Artificial Intelligence in Industry 4.0: The future that comes true: AI

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Implementation of Artificial Intelligence, Smart Sensors, Robots and Digital Transformation in Food and Agricultural Production

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Abstract: *Today, we use artificial intelligence every day without even being aware of it to a large extent. This paper systematically presents the development of artificial intelligence and its latest use together with sensors and robots in food and agricultural production. The application of such modern methods of production enables the monitoring of raw materials from the moment of production to the moment of consumption by the end user. Precise mapping and monitoring of crops is possible by using GPS receiver, as well as optimizing management through soil sampling, smart irrigation and fertilizer application. On the one hand, we initiate increased yield of agricultural products, and on the other hand, extended life of food, their health safety and reduced waste generation, which directly affects the economy and the environment. The paper presents concrete examples of the production of meals according to the user's wishes, as well as the development of the first energy drink using artificial intelligence.*

Keywords: *artificial inteligence, sensors, robots, food production, agricultural production.*

1. Introduction

The development of artificial intelligence began back in the mid-20th century, when many scientists and researchers began developing different approaches to create machines that could perform tasks typically associated with intelligent human behavior, such as image recognition, natural language processing, and problem solving.Since then it has taken place in several waves.In the 1970s it was slowed down by the limited computing power available and the lack of suitable algorithms.In the 1980s, it came back into focus thanks to the development of hardware that enabled faster and faster processing of ever larger amounts of data, and the development of neural networks and other machine learning techniques. In the last few years, the development of artificial intelligence has taken a significant leap thanks to the development of deep learning and the huge amounts of data that have become available in digital databases and on the Internet, and thanks to the fact that technology giants such as Google and Microsoft have begun to invest huge funds in artificial

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intelligence.We use artificial intelligence almost every day, for example to search for certain terms on the Internet, to play games, edit photos, drive using a navigation application (Google Maps), to shop on the Internet or to use a banking application. We use also artificial intelligence in numerous applications and tools such as automatic email classification, Internet search engines, smartphone cameras for face recognition and identification of people in photos, systems for finding new movies and series that we might likeon streaming platforms like Netflix and HBO, virtual assistants like Siri, Google Assistant and Amazon Alexa etc.

Artificial intelligence is ubiquitous around us and greatly helps modern man and makes his life easier. All these possibilities arise from the ability of artificial intelligence to imitate human traits such as reasoning, learning, planning and creativity. The computer receives data that has already been prepared or collected using its own sensors, processes it and gives answers.Artificial intelligence systems can adjust their behavior to a certain extent by analyzing previous situations and operating independently.

The market has expanded globally and become accessible to all, thanks to digitization and online business, resulting in intense competition. To stay ahead of the competition in global business, continuous advancement of current technology and the implementation of new artificial intelligence-based technologies are essential. Once considered a topic of science fiction, artificial intelligence (AI) has now emerged as a highly valuable asset in supermarkets and the food industry.

Since the inception of the Internet, AI has played a crucial role in gathering, categorizing, and distinguishing important information from irrelevant data in the vast sea of available information. In the upcoming section, we will examine in detail every aspect of how artificial intelligence is effective in both manufacturing and retail industries.

Artificial intelligence represents great potential for improving the food production and agriculture sectors and provides opportunities for improving effectiveness and encouraging sustainability.However, despite all the advantages, there are fears of inequality and job losses in rural areas, and there are also issues of high costs of implementing AI technologies.The future of food production and agriculture is most likely to be shaped by AI and machine learning technologies with possible applications in various fields – from agriculture to supply chain management [1]. In order for modern systems to be truly sustainable, numerous factors must be taken into account, including the development and application of AI technologies, the policies and regulations governing their use, as well as the way in which society adapts to the changes that artificial intelligence brings.Despite existing challenges such as data protection, privacy, high costs and ethical dilemmas, the future of applying the principles of artificial intelligence in agriculture looks promising [2].

1.1. Monitoring the Health of Crops

Monitoring the health of crops and controlling pests used to be simpler when farmers produced enough for their own consumption. With the shift to industrial agriculture, farmers now manage large areas of farmland, making it daunting to monitor the health of every hectare. However, the combination of AI and Internet-enabled devices can streamline this process. By placing sensors on either plants or soil, farmers can remotely track the well-being of their crops. When coupled with an artificial intelligence or machine learning system, this approach has the potential to generate data-driven insights that enhance plant breeding and overall yields.

