DOI: https://doi.org/10.33216/1998-7927-2024-285-5-65-71

УДК 004.9

INTERNET OF THINGS AND ARTIFICIAL INTELLIGENCE IN AGRICULTURE

Kunup T.V.

ІНТЕРНЕТ РЕЧЕЙ ТА ШТУЧНИЙ ІНТЕЛЕКТ У СІЛЬСЬКОМУ ГОСПОДАРСТВІ

Кунуп Т. В.

This article explores the role of modern technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI) in the development of agriculture. This combination facilitates process automation, increases production efficiency, optimizes resource utilization, and improves product quality. Applications in crop cultivation and livestock farming are discussed, helping farmers make more informed decisions based on real data. The challenges and economic benefits of implementing IoT and AI in agriculture are analyzed, including the need for substantial investments and ensuring cybersecurity across various countries worldwide.

Technological advancements in agriculture meet the growing demands for farm automation, economic digitalization, and environmental sustainability. Current industry trends emphasize the transition to precision farming, which allows for more efficient use of time and resources, reduces production costs, and minimizes crop losses.

The integration of innovative solutions in agricultural management processes shifts the balance of influence in domestic markets, creating new opportunities for growth. Artificial intelligence technologies significantly enhance efficiency across various sectors, including agriculture, and address many pressing challenges. Agricultural robots designed for AI integration ensure the effective use of this technology in agribusiness.

In the context of rapid global population growth, agriculture faces numerous challenges, and the use of AI and IoT can become a key element in overcoming them. Despite high initial costs, which may deter some producers, investments in innovative technologies typically pay off within a few years, demonstrating their economic viability.

By utilizing IoT and AI technologies, the agricultural sector can produce more with fewer resources, improve product quality, and accelerate time to market. With IoT sensors, farmers can more accurately calculate the required volumes of water, fertilizers, and pesticides, reducing their consumption. The rational use of energy and natural resources lowers costs and minimizes environmental harm. Continuous monitoring of growing conditions (temperature, humidity, light levels) enhances crop quality and livestock productivity. AI helps predict diseases and implement preventive measures.

These technologies prevent crop losses caused by adverse weather conditions, pests, or diseases. Supply chain monitoring ensures better control over product storage and transportation. AI algorithms analyze large volumes of data to forecast yields, determine optimal planting and harvesting times, and provide farmers with precise decision-making recommendations. Precision farming systems reduce dependence on climate variability through accurate data and adaptive management methods. IoT and AI technologies contribute to increased yields and agricultural stability, addressing the challenges posed by global population growth.

The implementation of IoT and AI in agriculture not only improves the efficiency and competitiveness of the sector but also creates the foundation for the sustainable development of the agricultural industry.

Key words: *Internet of Things, Artificial Intelligence, AIoT (Artificial Intelligence of Things) concept, innovative technologies.*

Introduction. This paper examines the implementation of the Internet of Things (IoT) and Artificial Intelligence (AI) in agriculture amidst contemporary challenges, including the need to enhance food security, adapt to climate change, and utilize resources efficiently. Integrating innovative technologies such as IoT and AI addresses global food issues, optimizes resource use, and improves agricultural production efficiency. In the context of Ukraine, state support for these technologies underscores the importance of introducing innovations in key economic sectors, contributing to

the country's strengthened position in the global market.

The aim of the work is to comprehensively study the implementation of Internet of Things (IoT) and artificial intelligence (AI) technologies in agriculture, in particular their impact on increasing productivity and optimizing resource use. The study also aims to analyze the benefits and problems of integrating modern technologies, assess various aspects of their application, and determine the prospects for the development of these technologies in the agricultural sector of Ukraine and the world.

Modern agriculture is rapidly evolving, with innovative technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI) coming to the forefront, promising to revolutionize the agricultural sector.

Modern agriculture requires high production efficiency combined with high-quality output. This applies to both crop production and livestock farming, among other areas. To meet these demands, advanced data analysis methods, including Artificial Intelligence (AI) techniques, are increasingly being utilized [7 p.62].

