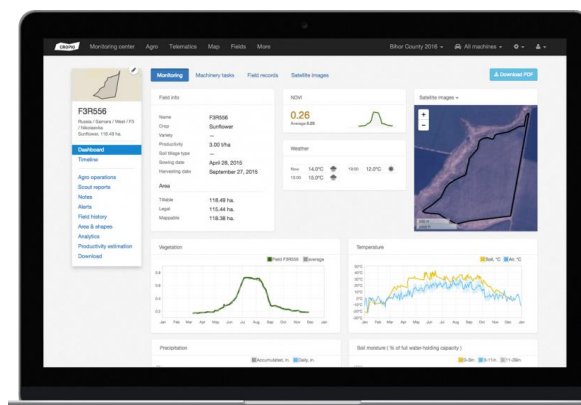


Fig.6. IoT Management System

This provides remote farm monitoring capabilities and enables business operations to be streamlined. Similar solutions are represented by FarmLogs and Cropio.

In addition to the cases of use of IoT agriculture listed, some important opportunities include vehicle tracking (or even automation), storage management, logistics, etc.

Autonomous tractors can be controlled remotely and only operator's invention is required during the initial configuration and machine maintenance on a regular basis.

Over time, smart tractors will become increasingly independent with technologies such as visibility systems, light detection tools, GPS, etc.

Bear Flag Robotics specializes in the construction of driverless tractors, with their help they can plan the route of the machine, receive reports and alerts in real time – the work can be done without the direct intervention of the man on the ground shown in Figure 7. [9]



Fig.7. Autonomous tractor [9]

Recently, China Mobile Zibo partnered with Huawei to deploy the first 5G site on the Hefeng unmanned farm in Zibo's Linzi district. The farm covers an area of about 33 hectares and was jointly established by Professor Lan Yubin of Shandong

University of Technology and Zibo Hefeng Seed, a seed production company. It is a national leading presentation of how modern and high-efficiency agriculture can be integrated with the new generation of ICT technology shown in Figure 8.



Fig. 8. New ICT technology

In the future, advanced technologies, such as 5G technology, image recognition, satellite remote detection and big data, will be combined with comprehensive information management systems using an agricultural cloud platform. This will allow the automated operation of various unmanned agricultural

machinery to cover the phases of ploughing, planting and management of wheat and maize crops. The technology can be applied to equipment such as crop protection drones, crop protection machines, rotary growers, maize planters and sprinkler systems shown in Figure 9 [8]



Fig. 9. Unmanned agricultural car [8]

The British 5G RuralFirst initiative launched a smartphone app called Me+Moo in 2019, allowing farmers to track a "connected" cow and receive daily updates on the health and behavior of the animal shown in Figure 10.

Cows wear collars connected to 5G, which send app data about everything from what they eat to how they sleep. Farmers can see the information instantly and pass it on to veterinarians or nutritionists. [10]

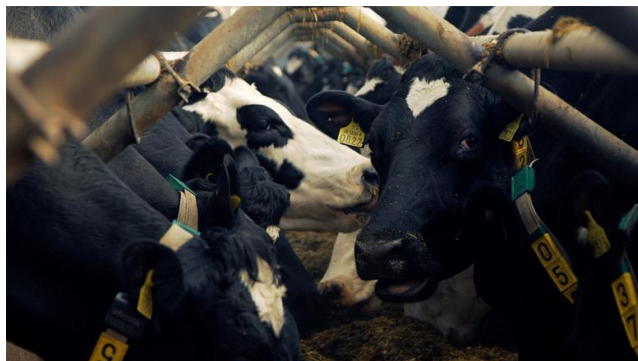


Fig. 10. Special collars 5G for bovine animals [10]

Another technology set up for cameras to distinguish between crops and weeds. A good example is a Vodafone 5G-powered system from Blue River, which is now owned by agricultural giant John Deere. "See & Spray" technology uses high-resolution cameras that capture 20 images per second, with AI applied to images to allow the system to recognize the difference between cultivated plants and weeds.

This machine is designed to operate autonomously without a guaranteed network connection, and all necessary processes are installed on the platform. However, if a 5G connection is available, you might report weed locations or possible problems to allow further follow-up by another machine. [11]



Fig.11. System Blue River [11]

CONCLUSIONS

Smart agriculture reduces the negative impact of agriculture on the environment, increases soil resilience and health, and lowers costs for farmers. The number and types of challenges associated with smart farming extend into different agricultural production systems, and the limitations apply when it comes to the implementation of IoT.

The beauty of 5G is that the machines

remain connected in the agricultural network, even if they operate outside the farm. A wide range of new technologies are being developed, such as crop control, irrigation regulation, climate sensors and autonomous vehicles, all benefiting from rapid data transmission. These technologies are undoubtedly important to make agricultural production more efficient and sustainable.

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