1.2. Packaging Improvement and Extending Shelf Life in Supermarkets

Convenient food will become more and more necessary, as will the requirement for packaging free of contaminants [3]. Between 2022 and 2026, smart storage, which encompasses automation and industrial IoT, is projected to expand at a CAGR of 55.2% [4]. Automation of any or all of the packing process can boost output and efficiency while enhancing food safety and lowering the possibility of contamination. Food processing plants generate a huge amount of data. Although sell-by or expiration dates may appear arbitrary to the typical consumer, plant operators can use data collected over months or years to better understand product shelf life thanks to the application of AI systems.

1.3. Increasing Food Safety with Artificial Intelligence Applications

Every time a corporation has to recall products because of contamination, consumers have questions about food safety. To keep food edible, equipment must be cleaned and maintained. Many of these jobs can be accomplished by implementing an artificial intelligence system, increasing industrial production and efficiency without sacrificing safety [5].

In order to monitor the levels of water quality, it can also be added to water sources in food and beverage manufacturing plants. This will enable food processors to guarantee that the water used for sanitizing equipment is free of contaminants. Beverage producers can also use this data to keep an eye on levels of sulfate and chloride, which can alter the flavor of wine, beer, and other produced beverages.

As artificial intelligence enters the food industry, people are beginning to wonder if food or drink created by artificial intelligence is safe and if artificial intelligence helps improve food quality? Food safety is of great importance for both consumers and the food industry. It is very important that the food we consume is safe to eat, and the application of artificial intelligence in the food industry is widely recognized as a promising solution related to this topic.Today, artificial intelligence is an increasingly important tool for improving

transparency, verification, validation, traceability and development, communication and security throughout the supply chain and quality control.For example, only a few decades ago it was man himself who controlled some important characteristics of food quality, but today in the modern age that process has been improved through automated food processing systems controlled by artificial intelligence.Using sensors and cameras, these systems can detect and correct problems such as temperature, liquid levels, gas flow, humidity and even control food hygiene.

1.4. Establishing a Transparent Supply Chain

Transparency in the supply chain is crucial to the operation of any modern company. Customers like to do business with firms who share their commitment to minimizing their carbon footprint and environmental impact. They are constantly searching for methods to do this. Businesses who decide not to provide all relevant information about their supply chain frequently discover that they are losing clients quickly and have to find new tactics to gain them back.
Transparency in the supply chain is also crucial for tracking connections in the event of contamination or the need for resistance. Artificial intelligence, according to research, can assist in precisely predicting crop yields, enabling farmers to provide increased transparency while establishing reasonable expectations for other businesses downstream in the supply chain.

1.5. Reducing Food Waste in The Food Industry

Food waste is a major global issue. In 2021, it was 9.5 million tons in Great Britain. In the US, food waste amounts to around 108 billion pounds each year [4]. By altering the algorithms used to identify food and determine whether it should be sold, artificial intelligence systems can contribute to a decrease in these numbers. Many of these seemingly "ugly" fruit and vegetable products are actually completely edible, but their imperfect appearance causes them to be thrown in the garbage.Reducing food waste and keeping otherwise edible items out of landfills can be accomplished by altering these algorithms to take into account other factors in addition to obvious flaws.

1.6. Tracking the Origin of Food

In addition, artificial intelligence can be used to trace the origin of food products.Using artificial intelligence technology and algorithms, food manufacturers can track food products from farm to table, providing consumers with greater transparency and accountability in the food supply chain. Also, food manufacturers can predict the quality of their products throughout the entire production process, from raw materials to finished products.This technology can detect potential problems or defects in time, allowing manufacturers to take

personal AI assistant for a nutritionally balanced diet developed to create an even better user experience on the largest regional culinary platform - Coolinarika, by integrating GPT technology (Fig. 1). In addition to the website, SuperfoodChef-AI is also present on the Coolinarika mobile app available on Google Play or the Apple Store.The first Croatian AI assistant in the kitchen was created in a partnership between Podravka and the leading regional IT company Infobip and the international digital agency C3 Croatia - 01 Content & Technology, and is currently in the beta phase of development, that is, it is still under development and being upgraded.