Artificial Intelligence is seen as a tool for improving crop quality, monitoring it at various stages, enhancing key agricultural operations, and advancing other technological components that can mitigate the negative effects of climate change and adapt the industry to the rapid growth of the global population.

The analysis of recent research and publications has shown that the primary providers of modern Artificial Intelligence systems for agriculture are countries in Western Europe, the United States, and China. The two most advanced agricultural nations in the world are the United States and the Netherlands, followed by France, Germany, Canada, and Australia. Their agricultural leadership is based on the use of high technologies. Ukrainians are also beginning to adopt these technologies, but to a much lesser extent. A diagram illustrating the implementation of Artificial Intelligence and the Internet of Things in agriculture worldwide is shown in Figure.

The following Artificial Intelligence and Internet of Things technologies have been implemented in agriculture: computer vision, robotics and automation, data analysis and forecasting, unmanned aerial vehicles (drones) with AI, AI for livestock management, smart irrigation systems (soil moisture sensors, automatic irrigation systems), smart systems for soil condition monitoring (soil temperature and pH sensors, nutrient level monitoring), smart farms for livestock (wearable devices for cattle, automated feeding and milking), agrometeorological stations (weather condition monitoring, forecasting, and alerts for extreme weather events), logistics tracking systems, and more [7].

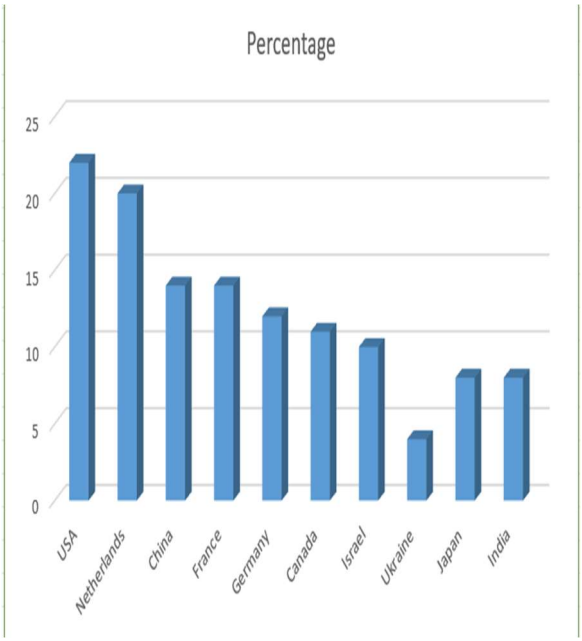

Fig. Introduction of artificial intelligence and the Internet of Things in agriculture

Agriculture encompasses a range of processes and stages, most of which involve manual labor. By complementing existing technologies, Artificial Intelligence (AI) can simplify the execution of the most complex and routine tasks. It can collect and process large amounts of data on a digital platform, devise the best course of action, and even initiate this action in combination with other technologies [7 p.64].

Artificial Intelligence can be utilized in various aspects of agricultural activities, such as precision farming, livestock management, crop production, poultry farming, smart irrigation systems, greenhouse automation, climate condition monitoring, raw material management, and more. Let us consider some of these in detail.

Precision Farming. International experience has demonstrated that crop yields depend 80% on natural conditions. However, with the use of precision farming systems, the influence of climate and weather conditions is reduced to 20%, while technology and management in agriculture become decisive factors, accounting for 80%. For Ukraine, as a region with high risks in agriculture, the implementation of precision farming systems is highly appropriate given the diversity of climatic

conditions and field heterogeneity. This allows for minimizing risks and optimizing costs.

Digital farming encompasses several stages: data collection, information analysis, and making agronomic decisions based on this analysis.

Agrochemical analysis of soil using sensor equipment allows for the assessment of its fertility, obtaining data on suitability for growing specific crops, optimizing nutrient systems, and reducing fertilizer costs. Monitoring crops with satellites or drones provides comprehensive information about the condition of the soil and plants, enabling prompt management decisions regarding soil treatment or pest control.

Meteorological monitoring helps determine optimal periods for planting, irrigation, and fertilization, which also reduces water consumption. Precision technologies in agriculture are focused on economic efficiency and soil conservation, increasing yield per hectare, reducing field losses, and, overall, improving the efficiency of land use in the country.

