FUTURE AND EMERGING TECHNOLOGIES IN AI&ML

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Future and Emerging Technologies in AI & ML

Review

Machine Learning in Food Production: The Prospects and Applications

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ABSTRACT

When it comes to globally competitive industrial industries, the food processing and handling business stands head and shoulders above the others. Manufacturing and packaging food goods efficiently is mostly dependent on human labor. Because of human error, the food industry is both inefficient and unsafe, and it can't keep up with consumer demand. Industrial automation is the way to go for fixing these problems in the food industry. Foundational algorithms for all automation include those involving artificial intelligence (AI), machine learning (ML), and deep learning (DL). Using the AI-based solution may enhance operational efficiency while also facilitating better management of the food production and delivery operations. This post will go over some of the ways AI is helping the food industry save money and cut down on mistakes made by humans. Using different fitting algorithms for sales projection and increasing production, AI and data science may improve the quality of food outlets, hotels, and online meal delivery networks. Artificial intelligence (AI) has the ability to revolutionize packaging, extend product shelf life, integrate menu items with AI algorithms, and improve food safety through the establishment of a more open system for managing the supply chain. Artificial intelligence (AI) has made smart farming, robotic farming, and drones crucial to the food industry's future.

Keywords

Artificial intelligence (AI); Machine learning (ML); Deep learning (DL).

INTRODUCTION

The distribution of food, in the form of rations, is a well-known and essential human need, and it is often said that this is the finest product of farming. Productivity in the food business is critical to every nation's progress [1]. Not only that, but it plays a major part in how the national and global economies are shaping up. Consequently, there is a great need for the food business to ensure the safety and quality of its goods via appropriate distribution. Recent technological developments, such as artificial intelligence (AI), have been effective in achieving these goals [2]. For that reason, looking into the cutting-edge features of the food sector and smart agriculture powered by AI. These methods provide high-quality goods on schedule while also meeting societal needs. The food sector may boost its economics in an exponential way by making more food items utilizing these new technologies in less time [2]. The training accuracy and training time of the classifiers might be drastically reduced since most of the created datasets include an overwhelming amount of unnecessary and duplicated features. The computational difficulty of building classifiers increases due to this issue, which is sometimes referred to as the "curse of dimensionality" in data mining approaches. Machine learning and data mining are at the heart of feature selection, a vibrant and practical field of research. In order to identify a subclass, non-predictive data is removed throughout the feature selection phase. In order to aid administrators in making informed decisions about how to improve the educational system, Data Mining techniques applied to educational settings might unearth previously unknown information and trends.

Autonomous systems, which are based on artificial intelligence, are widely used in almost every technological domain. Computerizing the food business and transforming food industry items are both made possible by this [3]. It also allows the world to optimize issues more efficiently. Optimal conditions, including seed selection, crop monitoring, watering, and temperature monitoring, may be examined and improved with the use of a computerized system, allowing the food sector to produce high-quality goods [4, 5]. There are many more applications of AI than these. Processing, storing, and transporting food goods may also benefit from it. Intelligent technologies, including robotics and intelligent drones, may drastically cut packaging costs. In addition, it will facilitate the delivery of food items, the completion of the activity in risky situations, and the production of high-quality goods [6-8]. It is possible to classify the substantial roles played by AI in the food industry into two broad areas: food quality control and food security management. Figure 1 shows the function of ML in the beverage and food sector. Considering every facet of artificial intelligence (AI) in the food sector, this study reviews the literature on machine learning and AI in the food industry.

Sections on smart farming and artificial intelligence in the food processing business make up the remainder of the material. By using ensemble techniques like bagging, boosting, and voting, we were able to enhance the accuracy of the student performance model's classifiers. Several categorization approaches have been suggested by researchers in machine learning, pattern recognition, and statistics to address issues in educational research and enhance learning experiences. After that, we'll take a look at data analysis's function in the food industry, and then we'll talk about how machine learning is being used in the restaurant business. Because AI is so important in this area, we will talk about it in the following section when it comes to food safety. We take a look at the food industry's future using AI and ML. The conclusion is located in the last part of the work.

SMARTER FARMING

Soil monitoring, robo cropping, and predictive analysis are just a few of the many notable uses of AI in the food industry [9–11]. As seen in Figure 2, the food industry often employs AI. A description of each application is provided in the next section.

