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AUTOMATION OF PRODUCTION PROCESSES IN AGRICULTURE USING SELECTED ARTIFICIAL INTELLIGENCE TOOLS

Key words: agriculture, artificial intelligence, process automation, production, economy

ABSTRACT. The agriculture industry is experiencing a transformative shift towards greater efficiency and sustainability through the integration of artificial intelligence (AI) tools into various production processes. This article presents an overview of selected AI tools and their practical utilization in agriculture, shedding light on their profound impact on enhancing crop yields, resource management, and overall farm productivity. The article also provides an overview of the definition of artificial intelligence and a timeline starting with the first mention of artificial intelligence and ending with the present to better understand the described issue. The article highlights the importance of responsible AI development and integration. The ethical and societal implications of AI in agriculture, such as job displacement and data privacy concerns, are also addressed. The adoption of AI technologies is expected to play a vital role in meeting the global food demand while addressing the challenges faced by the agriculture sector. However, it is crucial to navigate these advancements responsibly, ensuring that the benefits of AI in agriculture are maximized while minimizing potential drawbacks.

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INTRODUCTION

The world's population is growing at a very rapid rate. It is estimated that by 2050 it will reach almost 10 billion. This is a challenge that the agricultural sector must face due to the need to increase crop production [FAO 2017]. Current trends such as growing population and urbanization, poverty and inequality, conflicts, increasing competition for natural resources, macroeconomic instability, conflicts and geopolitical tensions as well as the already visible climate change have a very negative impact on socio-economic and environmental systems. [FAO 2022]. The last few years have been challenging for agriculture due to climate change and other environmental issues in achieving increased productivity [Subeesh, Mehta 2021].

Agriculture is one of the oldest and most important industries in the world. Due to such rapid and dynamic population growth, the demand for food is also increasing [Dharmaraj, Vijayanand 2018]. The introduction of automated methods of meeting food needs may become one of the answers to the challenges of the modern world food economy [Zhang et al. 2021]. Farmers are forced to look for new solutions due to labor shortages, more stringent regulations, a growing world population as well as a decreasing number of farmers [Jha et al. 2019]. Technologies such as the Internet of Things, analytics and Big Data, machine learning (ML) and artificial intelligence (AI) are now entering almost every area of life and business [Bannerjee et al. 2018, Jha et al. 2019].

Artificial intelligence as a general set of various tools is developing rapidly. With the advancement of computational capabilities and predictability of e.g. weather conditions, more and more areas of the global economy began to benefit from the opportunities offered by artificial intelligence tools [Vyas 2022]. Agriculture is one of the fields that began to benefit from it as soon as artificial intelligence tools were developed and improved. From simple weed control to calculating the best time to harvest, monitoring crop and soil health, and predicting yields in advance [Shankar et al. 2020]. The last decade has been used to test artificial intelligence and machine learning as development tools that can be used in various industries. However, it is only recently that the potential of artificial intelligence to improve decision-making in agriculture has been seen [Bhardwaj et al. 2021]. This, in turn, may contribute to increasing the efficiency of both agricultural and animal production, at least by increasing the amount of data and ease of access to it [Rodzalan et al. 2020].

MATERIAL AND METHODS

The main goal of the article was to show the key artificial intelligence tools currently used in the automation of production processes in agriculture and what impact they have on the efficiency of agricultural activities. To provide a complete set of information about the artificial definition, selected definitions of the studied issue are presented, as well as a short historical description. These activities were intended, firstly, to introduce the issue of artificial intelligence, which is currently gaining popularity due to the availability of various definitions describing a given issue. As well as using a timeline figure to show that the concept of "artificial intelligence" has been known in the literature for several decades. However, only rapid technological progress contributed to the rapid development and increase in popularity of artificial intelligence, and therefore also to various types of risks that occur whenever an unexplored topic appears. The work indicates the possibilities and current practices of using artificial intelligence in the automation of production processes in agriculture. For a more precise description of the issue, a description of exemplary artificial intelligence tools in agriculture was used, with an indication of their functionality and capabilities. The work used secondary research from the literature on the subject, including data from the FAO reports.

