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A Survey of Artificial Intelligence Use in the Food Industry

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ABSTRACT: Artificial intelligence has been widely used in the food business in recent years. Artificial intelligence has evolved into a catch-all word for systems that execute sophisticated tasks that formerly required human participation, such as conversing with clients via the Internet. The food business is increasingly relying on artificial intelligence to comprehend the various connections between tastes, smells, and other aspects that contribute to the success of food products. Artificial intelligence has grown in popularity in recent years as many organizations have invested in researching AI capabilities in the sector. This has aided food companies in managing their supply chains via logistics, predictive analytics, and transparency. We give a comprehensive assessment of the rapidly increasing use of artificial intelligence in the food industry. We introduce each paradigm and draw attention to associated research efforts in the area of artificial intelligence in the food industry. In addition, we discuss emerging developments in this field of study.

Keywords: (AI) Artificial Intelligence; Food industry

Introduction: Artificial intelligence (AI) has incorporated modern technology in the food business during the last few decades as food demands have increased in tandem with the world population. The ability of the aforementioned intelligent systems to perform a variety of activities such as food quality determination, control tools, food classification, and prediction purposes has increased their demand in the food business. Food consumption is expected to increase from 59 to 98% by 2050 [1]. Thus, in order to satisfy growing food demand, AI has been used in areas such as supply chain management, food sorting, production development, food quality improvements, and suitable industrial hygiene [2–3]. According to Sharma, the food processing and handling industries are predicted to develop at a CAGR of 5% or higher till 2021 [4]. According to Funes and coworkers [5,] ANN has been utilized as a tool to aid in difficult problem-solving in the food business, whereas Correa et al. claim that employing ANN makes parameter classification and prediction easier, which has resulted in increased ANN utilization demand in recent years

[6]. Also, FL and ANN acted as controllers in ensuring food safety, quality control, yield increase, and cost reduction [7, 8]. AI technologies have also been shown to be useful in food drying technology and drying process control [9–10]. Previous studies have shown multiple uses of AI in the food industry, with a focus on individual targets and goals. A study was undertaken on the various ANN applications in food process modeling, with the focus solely on food process modeling using ANN [11]. Aside from that, the application of artificial intelligence (AI) such as ANN, FL, and expert systems in the food industry has been examined, with an emphasis on the drying of fresh fruits [12]. A review has been conducted on how food safety has been one of the primary issues in the food business, leading to the creation of smart packaging solutions to meet the needs of the food supply chain. Intelligent packaging monitors the state of foods to provide information on the quality of the food during storage and transportation [13], Another study noted intelligent packaging as a technique for reducing food waste, and 45 recent improvements in the field of optical systems for freshness monitoring were described. The study focused on meat, fish products, fruits, and vegetables because they are the most representative fields of application [14]. Multiple studies on intelligent packaging have been conducted, and these studies proved that the use of intelligent packaging systems plays an essential role in the food factory in the context

The following contributions to cases of AI use in the food industry are made by this study:

1- Food safety:

The food safety system has emerged as one of the most significant application scenarios that use data-intensive methods to promote human sustainability and reduce its environmental impact.

Food safety is essential to human health and survival and requires advanced technologies to protect both consumers from foodborne illness and businesses from harm to their reputations [28]. By increasing food production, quality, and nutrition while lowering resource consumption and waste, AI and big data, often referred to as the fourth industrial revolution, have already had an important effect on the food sector [29]. Furthermore, recent research has looked into AI-based solutions for dealing with dietary issues that can lead to chronic disorders like hypertension [30]. AI tools also provide a powerful approach for predicting times and locations where there is an increased risk of foodborne pathogen presence or food contamination with foodborne pathogens (e.g., due to the presence of factors that facilitate pathogen transfer from the environment or other vectors to the finished product). Several studies that employed several predictor factors to estimate the risk of pathogen contamination of agricultural water and the likelihood of pathogen presence in fields used for produce production confirmed the power of this technique

particularly effectively. AI has the ability to influence various aspects of microbial food safety risk prediction. For example, a study on qPCR (quantitative polymerase chain reaction)-based COVID-19 diagnosis showed that AI-based techniques may be used to integrate PCR findings with data from completely different tests (in this case, CT scans of patients) to increase diagnostic accuracy (Mei et al. 2020). [31]. In a food safety context, a similar approach could be used during production or in the finished product to analyze qPCR amplification curves, which are used for pathogen detection, along with other data from the same sample (e.g., water turbidity, pH) to improve identification of foodborne pathogens in raw materials.