The food industries are now considering the advantages of AI-based systems for soil monitoring (2.1). To monitor the progress of soil and crop health in an AI-based system, computer vision and deep learning algorithms are vital for analyzing the data flow that AI-based agents get [10, 12-22]. Clients are given a detailed picture of their soil's advantages and disadvantages thanks to computerized technologies. Identifying ill crops and determining the most probable method for their growth is the key cause for developing the established system. In the present Soil Monitoring (SM) scenario, a comprehensive breakdown of the field soil's contents is sent to the client when the farmer provides a sample of the soil to the monitoring organization. Based on the results, the right choice has been made for the development of various microorganisms, including bacteria, fungi, and others.

More advanced technology has ushered in a new era of progress known as the Internet of Things (IoT). Decisions on agricultural and soil monitoring are greatly impacted by the Internet of Things [16]. The SM with IoT AI program aids the agricultural and food industries in maximising their profits, decreasing the probability of disease, and making the most of their current resources. These employ sensors to measure soil temperature, NPK (nitrogen, phosphorus, and potassium) concentration, moisture, water content, soil potential, photosynthesis, and oxygen levels [17]. In order to make the right decisions and take the right action at the right time, the data gathered from the different sensors is sent to the data center or the cloud. The data visualization that comes out of the study is great for making use of resources. For optimal crop yields and high-quality end results, it is necessary to understand system behavior by tracking soil trends and responding appropriately to events [16, 17]. Internet of Things is known as "smart agriculture" in the agricultural sector. The food sector that relies on the internet of things is called the smart food industry. It is possible that certain traits are unnecessary, useless, or have the same predictive power as others. "To evaluate these high-dimensional, multivariate data successfully, effective and robust feature selection (FS) approaches must be employed. This massive amount of data requires more memory space, more computing time and effort, and could potentially reduce the classifier's accuracy."

The Internet of Things (IoT) forms the backbone of agriculture by tracking soil, weather, and crops. The importance of weather and irrigation in agriculture based on the Internet of Things is well-known. An exquisite setting, including clean air and a well-kept irrigation system, is likewise linked to the astute agricultural explanations. The most common sensors and the types of measures they measure are listed in Table 1. A plethora of research [13–20] on smart farming has shown that by using these contemporary methods, revenue may be maximized and resources can be used to their full potential.

Table 1: Sensors And Types Of Measures Considered By The Respective Sensors

Type of sensor	Measurement
Weather	Rainfall, Warmth, Moisture, Air pressure, Speed of wind, Flow direction of wind
Temperature sensor	Soil temperature, Noncontact shell temperature
NPK soil sensors	Temperature level, Nitrogen level, Potassium level, pH level, Moisture level
	Phosphorous level
Moisture sensor	Volumetric water content, Water potential, Soil wetness, Conductivity
Solar radiation	Solar-shortwave, Active radiation, UV radiation

2.2 Predictive Analysis:

For instance, there are a number of environmental impacts on agricultural output that may be tracked and predicted using weather patterns. Important to this are machine learning algorithms. ML algorithms and satellites work together to evaluate farms for the presence of pests and illnesses, anticipate weather, and analyze agricultural sustainability. The model is great at providing up-to-date, high-quality data or information. In addition, the company has consistent access to over a billion stacks of agronomic data, so it is confident in the data it provides to customers. Important for forecasting

purposes are current and past values of precipitation, wind speed, sun radiation, and temperature. Those that were research considers a significant function in ensuring proper planning and crop choices for individual plots of farmland [20].

2.3 Robocrop:

The food industry is also making use of current technology-based tools to increase production, thanks to technological breakthroughs. Among the technologies developed by many research groups is robocrop [18]. Maximizing utility and consistency, this robotic system driven by AI boosts yields. All of the crop tools are lined up in the best possible way. A system that is both exact and high-resolution watches over food products when they enter the system. The collected picture is processed by a high-performance computer with a keen eye for the green band pixels along the crop line. Great typical crop center-line tracking is accomplished because to the many processing lines and the huge area gathered by the input devices [19]. Using the crop line region, the produced picture is contrasted with a ground truth gridiron pattern. Next, a hydraulic-based shift is used to align the instruments in the row depending on the gathered data. In addition to being able to select over infections in the background, the pattern-based feature makes the system incredibly healthy. Performance and output are both enhanced by the many cameras and sensors.