In livestock farming, Artificial Intelligence plays a key role due to its powerful capabilities in analyzing large volumes of data and computing complex algorithms. It contributes to increased efficiency in various areas, such as breeding livestock, poultry farming, rabbit farming, aquaculture, and others.

One of the main advantages of Artificial Intelligence in livestock farming is its application in the animal breeding process. By using machines to learn algorithms and big data analysis, farmers can select optimal pairs for breeding, which improves the genetic quality of the herd and results in healthier and more productive offspring. This contributes to increased productivity, meeting market demands, and enhancing the characteristics of the animals [9].

Additionally, Artificial Intelligence significantly simplifies farm management. AI enables the monitoring of animal housing conditions, such as temperature, humidity, lighting, and ventilation. Algorithms help ensure optimal conditions to minimize risks of diseases and stress, which positively impacts the health and productivity of animals. AI also generates recommendations for improving living conditions, promoting animal welfare.

Monitoring feeding behavior is a key element of livestock management, as it provides essential information about the health, productivity, and overall well-being of animals. With Artificial Intelligence and sensor systems, this process is automated, delivering real-time data. RFID (radio frequency identification) tags or smart collars are commonly used to track feeding times and frequency, as well as the duration of an animal's stay at the feeding station. The collected data is analyzed by AI to improve animal management [5].

Automated counting of cattle and tracking their movements are crucial for supply chain management. Beyond mere numbers, herd monitoring plays a significant role in disease control, inventory management, movement tracking, productivity enhancement, and ensuring the profitability of enterprises. Traditional methods of manual animal counting are often inaccurate, labor-intensive, and challenging for large herds.

Artificial Intelligence and sensor technologies offer a transformative solution to this problem. Radio Frequency Identification (RFID) has become a key technology for automatic counting and tracking animals. RFID tags implanted in livestock provide automatic identification and tracking of each animal at various stages of the supply chain. Readers, strategically placed along this chain, collect data, ensuring comprehensive record-keeping and minimizing errors compared to traditional counting methods [5].

In modern crop production, robotics holds significant potential for automating various processes, contributing to improved cultivation quality, increased yields, and reduced costs. Robotics is utilized at different levels, from large farming enterprises to greenhouses and even private households. It finds applications in areas such as grain cultivation, horticulture, viticulture, berry farming, and vegetable gardening. The main directions for the use of robots in crop production include:

1. **Irrigation and Plant Nutrition:** Irrigation robots can automatically water plants, taking into account their needs, soil type, and weather conditions. This enables efficient water use and maintains optimal growth conditions.

2. **Soil Tilling and Seed Sowing:** Specialized robots can automatically till the soil and plant seeds at a specified depth and with the required spacing, ensuring uniform seed placement and optimal use of the available area.

3. **Weed Removal:** Weed-removal robots can identify and eliminate weeds without manual intervention, ensuring clean fields and reducing the negative impact of weeds on crop yields.

4. **Harvesting:** Harvesting robots automatically determine the ripeness of fruits using sensors or computer vision and carefully harvest the crops, minimizing damage to the fruits.

5. **Pest and Disease Control:** Plant treatment robots can detect pests and signs of diseases and automatically apply pesticides or fertilizers as needed. Utilizing sensors and cameras, these robots conduct precise monitoring and treatment of specific areas, effectively controlling pests and plant diseases.

These technologies enable the optimization of processes in crop production, improving the quality and productivity of farms.

In poultry farming, artificial intelligence is used for process automation, production monitoring, and disease diagnostics. Artificial intelligence analyzes the behavior of birds, helping to detect signs of stress or illness, which allows for quick responses and the prevention of potential problems.

An intriguing development comes from a team of Japanese researchers led by Professor Adrian David Cheok from the University of Tokyo, who created a system capable of translating chicken clucking into human language using Artificial Intelligence. Their system interprets various emotional states of chickens, such as hunger, fear, anger, satisfaction, excitement, and distress, through a method they call "deep emotional analysis." [6].