The information provided in this article allows to answer the following questions:

- Is there one right definition of artificial intelligence?
- How has the history of artificial intelligence evolved?
- What is the current state of artificial intelligence adoption in the agricultural sector?
- What are the specific artificial intelligence tools that are being used in the agricultural sector?
- What are the primary challenges and benefits associated with integrating AI into agricultural production processes?

ARTIFICIAL INTELLIGENCE DEFINITION AND HISTORY BRIEF

Artificial intelligence is defined as the field of computer science that deals with the simulation of intelligent behavior in computers. Artificial intelligence is also the ability of machines to imitate intelligent human behavior [AI 2023]. In turn, according to the Britannica, Artificial intelligence is the ability of a computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. The term is often used to refer to projects to develop systems equipped with human-specific intellectual processes such as the ability to reason, discover meaning, generalize, or learn from past experience [Copeland 2023]. Another definition of artificial intelligence indicates that it is a subdiscipline of computer science dealing with the creation of information systems that

can learn and operate autonomously [Piwowar et al. 2023]. The definition of AI proposed by the European Parliament defines it as a machine-based system that can operate with varying levels of autonomy and can, for explicit or implicit purposes, generate results such as predictions, recommendations or decisions affecting a real or virtual environment (Artificial Intelligence Act, art. 2, p. 1 [EPRS 2023]). Provided that in any new legal instrument the definition of artificial intelligence will need to be flexible enough to adapt to technological progress, while at the same time precise enough to provide the necessary legal certainty [EC 2020].

The beginning of the history of artificial intelligence in literature is considered to be the summer of 1956 at Dartmouth College in Hanover, New Hampshire. It was then that John McCarthy invited a group of researchers to pursue a wide range of advanced research topics, including: you could find automatic computers, creativity, randomness and neural networks. The term artificial intelligence was also used for the first time [Rodzalan et al. 2020]. However, in the literature on the subject there are also mentions that the beginnings of artificial intelligence date back to the 1940s. The chart below presents a brief description of the individual historical stages of the development of artificial intelligence in the world from the beginning to the present (Figure 1).

In the early 1980s and 1990s, rule-based expert systems were widely used, and since 1990, models of artificial neural networks and fuzzy inference systems have begun to play a dominant role. Nowadays, hybrid systems such as neuro-fuzzy or image processing combined with neural networks are gaining popularity. These activities are moving towards automated and more accurate real-time systems [Bannerjee et al. 2018].

ARTIFICIAL INTELLIGENCE IN THE AGRICULTURAL SECTOR

Artificial intelligence is currently providing more and more real value, driven by progress in the availability of appropriate quality and quantity of data, calculations, and algorithms. Such activities include improving the precision in the information collection process, the ability to understand the occurrence of various phenomena in agricultural systems as well as their subsequent more efficient management, improved predictions, enabling more optimal decisions regarding the management of agricultural systems, and stimulating the development of decision support systems and recommendations. [Smith 2018].

The behavior of modern consumers is changing as the amount of available resources increases. Farmers therefore face challenges in increasing production and are under great pressure to meet growing demand [Sharma 2021]. Especially since 30.7% of the world's population is engaged in 2,781 million hectares of agricultural land [Bannerjee et al. 2018]. Therefore, it is very important to introduce various types of innovations in the agricultural