Robocropping, also known as agricultural automation, has greatly increased output in the last several decades, and many authors have accomplished outstanding work in this area [23–25]. As technology progressed and other advantages, including higher productivity and a smaller workforce, became apparent, these systems became more popular. The dual-arm harvesting robot, described in a previous publication [23], has two strategically positioned arms. The dual-arm robot that uses support vector machines is well-suited for picking fruits. Robotic weeding is a tool for agricultural automation that helps keep weeds at bay in specific areas, such as between rows of crops. A system that uses image processing to detect agricultural plants at different stages of development was developed for robotic weeding control [24]. One of the current systems is the Adaptive Robotic Chassis (ARC) [25], which was developed specifically for strawberry blossoms. The system's built-in camera records strawberry blossoms for analysis. The last step is to set the target coordinate, and then the robot may carry out the required operations. Input picture properties are the only determinant of the robocrop's performance. When the provided picture has more noticeable features, it yields great results. The crop shrubbery in each input picture sample should be around the RGB color band mean, and there should be more shrubbery in the crop than in the wildflower. An ADC adapter, a high-definition camera, several speed sensors, a hydraulic-based shaft, a three-point linkage frame, and other components make up a standard robocrop system. As seen in Figure 3, a robocrop is harvesting fruits [19].

Figure 3: Robocrop picking Fruits

2. MACHINE LEARNING UTILIZATION IN FOOD PROCESSING INDUSTRY

In this section, the writers will explore the significance and use of many aspects of artificial intelligence in the food processing business, such as pattern recognition, data science, deep learning, machine learning, and robots. Along with food processing, the food handling business is significant, with AI playing an important role in managing the complete processing unit task. Figure 4 depicts some major applications from the food processing and handling business.

Figure 4: Important Applications Taken From Food Processing And Handling Industry

2.1. Equipment upkeep and cleaning: The correct care and upkeep of processing equipment is crucial in the food processing sectors. AI-based systems can do this task with ease [33]. Numerous sensors and cameras are used to carry out the task in order to do this. One Whitwell and Martec product suffers from the fact that it can only be reduced to 50%, allowing for high efficiency and

less time. Martec is currently attempting to defend its AI-based cleaning place model. In order to cultivate the knowledge received for the development of the AI system, Martec uses optical fluorescence technologies and ultrasonic sensing imaging methods [34]. It counts how much food and microbiological waste are still present inside the appliance. After the whole testing result is made public, the system will take stand.

2.2. System for Customers' Decision-Making: It has been observed in numerous organizations that AI not only aids the food processing sectors in creating a variety of flavour amalgamations but also aids consumers in selecting cutting-edge essences [31]. In 2018, Kellog introduced Bear- Naked-Custom, a product that allows users to customize their granola using more than 50 ingredients.

It keeps track of each person's flavours, client preferences, and much more while taking care of them individually. Such information is crucial for the introduction of new products to the market [31, 32]. Consequently, AI once more played a beneficial role in the development of customer decision-making systems.

2.3. Demand-Supply Chain Management: As long as food industries are concerned about food safety policies, they must be more transparent about the journey of food products in the supply chain system. AI is used to monitor each stage of the process [1]. It handles everything from pricing to inventory management. It also handles forecasting and monitoring the course of possessions from where they are grown to where clients collect them. Symphony Retail, powered by AI, offers transportation booking, billing, and inventory management [36]. It also maintains discipline and avoids acquiring a large number of goods that result in depleted material.

2.4. Personal hygiene and sanitization: It has also been discovered in the literature that numerous nations around the world, including the USA, introduced a guideline for food processing unit sanitation. The AI-based systems have also taken care of these rules. Initially, an AI-based system was created in collaboration with Kan-Kan and the Shanghai municipal health office. The first AI- based system is made to recognise objects and faces for an anonymous user. The method is used to keep an eye on people who disobey the rules [30]. If there are any matches, the situation can be settled immediately and without any wait. The developed system produces excellent outcomes, hence it has been intended to be expanded to include an increasing number of organizations.

2.5. Launching New Products: For any production unit, the in-

troduction of new items is a laborious task. It entirely depends on the interests of the consumer, particularly in the case of the food businesses. As a result, the data gathered for customers by the various decision-making processes is beneficial for the introduction of new items. The ML-based module processes the information that has been gathered before making the appropriate decision for the product [2, 35]. Questions like "what customers are exactly looking out for" have been addressed by adopting an ML-based strategy. The power of artificial intelligence is currently being used by almost all food processing and food product packaging sectors to grow and introduce new items to the market. Previously, this task was done through a case study or a survey. As a result, the system's success rate is extremely low. The entire scenario has changed, and AI and ML are now widely used for such tasks.