To test the system, the team recorded and analyzed sound samples from 80 chickens and then fed this data into an AI algorithm. The algorithm matched these vocal samples with the corresponding emotional states of the birds. In collaboration with psychologists, animal behaviorists, and veterinarians, the researchers achieved high accuracy in determining the mental states of individual birds. They also trained artificial intelligence to recognize the emotional state of chickens based on their sounds, which could significantly improve their living conditions and production [5].

Definition and Tracking of Animals as Key Aspects.

Many livestock-producing countries have recognized artificial intelligence and digital transformation as effective and practical solutions to address numerous challenges in monitoring and decision-making within the industry.

Biometric Methods for Assessing Animal Health and Welfare.

The most common methods for evaluating animal health and welfare include visual and subjective approaches, particularly for analyzing animal behavior, or invasive methods.

Let us consider some methods for monitoring animal health:

1. Thermal Imaging

The use of infrared cameras enables the detection of localized temperature increases on the animal's skin, which may indicate inflammatory processes or infections. The temperature T is measured using the formula:

$$T = \left(\frac{R \cdot E}{\sigma}\right)^{\frac{1}{4}} \quad (1)$$

where: R - radiation intensity recorded by the camera,
E - emissivity coefficient of the Sirface (for animal skin about 0.98),
σ - Stefan-Boltzmann constant (5.67×10^{-8}Вт/ м^2 К^4).

This method provides non-invasive, real-time insights into potential health issues, making it an essential tool for modern livestock management.

1.1. Photoplethysmography (PPG).

Heart rate (HR) and respiration rate (RR) are assessed by analyzing changes in skin color in RGB video streams. The algorithm extracts the signal from the variations in the intensity of the green channel G(t)G(t), processing it using the Fast Fourier Transform (FFT):

$$HR = f_{\max} \cdot 60 \quad (2)$$

where: *fmax* - the signal frequency with the highest intensity in the spectrum.

2. Performance Analysis

2.1. Milk Yield Prediction

Milk yield prediction is based on multivariate regression:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \quad (3)$$

where: Y - expected milk yield (liters),
$X_1, X_2, \ldots, X_n$ - factors (temperature, humidity, diet),
$\beta_0, \beta_1, \ldots, \beta_n$ - model coefficients,
ε - residual noise.

2.2. The heat stress index (THI) is calculated using the formula:

$$THI = (1.8 \cdot T + 32) - (0.55 - 0.0055 \cdot RH) \cdot (1.8 \cdot T - 26) \quad (4)$$

where: T - air temperature ($^\circ\text{C}$),
RH - relative humidity (%).

When THI >72, the likelihood of decreased productivity and deteriorating health increases significantly.

3. Optimization of Well-being

3.1. Stress Detection through Behavior Analysis

Video analysis of animal motor activity enables the identification of signs of stress or discomfort. Optical flow is used:

$$V(t) = \sum_{i=1}^{N} \sqrt{(x_i - x_{i-1})^2 + (y_i - y_{i-1})^2} \quad (5)$$

where: $V(t)$ - the average movement speed of animals,
x_i, y_i - coordinates of the position in the frame.

3.2 Predictive Model Construction

To assess the impact of environmental changes on animal behavior, gradient boosting is employed:

$$F_m(x) = F_{m-1}(x) + \gamma_m \cdot h_m(x) \quad (6)$$

where: $F_m(x)$ - the current model,
γ_m - learning rate,
$h_m(x)$ - loss function gradient.

The main drawback of traditional methods based on the use of contact or invasive sensors for assessing physiological responses is that they may cause stress in the animal, which, in turn, can distort the results.

Another example is "smart greenhouses," where the Internet of Things enables the creation of optimal microclimates for "sensitive" crops. IoT systems manage irrigation, lighting, air humidity, and temperature. For instance, Artificial Intelligence can predict plants' needs for watering or fertilization to ensure optimal growth. To use water efficiently across the entire field, sensors are installed to monitor soil dryness and looseness. As soon as the system detects deviations from the norm, automatic irrigation is activated. This solution prevents both dryness and overwatering.