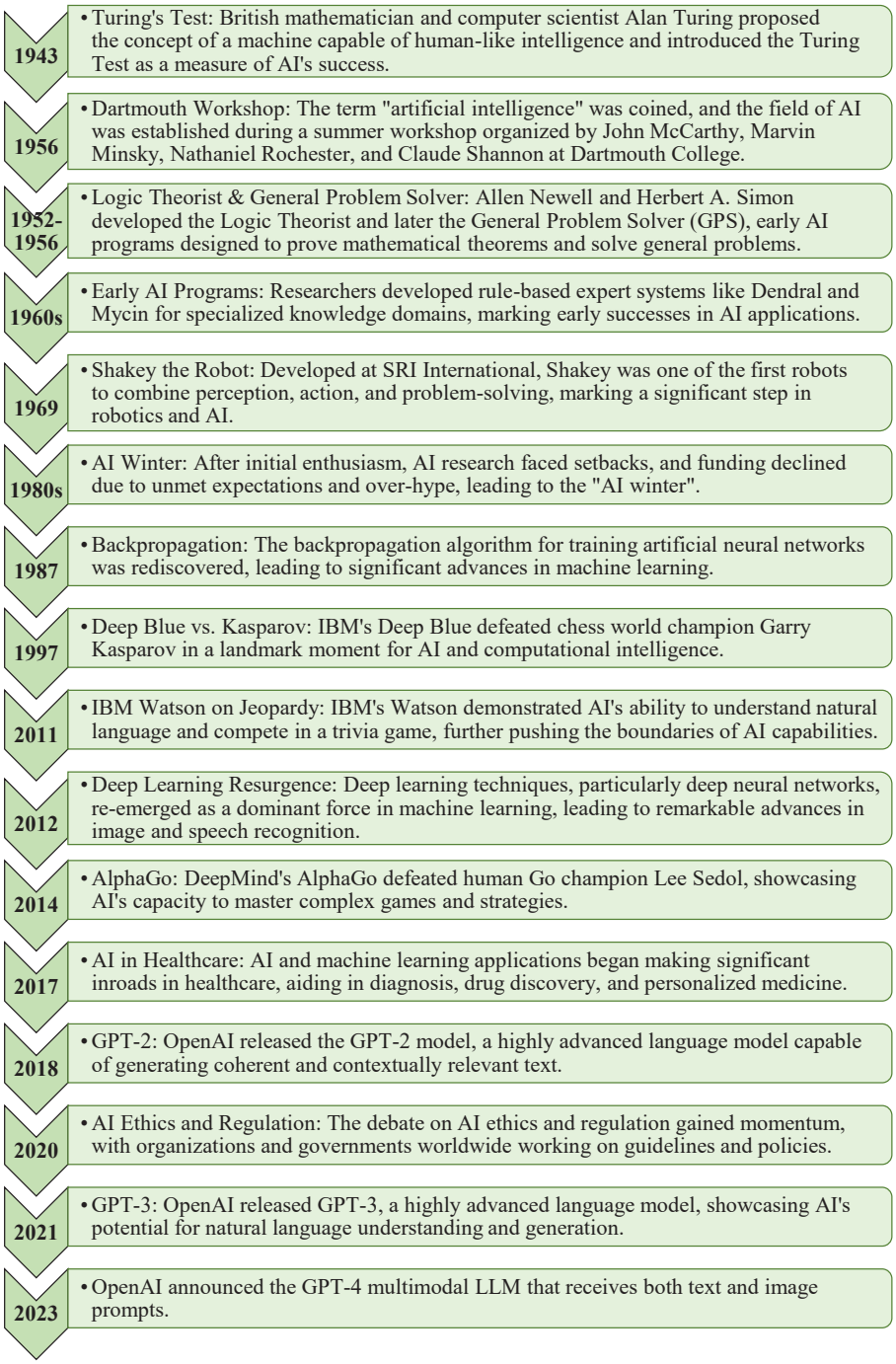

Figure 1. Artificial Intelligence timeline

Source: own elaboration based on [Buchanan 2005, Anyoha 2017, Karijan 2023]

sector that appear on the market in real time. Global adoption of artificial intelligence in agriculture is one of the most promising opportunities [Mohr, Kühl 2021]. Agriculture is an enterprise in constant change that faces many challenges, including: with invasion of pests and diseases, improper use of chemicals, weed control, improper drainage and irrigation, more precise crop forecasting, difficult to predict weather conditions, etc. [Bannerjee et al. 2018].

The use of computers in the agricultural sector was first described in 1983 [Baker 1983]. In order to solve current problems in the agricultural sector, various solutions have been used, ranging from databases to systems supporting the decision-making process [Martiniello 1988, Thorpe et al. 1992]. Over time, among various solutions, systems using artificial intelligence have proven to be the most effective in terms of their accuracy and reliability. The dynamics of changes and conditions in agriculture do not allow to generalize the situation in order to find and use only one common solution. Artificial intelligence tools can identify complex details in almost any situation and provide solutions that best fit the specific problem. More complex problems are being solved gradually and with greater accuracy as existing artificial intelligence techniques are developed and improved [Bannerjee et al. 2018].