Figure 1. SuperfoodChef-AI by Coolinarika

Podravka is among the leading brands in the world that have integrated generative AI technology on their digital channels.SuperfoodChef-AI is designed to show users the importance of a varied and nutritionally rich diet in a simple and interesting way, through an interesting conversation.The AI guide helps users with culinary and nutritional advice and recommendations of tasty and healthy recipes, with an emphasis on the so-calledsuperfoods.For example, they will answer questions about the nutritional value of beans and bananas or suggest a recipe rich in proteins. With this use of artificial intelligence, Podravka confirms its focus on innovation and the use of new, modern technologies, not only in production processes, but also in communication with consumers.At the time it was created, Coolinarika was an innovative and unique step forward for the food industry in direct communication with consumers, and today it is one of the most visited portals in Croatia, with almost 70,000 users visiting it every day.

The development of its own AI tool is another step in Podravka's development and improvement of user satisfaction and its relationship with consumers. They believe that this virtual assistant will contribute to the popularization of healthy eating and the promotion of healthy eating habits among visitors to Coolinarika. They continue to work on developments that will further improve user satisfaction, increase their engagement and further improve their user

experience. They are continuously working on the development of AI solutions that enable personalization of communication and provide users with innovative ways to interact with brands. For now, SuperfoodChef-AI has information on 30 foods and a database of about a hundred recipes, but it learns quickly and develops, enriches and supplements the knowledge base every day. The more it is used, the more successful it will become as an assistant in the daily cooking of nutritionally balanced meals [9].

2.2. Drinks Powered by AI

The first energy drink was completely developed by artificial intelligence in cooperation with the leading Hungarian energy drink manufacturer.Moreover, the artificial intelligence did not just come up with a new product, but tested and tasted the three flavors it proposed and, based on its own testing, chose the right one.After all this, the questions arise: How is artificial intelligence capable of tasting, how can it replace human perception, taste and smell?And how does he predict? Artificial intelligence is able to process an incredible amount of information from the web and add new data at a speed almost incomprehensible to humans.However, translating the human sense of taste into an artificial algorithm seems so unrealistic that we investigated how such a process takes place.

Namely, several companies around the world specialize in the digitization of tastes and smells. These companies use specially developed equipment, such as the so-called e-mouth and e-nose. For example, one company in New York has been collecting and processing primary samples for 10 years, digitizing ten years of sensor data and processing the largest and most diverse set of food and beverage sensor data on the market. This digital database is constantly expanding and updating, enabling accurate monitoring of changes and trends in perception and preferences. This is where artificial intelligence comes in, which can reliably predict from digital data entry how different consumers will react to a new product - without tasting it live.Hell was digitized by a New York based company and after analyzing a lot of data and statistics, the artificial intelligence used predictive intelligence to choose which flavor would be best for their new product.Artificial intelligence, in fact, can use the collected data to understand how different demographic groups perceive tastes, what they like and what they don't like. Based on this, artificial intelligence algorithms can predict how each demographic group (based on age, gender, socioeconomic status and place of residence) will like the taste, smell and texture of a new product.This recent innovation has resulted in, for the first time in the world, artificial intelligence being used in such a complex product development process in the energy drinks sector.The resulting product, Hell AI, one of Europe's most modern beverage production lines is already available to consumers (Fig. 2).

Figure 2. "Hell A.I." energy drink produced by the Hungarian company Hell energy

It is obvious that artificial intelligence has enormous potential in the field of product development, breaking down previously unimaginable boundaries and bringing new opportunities to the food industry.The ability of artificial intelligence to sort and analyze the vast amount of data available on the web in minutes or seconds can shorten the product development cycle from one to two years – or even half a year, at best – to one month.There are currently more than 100 artificial intelligences in the world - all of them are excellent in different areas and their combined action guarantees a high level of innovation. Therefore, one should definitely pay attention to the culinary revolution, which seems to be full of surprises that artificial intelligence can bring to the food industry in the near future.The possibilities offered by artificial intelligence are endless, and we are only just beginning to discover what it is capable of [10].
Use of technology Many companies today are turning to the use of artificial intelligence because it can be of great help in various industries.The capabilities of systems based on artificial intelligence are such that they process large amounts of data with the help of algorithms, make decisions in a short time, provide automated data analysis, and thus shorten many processes and save time. A recent example of the use of artificial intelligence comes from the Hungarian company Hell Energy which used artificial intelligence to develop every element of a new product from its taste, carefully selected ingredients, design and even marketing elements and guess what - the new product was even tried by artificial intelligence! So, artificial intelligence has already proven its value in various industries, from healthcare to finance, and now it is slowly entering the food industry as well.