An American farmer, Dorn Cox, co-founder of "Farm Hack"—a global community of farmers who create and modify their own tools—produces organic products on his 120-hectare farm in New Hampshire, primarily for restaurants. His farm grows blueberries, mushrooms, vegetables, maple syrup, sunflower oil, and baked goods from his own grain. In 2011, when the community was formed, one of the first problems discussed was the remote detection of critical temperature rises in greenhouses. Using a modified GSM signal and a mobile phone, the project created a temperature sensor that sends a text message if the greenhouse temperature exceeds acceptable levels [10].

Quality control of food products is a crucial aspect of protecting consumer health and safety. An important component of quality control is monitoring storage and transportation conditions, which is especially critical for perishable goods. Selecting the right software for these processes is also essential to ensuring product quality. The use of sensors enables real-time monitoring of temperature, humidity, and other parameters that affect product quality.

The implementation of strict standards and regular inspections at all stages of production and distribution is key to maintaining high quality and safety of food products. Thus, modern technologies and rigorous agricultural control standards help protect consumer health and build trust in producers [14].

The economic aspects of implementing Artificial Intelligence (AI) and the Internet of Things (IoT) in agriculture across various sectors open new opportunities for optimizing decisions and managing processes. A key economic benefit is the reduction of production and operational costs.

In recent years, the introduction of information technologies in agriculture has led to adjustments in crop processing methods and field management. These technologies have fundamentally changed the concept of agriculture, making it more profitable, efficient, safe, and straightforward.

Therefore, examining the experience of implementing artificial intelligence and Internet of Things in agriculture leads to the conclusion that these technologies are fundamentally transforming the industry. They are turning a millennia-old human endeavor into a technological business with high productivity.

Conclusions. The implementation of artificial intelligence and the Internet of Things in agriculture creates broad opportunities for increasing productivity, efficiency, and competitiveness in the agricultural sector. These technologies enable process automation, resource optimization, cost reduction, and improved product quality.

The advantages of artificial intelligence and Internet of Things integration in agriculture include accurate monitoring of soil, crops, and livestock using sensors, drones, and analytical platforms. Routine processes such as irrigation, fertilization, harvesting, and livestock care can be automated, leading to enhanced resource efficiency, including water, fertilizers, and energy.

In crop production, these technologies reduce dependence on climatic conditions, increase yields, and minimize losses.

In livestock farming, artificial intelligence supports breeding, animal health management, monitoring of feeding behavior, and automation of livestock tracking.

Monitoring storage and transportation conditions ensures high product quality and consumer safety.

Challenges in implementing artificial intelligence and Internet of Things include the need for significant investments in infrastructure development, ensuring cybersecurity and data protection, and addressing the shortage of qualified professionals to operate these advanced technologies.

For Ukraine, integrating innovative technologies allows for mitigating climatic risks and improving the country's competitiveness in the global market. It reduces production costs through process optimization and increases profitability by enhancing the efficient use of land resources and reducing losses.

State support for the development of these technologies will contribute to their more active implementation.

Artificial intelligence and Internet of Things have the potential to fundamentally transform the agricultural sector, turning traditional farming into a high-tech business with maximum productivity and efficiency. Implementing these technologies is strategically important for ensuring food security and the sustainable development of Ukraine's agricultural industry.