Traditional methods used in agriculture have less and less influence on the modern world. Digitization in agriculture enables real-time analysis for more effective use of spraying, land management, and water management. The use of constantly evolving digital technology will also enable the agricultural industry to achieve benefits such as reducing production costs and preventing waste, achieving sustainable practices along with increasing productivity to meet the growing demand for food [Subeesh, Mehta 2021].

Artificial intelligence tools are great in agriculture at the stage of monitoring various processes and activities, thus allowing to reduce the labour force, but also to increase production. They can also be used to select crops and help the farmer select fertilizers. Using the database, machines can "communicate" with each other to decide which crop is suitable for harvesting and which fertilizers can ensure maximum growth [Jha et al. 2019].

ARTIFICIAL INTELLIGENCE TOOLS IN THE AGRICULTURAL SECTOR

Agriculture as a sector is labour-intensive. Work automation may be the solution to a given problem. Examples include automatic tractors, intelligent irrigation systems, spraying, fertilization systems, and artificial intelligence harvesting robots [Wongchai et al. 2022]. Artificial intelligence increases the flexibility of the agricultural sector by using modern technological solutions in the production process. For example, biosensors that allow you to monitor soil moisture and fertility [Anitha et al. 2022]. Instead of using

Table 1. Artificial intelligence tools used in agriculture with short description

Application	Description	References
Automation techniques in irrigation and fertilization	Automatic dosing of water and fertilizers depending on physicochemical conditions	Sitharthan et al. 2023
Crop health monitoring	Distinguishing healthy from diseased plants and transferring data for further processing	Tetila et al. 2017 Zermas et al. 2015
Identification of fruit maturity and size in crops	Distinguishing ripe from unripe fruit and sending data to the computer about the possibility of picking the fruit	Miranda et al. 2023
Usage of drones and wheel-robots	Identification of weeds by drones or wheel robots and use of chemical weed control	Wang et al. 2022
The Internet of Things (IoT) driven development	The use of several machines equipped with sensors and operating in a common Internet network in field management	Sitharthan et al. 2023
Prediction of weather	Predicting weather and other agricultural conditions such as land quality, groundwater, crop cycle, and plant disease detection	Tzachor et al. 2022
Improve decision making process	Data is being analysed and used for agricultural decision-making. The more significant usage of sensors, quicker access to satellite photos, lower prices for data loggers, expanded use of drones, and easier access to data. Surrounding temperature, weather conditions, water usage or soil conditions, and other farm-related data can be analysed to make better agricultural decisions.	Hemming et al. 2019, Banthia, Chaudaki 2021
Proper guidance on water management	Right advice on water management, crop rotation, timely harvesting, optimal planting, insect infestations, and other topics, identify potential diseases and pests in plant root systems.	Zhang 2020
Detect insects	Real-time analysis of crop yield, output, yield pattern, and price forecast based on previous data. Ai algorithms detect even very small insects. When an intrusion is detected, alerts are immediately sent to farmers' application, allowing them to take the necessary precautions.	Upadhyay, Gupta 2021

Source: own elaboration

basic linear regression models, raw data is collected using a variety of methods. Neural networks, in turn, can calculate and predict weather trends with non-linear relationships [Gambhire, Shaikh Mohammad 2020]. In the case of basic crops such as wheat or corn, artificial intelligence can be used to sow seeds at a specific time, because they require abundant rainfall to grow and their cultivation is traditional [Chen, Kuo 2022].

Artificial intelligence systems support the functioning of precision agriculture, increasing the accuracy and quality of harvests. Artificial intelligence tools enable early identification of pests, diseases, and nutrient deficiencies in agricultural production [Fariza et al. 2022]. Other parameters that can be monitored using artificial intelligence tools are: irrigation, weed protection, warehousing, pest protection, agriculture supply chain, soil management, harvesting, weather forecasting, decision making, or intelligent spraying [Javaid et al. 2023]. Examples of selected artificial intelligence tools with a brief description are provided in Table 1.