2- Improve food production quality:

Food is one of the complex activities developed by man throughout his history, beginning with his stability and knowledge of agriculture as a means to achieve something, influenced by his cultural and social background, which also contributed to his formation and helped him in his upbringing and gaining experiences around him. And now, less than 70 years after the phrase AI first arose, it has rapidly become a vital element of the world's most demanding sectors, and its impact has expanded oddly to all activities and fields. Artificial intelligence (AI) is altering the industry by finishing activities and making them more efficient. One area where AI can have a significant impact on day-to-day operations is the food industry allowing us to continue to offer always-diverse menus while also making it easier for consumers to identify products that match their tastes. AI skills have aided in the detection of plant pests and diseases as well as the improvement of soil health, resulting in perfect growing conditions and increased crop quality and quantity. For example, the Massachusetts Institute of Technology cooperated with the information technology firm Cognizant to find the best conditions for growing basil. They investigated ultraviolet radiation, light, heat, and soil salinity. By pooling this data, they can grow little amounts of basil in a controlled environment and then grow larger amounts with greater compounds that help them build basil plants that can combat diseases like diabetes. For Example [32].

Fig1. Artificial intelligence in the food industry

3- Cleaning and sterilization of production line equipment:

It is critical to clean all equipment and machinery used in food production to avoid food contamination and cross-infection, which requires a significant amount of time and money dependent on manpower. As a result, relying on artificial intelligence began to save a lot of money on industrial facilities. The University of Nottingham developed a self-improvement and cleaning-in-place system that uses fluorescence imaging and ultrasound to scan food residues in machinery and equipment after use, providing a more effective cleaning process by reducing the amount of water used (20%) to 40% and saving time by 50% due to the ability of this technology to clean without the need to disassemble the equipment. Food safety violations are among the most serious issues affecting establishments' reputations. It cost them millions of dollars in fines, prompting corporations to deploy robots that rely on artificial intelligence to reduce the dangers of food poisoning. Robots not only boost productivity and efficiency but the more they are used in manufacturing processes, the better the sanitation of machinery. Fraunhofer Institute for Process and Packaging Engineering scientists created two versions of the Mobile Scrubber Robot (4.0), which disinfects floors and manufacturing equipment using fluorescence sensing technology to identify any contamination. The built-in sensors use artificial intelligence to assess and estimate the amount of pollution in order to execute the sterilizing procedure, and the robot may be operated remotely over a Wi-Fi network [33]

4- Supply chain management:

One of the most significant concerns for food producers is managing supply chains as efficiently as possible since food companies utilize algorithms based on neural networks to monitor food shipments at every stage of the supply chain. Artificial intelligence also allows businesses to have a better understanding of their supply chains despite their complexity and ramifications, and it assists them in avoiding waste. For example, AI Company C3 has created an application that uses AI to improve inventory management, providing warehouse managers with real-time data on inventory levels and making stocking suggestions based on data from production and purchase orders over time [34].

5- Food processing and packaging:

Arranging food products in the correct place is one of the difficult tasks that require a lot of effort and time, so artificial intelligence is used to carry out these arduous tasks, but developing an artificial intelligence-based system to manage sorting and arrangement is very difficult due to the different shapes and sizes of food products. As a result, in order to perform its functions correctly and accurately, the artificial intelligence system must be trained. One of these systems is the Tomra system, which was created by the same-named prominent

food sorting company. Its use enhanced production accuracy immediately, by up to 90% The cameras in the system use near-infrared spectroscopy, X-rays, and lasers to measure and analyze all characteristics of moving vegetables [35] .