References

1. Gutierrez J. V., et al. Smart Agriculture: IoT, AI and Their Applications in Agriculture. Wiley, 2023. 320 p.
2. Lenniy D. Artificial Intelligence in Agriculture: Rooting Out the Seed of Doubt [Електронний ресурс] / Dmytro Lenniy // Intellia Karolinska Street 15 and 39, 04080, Kyiv, Ukraine. 2022. https://intellias.com/artificial-intelligence-inagriculture/.
3. Sandeep Kumar, Vikas Artificial Intelligence and Machine Learning in Agriculture. Kyiv: Naukova Dumka, 2021. 280 p.
4. Sharma, R. K., Singh, A. K. IoT in Agriculture: Innovation, Applications, and Challenges. Elsevier. 2022. 350 p.
5. Suresh Neethiraja. Artificial Intelligence and Sensor Technologies in Dairy Livestock Export: Charting a Digital Transformation. 2023. https://doi.org/10.3390/s23167045
6. https://psm7.com/uk/iskusstvennyj-intellekt/yaponiya-sozdala-iskusstvennyj-intellekt-rasshifrovyvayushhij-yazyk-kur.html
7. Tahsin KN (2016) Development of a propeller P8X 32A based wireless biosensor system for cattle health monitoring and disease detection. British Journal of Applied Science and Technology 18(2), 1-14
8. Bondarenko D. A. Zastosuvannya tekhnolohiy internetu rechey v silskomu hospodarstvi. Telekomunikatsiyni ta informatsiyni tekhnolohiyi. 2022. №2(75).
9. Humenyuk, V. I., Kovalchuk, S. M. Internet rechey u silskomu hospodarstvi: tekhnolohiyi ta zastosuvannya. Kyiv: Agrarna osvita, 2021. 350 s.
10. Kyivstar biznes. Internet rechey u silskomu hospodarstvi. https://hub.kyivstar.ua/articles/efektyvna–robota–agrotehniky–za–dopomogoyu–iot–rishenhttps
11. Petrenko, O. M. Shtuchnyy intelekt u silskomu hospodarstvi: praktychnyy posibnyk. Lviv: Vydavnytstvo "Agroosvita", 2022. – 280 s.
12. Savchenko A. S. Metody ta systemy shtuchnoho intelektu: posibnyk. NAU: 2017. – 176 s.
13. Solona O. V., Skoromna O.I. Tekhnika, enerhetyka, transport APK. 2023. №4(123). s.43–50. http://tetapk.vsau.org/storage/articles/January2024/5gJoIndA33kbLIZav2WI.pdf
14. Propozytsiya. Holovnyy zhurnal z pytan ahrobiznesu. Big Data v velykykh hospodarstvakh. https://propozitsiya.com/ua/big–data–v–bolshih–hozyaystvah

Література

1. Gutierrez J. V., et al. Smart Agriculture: IoT, AI and Their Applications in Agriculture. Wiley, 2023. 320 p.
2. Lenniy D. Artificial Intelligence in Agriculture: Rooting Out the Seed of Doubt [Електронний ресурс] / Dmytro Lenniy // Intellia Karolinska Street 15 and 39, 04080, Kyiv, Ukraine. 2022. https://intellias.com/artificial-intelligence-inagriculture/.
3. Sandeep Kumar, Vikas Artificial Intelligence and Machine Learning in Agriculture. Kyiv: Naukova Dumka, 2021. 280 p.
4. Sharma, R. K., Singh, A. K. IoT in Agriculture: Innovation, Applications, and Challenges. Elsevier. 2022.350 p.
5. Suresh Neethiraja. Artificial Intelligence and Sensor Technologies in Dairy Livestock Export: Charting a Digital Transformation. 2023. https://doi.org/10.3390/s23167045
6. https://psm7.com/uk/iskusstvennyj-intellekt/yaponiya-sozdala-iskusstvennyj-intellekt-rasshifrovyvayushhij-yazyk-kur.html
7. Tahsin KN (2016) Development of a propeller P8X 32A based wireless biosensor system for cattle health monitoring and disease detection. British Journal of Applied Science and Technology 18(2), 1-14

8. Бондаренко Д. А. Застосування технологій інтернету речей в сільському господарстві. Телекомунікаційні та інформаційні технології. 2022. № 2 (75).
9. Гуменюк, В. І., Ковальчук, С. М. Інтернет речей у сільському господарстві: технології та застосування. Київ: Аграрна освіта, 2021. 350 с.
10. Київстар бізнес. Інтернет речей у сільському господарстві. https://hub.kyivstar.ua/articles/efektyvna–robota–agrotehniky–za–dopomogoyu–iot–rishenhttps
11. Петренко, О. М. Штучний інтелект у сільському господарстві: практичний посібник. Львів: Видавництво "Агроосвіта", 2022. 280 с.
12. Савченко А. С. Методи та системи штучного інтелекту: посібник. НАУ: 2017. 176 с.
13. Солона О. В., Скоромна О.І. Техніка, енергетика, транспорт АПК. 2023. №4(123). С. 43-50. https://eos.com/uk/blog/suchasni–tekhnolohii–v–silskomu–hospodarstvi/
14. Пропозиція. Головний журнал з питань аграробізнесу. Big Data в великих господарствах. https://propozitsiya.com/ua/big–data–v–bolshih–hozyaystvah