Artificial intelligence creates opportunities to automate various processes in the agricultural sector, thus moving towards more precise cultivation to improve the efficiency and quality of crops with limited availability of human resources. Nevertheless, it faces a number of challenges, including:

- AI ethics – responsibility for decisions made by AI systems, as well as issues related to the creation of false information;
- privacy and security – the challenge of protecting privacy and information security;
- changes in the labor market – AI may lead to the automation of some professions, especially those involving repetitive activities;
- investments in infrastructure – the development of AI requires large investment outlays both in equipment (e.g. communication networks, data centers, computer equipment, etc.) and in education;
- legal regulations – due to the dynamic development and ubiquity, there is a need to regulate the use of AI tools;
- natural environment – the impact of AI on the environment is complex. For example, the carbon dioxide emissions resulting from training one language processing model can be compared to the emissions needed to build and maintain 5 gasoline cars for 20 years;
- equal access of all countries to AI – there is a risk that the development of AI may lead to social and economic inequalities;
- bias – artificial intelligence trained on distorted data may generate distorted results;
- human safety – improper design of AI applications may pose a serious threat to humans [Piwowar et al. 2023].

CONCLUSIONS

Artificial intelligence will use data more and more intensively and involve human talents, and to a lesser extent factors of production known from the industrial era.

The future of artificial intelligence in agriculture will require a significant focus on universal access, as most modern and advanced technologies are mainly used on large and well-connected farms. Artificial intelligence has enormous potential to transform agriculture and may play a key role in its future. First, by analyzing huge amounts of data, AI can help farmers optimize their cultivation processes, which will increase efficiency and reduce production costs. Secondly, agriculture can use autonomous machines and robots that are controlled by AI, which will improve harvest efficiency and reduce the need for manual work. Third, artificial intelligence will allow for more accurate monitoring and management of soil and plant quality, which is crucial for healthy crop development and minimizing losses.

Additionally, AI can help identify plant pests and diseases and provide farmers with tools to manage them more effectively. In the future, artificial intelligence can be expected to support farmers in making fertilization and irrigation decisions based on accurate data and forecasts. Additionally, AI can help create more sustainable agricultural practices by optimizing the use of resources such as water and energy. Finally, emerging artificial intelligence will continue to transform agriculture, creating new opportunities and innovations that will help meet the growing demand for food on a global scale.

The automation of production processes in agriculture through the use of AI tools presents a promising future for sustainable and efficient food production. The adoption of these technologies is expected to play a vital role in meeting the global food demand while addressing the challenges faced by the agriculture sector. However, it is crucial to navigate these advancements responsibly, ensuring that the benefits of AI in agriculture are maximized while minimizing potential drawbacks

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AUTOMATYZACJA PROCESÓW PRODUKCYJNYCH W ROLNICTWIE Z WYKORZYSTANIEM WYBRANYCH NARZĘDZI SZTUCZNEJ INTELIGENCJI

Słowa kluczowe: rolnictwo, sztuczna inteligencja, automatyzacja procesów, produkcja, gospodarka

ABSTRAKT. W branży rolniczej następuje transformacyjna zmiana w kierunku większej wydajności i zrównoważonego rozwoju, przez integrację narzędzi sztucznej inteligencji (AI) z różnymi procesami produkcyjnymi. W artykule przedstawiono przegląd wybranych narzędzi AI i ich praktyczne zastosowanie w rolnictwie, rzucając światło na ich głęboki wpływ na zwiększanie plonów, zarządzanie zasobami i ogólną produktywność gospodarstwa. Przedstawiono także przegląd definicji sztucznej inteligencji (AI) oraz kalendarium rozpoczynające się od pierwszej wzmianki o sztucznej inteligencji, a kończące na teraźniejszości, umożliwiające lepsze zrozumienie opisywanego zagadnienia. Podkreślono znaczenie odpowiedzialnego rozwoju i integracji sztucznej inteligencji. Omówiono także etyczne i społeczne skutki sztucznej inteligencji w rolnictwie, takie jak przenoszenie stanowisk pracy i obawy dotyczące prywatności danych. Oczekuje się, że przyjęcie technologii sztucznej inteligencji odegra kluczową rolę w zaspokajaniu światowego zapotrzebowania na żywność, a jednocześnie pozwoli stawić czoła wyzwaniom stojącym przed sektorem rolnictwa. Jednak niezwykle istotne jest odpowiedzialne podejście do tych postępów, zapewniając maksymalizację korzyści ze sztucznej inteligencji w rolnictwie przy jednoczesnej minimalizacji potencjalnych wad.

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