2.3. Artificial Intelligence in Agriculture

Artificial intelligence (AI - Artificial Intelligence) in agriculture, by applying different methods of machine learning, algorithms and sensors, increases

efficiency, total yields and reduces costs in food production. Over time, agriculture has adapted to new technologies and scientific discoveries, with the aim of increasing productivity and optimizing food production.In the last few years, one of the most influential technological trends transforming agriculture is artificial intelligence (Fig. 3). Artificial intelligence (AI) refers to the ability of computer systems to perform tasks that typically require human intelligence, such as image recognition, natural language interpretation, decision making, and problem solving. AI in agriculture has started to gain importance in view of the growing global challenges such as climate change, loss of biodiversity and increased demand for food due to the growth of world population.The application of AI in agriculture is only in its initial phase and its impact is expected to only increase in the future.

Figure 3. Application of drones in precision agriculture

Precision agriculture represents a synergy between advanced technologies in the era of global information and established agricultural practices, and implies an integrated management approach that tries to adapt to the needs of crops on individual parts of the agricultural area.Precision agriculture distances itself from traditional practices through the application of advanced technologies such as GPS receivers that enable precise mapping and tracking of crops, thereby optimizing management and, for example, soil sampling methods and fertilizer application, for example, in adjusted and variable rations. Remote sensing methods are used to assess crop health and detect plant stress.The amount and speed of information that can be obtained through modern information systems change the traditional approach through the level of management that is specific to smaller units within the board or field.Key tools in precision agriculture include GIS systems, which are used to collect, visualize and analyze data, providing better insight for management decision-making. Efficient information management is essential for the application of precision agriculture techniques

and requires clearly defined goals and input parameters for decision-making. Precision agriculture enables farmers to use resources more efficiently, such as fertilizers, pesticides, biostimulators, feed, irrigation, etc., thereby achieving a higher yield and quality of crops with a reduced rate of environmental pollution with more efficient and rational agrotechnical procedures and reducing the impact of agricultural production on the soil, air andwater [11]. Agricultural robots are automated machines or robotic systems capable of performing tasks in an agricultural environment.The use of robots in agriculture offers a number of advantages including an economically viable way to keep up with growing demand through cheaper production (Fig. 4).Agricultural robots, such as those intended for harvesting or packaging products, are becoming more and more present in the agricultural sector.Autonomous machinery and drones are especially used on large agricultural areas.As technology and information systems advance, so do the number of tasks these robots can perform, including harvesting, sowing and even livestock tasks like shearing sheep and milking cows.

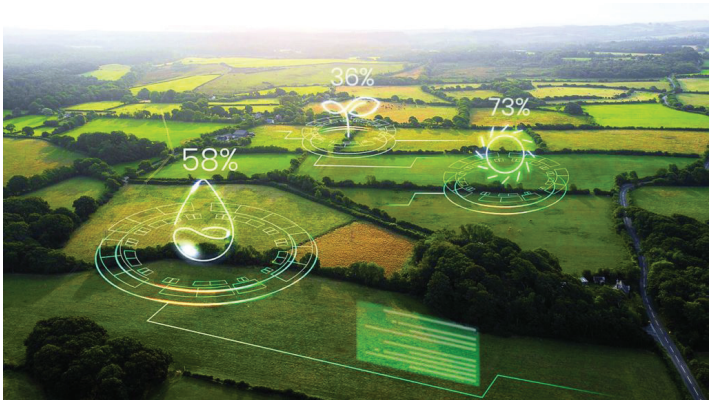

Figure 4. Collecting information from the field

2.3.1. Application of robots in agriculture

Predictive analytics tools use artificial intelligence, machine learning and advanced algorithms to predict future outcomes in agricultural production.These tools enable the analysis of large amounts of agricultural, biological, climatic, hydrological and economic data to predict crop outcomes, management changes, and other key issues in agricultural systems. Through crop modeling, the application of machine learning techniques and data analysis, precise forecasting and better decision-making is possible.With advances in analytical techniques, precision agriculture is being raised to a new level. One of the key advantages of using the mentioned models is the possibility of anticipating problems before

they appear.The key for the farmer is to anticipate and prevent problems, such as crop diseases or unfavorable growing conditions [12].This proactive approach not only minimizes risks, but also saves time, money and resources, instead of dealing with the consequences after a problem occurs.This strategy, in addition to preserving profitability, additionally ensures the sustainability of agricultural operations. The advantages of using such systems are numerous and include: selecting the best crop for certain climatic conditions, optimizing management procedures, improving crop productivity and making decisions in real time that are sustainable and economically profitable in the long run.In addition, the algorithms used to predict future outcomes can play a key role in reducing negative climate change, allowing farmers to better understand the impact of their production on the environment (Fig. 5).