Кунуп Т. В. Інтернет речей та штучний інтелект у сільському господарстві

У цій статті досліджується роль сучасних технологій, таких як інтернет речей (IoT) і штучний інтелект (AI) у розвитку сільського господарства. Ця комбінація полегшує автоматизацію процесів, підвищує ефективність виробництва, оптимізує використання ресурсів і покращує якість продукції. Обговорюється застосування у вирощуванні сільськогосподарських культур і тваринництві, що допомагає фермерам приймати більш обґрунтовані рішення на основі реальних даних. Проаналізовано проблеми та економічні переваги впровадження інтернету речей та штучного інтелекту у сільському господарстві, включаючи потребу в значних інвестиціях та забезпечення кібербезпеки в різних країнах світу.

Технологічний прогрес у сільському господарстві відповідає зростаючим вимогам до автоматизації ферм, цифровізації економіки та екологічної стійкості. Сучасні тенденції галузі підкреслюють перехід до точного землеробства, що дозволяє більш ефективно використовувати час і ресурси, зменшити собівартість виробництва та мінімізувати втрати врожаю.

Інтеграція інноваційних рішень у процеси управління сільським господарством змінює баланс впливу на внутрішніх ринках, створюючи нові можливості для зростання. Технології штучного інтелекту значно підвищують ефективність у різних секторах, включаючи сільське господарство, і вирішують багато нагальних проблем. Сільськогосподарські роботи, розроблені для інтеграції штучного інтелекту, забезпечують ефективне використання цієї технології в агробізнесі.

В умовах стрімкого зростання глобального населення сільське господарство стикається з численними викликами, і використання штучного інтелекту та інтернету речей може стати ключовим елементом у їх подоланні. Незважаючи на високі початкові витрати, які можуть стримувати деяких виробників, інвестиції в інноваційні технології зазвичай окупаються протягом кількох років, демонструючи свою економічну життєздатність.

Використовуючи технології інтернету речей та штучного інтелекту, сільськогосподарський сектор може виробляти більше з меншими ресурсами, покращувати якість продукції та прискорювати час виходу на ринок. За допомогою датчиків IoT фермери можуть точніше розраховувати необхідні обсяги води, добрив і пестицидів, зменшуючи їх споживання. Раціональне використання енергії та природних ресурсів знижує витрати та мінімізує шкоду навколишньому середовищу. Постійний моніторинг умов вирощування (температура, вологість, освітленість) покращує якість врожаю та продуктивність худоби. ШІ допомагає прогнозувати захворювання та впроваджувати профілактичні заходи.

Ці технології запобігають втратам врожаю через несприятливі погодні умови, шкідників або хвороби. Моніторинг ланцюга постачання забезпечує кращий контроль за зберіганням і транспортуванням продукції. Алгоритми штучного інтелекту аналізують великі обсяги даних, щоб прогнозувати врожайність, визначати оптимальний час посіву та збору врожаю та надавати фермерам точні рекомендації щодо прийняття рішень. Системи точного землеробства зменшують залежність від мінливості клімату завдяки точним даним і адаптивним методам управління. Технології інтернету речей та штучного інтелекту сприяють підвищенню врожайності та стабільності сільського господарства, вирішуючи проблеми, пов'язані зі зростанням населення планети.

Впровадження Інтернету речей та штучного інтелекту в сільському господарстві не тільки підвищує ефективність і конкурентоспроможність галузі, але й створює основу для сталого розвитку аграрної галузі.

Ключові слова: *Інтернет речей, штучний інтелект, концепція AIoT (Artificial Intelligence of Things), інноваційні технології.*

Кунуп Тетяна Василівна – к.т.н., старший викладач кафедри Інформаційних технологій, Національного університету «Одеська політехніка».
e-mail: Kunup.t.v.@op.edu.ua.

Стаття подана 22.10.2024.