6- Predicting purchasing trends:

Artificial intelligence allows facilities to predict what their customers prefer by analyzing massive amounts of data, such as the nature of their purchases and their preferred flavors. This allows manufacturers to model future trends and develop their products faster, making it easier for companies to launch new products and recipes customized according to customers' desires at a faster rate and at a lower cost. For example, the Sears Palace Hotel uses artificial intelligence to collect data about its guests and then uses it to know their preferences, improve their reservations, and provide some complimentary meals for the guests to have a good experience, which helps them. Predict their future patterns and acquire them as long-term consumers. The Count is one of the Saudi companies that provide solutions in this field. It launched a product called Fruits360 that allows companies in this industry to make marketing and operational decisions based on historical data analysis, which helps them improve efficiency, boost sales, and reduce costs [36].

7- Self-service systems:

Customers enjoy self-service systems at restaurants because they assist them in their ordering process by presenting information about the nature of the order, their preferences, and newly added goods. This technology has aided in dealing with issues such as labor shortages, customer interaction, and others. Cecilia AI is an example of an artificial intelligence application. A skilled bartender can offer drinks with novel combinations in less than 30 seconds. It also informs customers about the drink menu and new products. It is distinguished by its modest size, making it appropriate for usage in restaurants, hotels, and ships [37].

Fig2. Image showing restaurants using visual artificial intelligence to double their profits

8- Automated services:

Some restaurants around the world use robots to serve meals to customers and prepare food, such as burgers, and drones are used to deliver food to customers faster than human forces, such as the Flippy robot developed by Caliburger, which can flip and prepare burgers and make fries using the Meizu analysis platform system, which provides deep insight to improve food quality and cook more accurately. However, due to exorbitant costs and regulatory considerations, adoption of this technology is still limited [38].

9- Customer feedback system:

Restaurants and cafes use artificial intelligence-based applications to predict the number and type of requests that are most acceptable to customers, as well as determine the foods and drinks that are required during certain seasonal periods and analyze the movements of customers and visitors to determine their food preferences and complaints. This assists in securing more orders that consumers desire, thus retaining their loyalty to the restaurant or café. McDonald's fast food firm used artificial intelligence in 2019 AD to examine previous data about the nature of what consumers order and was able to predict crowd times and anticipate the most popular dish during particular times. In the food business, AI can help improve the customer experience by controlling employee schedules and coordinating better customer service. It is also useful in identifying client trends and projecting future demands, giving you time to focus on other duties and opportunities. As a result, clients will receive better service and have a more satisfying experience overall. In this scenario, AI can be applied in two ways: prediction or guidance. One way technology can improve the customer experience is by personalizing the global experience and making it available to many other customers. The customer responds to certain interactions and then customizes what they do accordingly, and prescriptive intelligence makes recommendations based on customers' past experiences.

10- Reducing food waste:

Food waste is a major issue in the food industry, costing companies billions of dollars each year, and artificial intelligence can help limit this problem by working to solve it early, allowing supermarkets to scan and identify products that are still edible, allowing the producing entity to avoid throwing them away. Artificial intelligence also enables shops and restaurants with limited resources to evaluate the quality of food before putting it on the market and determine whether they need more of it or not, saving money. The Symphony Retail AI platform, for example, employs artificial intelligence to improve efficiency in the food supply chain, a process in which all procedures that make the end product edible and palatable are considered. Human consumption is tracked in order to reduce waste by pricing things fairly and delivering them to clients in the most efficient way possible. Artificial intelligence can help reduce food

waste at all stages of the supply chain by assessing data such as stock levels, order patterns, and expiration dates. Artificial intelligence algorithms can also help with production, distribution, and inventory management. AI-powered systems can more accurately estimate consumer demand, lowering the risk of unsold products and waste. AI's capacity to swiftly collect and evaluate massive volumes of data allows it to deliver actionable insights to avoid food waste and enhance resource use [39].

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