Figure 5. Application of robots in agriculture

3. Conclusion

In this work, we have seen that the application of AI as a tool has a positive effect on increasing productivity and product quality.Although it cannot be said with certainty, but after technological innovations, i.e. the introduction of AI in food and agricultural production, new jobs will be created that will require new competencies of workers.Digitization, standardization and automation are all trends that no industrial sector can avoid.However, strengthening education and vocational training is extremely important for the development of new skills and occupations so that people do not become unemployed, because otherwise people would become incapable of participating in the development of society and technology.

4. References

[1] Bratovcic, A. (2022) Smart and sustainable food processing sector by integration of the concepts of the technologies behind Industry 4.0, Conference: International scientific conference Application of Industry 4.0 An opportunity for a new step forward in all industrial branches,146-163. DOI: 10.5644/PI2022.202.28

[2] Brandić, I. (2023) Kako umjetna inteligencija mijenja način proizvodnje hrane?, Poljoprivredna revolucija (gospodarski list) https://gospodarski.hr/rubrike/nove-tehnologije/kako-umjetna-inteligencija-mijenja-nacin-proizvodnje-hrane/

[3] Bratovcic, A. (2021). Physical – Chemical, Mechanical and Antimicrobial Properties of Bio-Nanocomposite Films and Edible Coatings. *International Journal for Research in Applied Sciences and Biotechnology*, *8*(5), 151–161. Retrieved from https://www.ijrasb.com/index.php/ijrasb/article/view/236

[4] [4] Steve Wynne-Jones, How AI Technology Can Make Food and Beverage Better, 20.07.2022. https://www.esmmagazine.com/technology/what-unique-applications-of-ai-can-make-food-and-beverage-better-analysis-180918 accessed on 23.06.2024.

[5] Bratovcic, A. (2023) Najnovija dostignuća u primjeni senzora, umjetne inteligencije i digitalne transformacije u prehrambenoj industriji, Časopis za savremena privredna kretanja, 1(*1*):76-84.

[6] Bratovcic, A. (2023) Sophisticated Transformation of Chemical, Pharmaceutical and Food Industry byImplementation of Digitalization and Automatization, *in Proceedings - International Scientific Conference Basic Technologies and Models for Implementation of Industry 4.0*, 21, 241-253. DOI: 10.5644/PI2023.209.11

[7] Umjetnainteligencijakaosvevažnijialat u prehrambenojindustriji, Čapljinski portal, https://caportal.net/2023/11/08/umjetna-inteligencija-kao-sve-vazniji-alat-u-prehrambenoj-industriji/

[8] Mesic, I. (2022),Učinkovitost umjetneinte ligencije u prehrambenoj industrij, In Store, https://instore.ba/ucinkovitost-umjetne-inteligencije-u-prehrambenoj-industriji/

[9] Spiljak, L. (2023) Podravka razvija prvog AI asistenta u prehrambenoj industriji u regiji

[10] https://www.tportal.hr/tehno/clanak/podravka-razvija-prvog-ai-asistenta-u-prehrambenoj-industriji-u-regiji-20231012

[11] Kako umjetna inteligencija može kušati i mirisati napitke?, Progressive, https://progressive.com.hr/?p=28529

[12] Bratovcic, A. (2022) Positive Aspects Of Nanotechnology On Agricultural Sustainable Development: Application Of Nanoparticles And Fibers For

Increasing Agricultural Yield, International Journal of Agriculture and Environmental Research, 8(6): 780 – 798. doi: 10.22004/ag.econ.333370

[13] Bratovcic, A. (2024) Role of Nanocomposites Using Graphene-Based Materials for food/Toxin-Sensing Applications in Agriculture, In Book Graphene-Based Nanomaterials, eBook ISBN 9781003300540. https://www.taylorfrancis.com/chapters/edit/10.1201/9781003300540-10/role-nanocomposites-using-graphene-based-materials-food-toxin-sensing-applications-agriculture-amra-bratovcic