2.6. Sorting and packaging of products: One of the time-consuming and tiresome jobs for production units in the food processing business is the proper ordering and packing of food goods. Therefore, such a tedious task can be handled by AI-based systems, reducing the possibility of error and rapidly increasing the industry's production rate. The development of AI-based systems is a difficult task due to the irregularities in shapes, colours, and sizes of vegetables and fruits. A substantial amount of data is required for the development of an AI-based sorting and packing system in order for the system to be correctly trained and perform the task efficiently [26, 27].

Various research groups created various systems for the same objective. TOMRA is one of them, and it executes the sorting process quite efficiently. It quickly enhanced manufacturing with a 90% accuracy. The majority of product sorting and packaging operations are now performed by an automated system. Industries got benefits from employing such methods, such as faster production rates, higher quality yields, and lower labour costs.

Figure 4 depicts significant applications from the food processing and handling industry. The AI- based intelligent decision-making systems are made up of a variety of instruments and approaches, such as high-resolution cameras, laser-technology-based systems, X-ray-based systems, and IR spectroscopy. At the input channel, these techniques and technologies are utilised to analyse every element of food goods such as fruits and vegetables. Conventional systems can only distinguish between good and bad products based on their look. TOMRA has been shown to improve the detaching and ordering problem by 5-10% in the instance of potatoes alone [28, 29]. The same type of challenge was handled by a Japanese corporation that employs a TensorFlow ML-based system and obtained a spectacular result and huge benefit in their assembling unit. This approach produced outstanding outcomes for other food processing industries also. In addition, each organization found that the AI-based system works more precisely.

3. THE EVALUATION OF DATA IN THE FOOD SECTOR

There are numerous well-known brands and food outlets in the food industry. Because of increased rivalry, this industry is losing its allure for starting a new business [37]. In the food sector, leveraging technology, particularly data science, is the only way to stay ahead of the competition. Figure 5 depicts information on data analysis in the food industry.

3.1. Sharing New Recipes: By combining the ingredients, a same recipe can be cooked in a variety of ways. Furthermore, those elements can be prepared in a variety of various ways, opening up a world of unlimited possibilities for cooking dishes. Multiple recipes are available online and contain a large dataset that allows for the research of components in various cuisines from the common man to pros. The scholars can identify both the differences and similarities across various cuisines [40]. North American and Western European cuisines, for example, are entirely reliant on items that contain the same flavour components that East Asian and Southern European cuisines reject.

3.2. Food Delivery Reimagined: Swiggy, Zomato, and Ubereat, for example, contain a vast quantity of data based on their customers' ordering behaviours and dish preferences. Data science and artificial intelligence (AI) can be used by food-based professionals to create simpler, more cost-effective, and time-efficient means of delivering the product [41]. AI is providing some established sectors with legitimate opportunities for market dominance. However, it is still in its infancy in the food sector and, as such, requires more skilled optimisation by food firms as well so that customers can acquire their food with better services.

3.3. Customer Satisfaction: The founder of Gobble, Ooshma Garg, expressed the idea that the food sector can be compared to a software company. For the rest of the world, it was a debatable claim, but there is some truth to it [37, 38]. For modern technology-driven industries to elevate and manage their different business practises, data science has become a requirement. Gobble is an excellent example of a sector that totally depends on data science to forecast both its clients' supply and demand. It provides ten-minute supper kits to its customers and has thousands of regular customers who can choose from a variety of menu options. It gathers information about past purchases, customer behaviour, feedback, and food preferences throughout various time periods.

Figure 5: Evaluation of Data in the Food Sector

4. MACHINE LEARNING APPLICATION IN RESTAURANT BUSINESSES

Machine learning techniques have several potential applications beyond the development of automated systems, robocrops, soil monitoring, and the introduction of new products. The hospitality sector may find it helpful for a range of tasks as well [42, 43]. Several machine learning (ML) uses in the food service sector are shown in Figure 6.

A Search Engine for Online Restaurants Driven by AI: Customers often see how a café, bar, or restaurant stacks up against its rivals before making a final decision. Therefore, in order to draw in new customers and hold on to the ones they already have, it is crucial for a food and beverage firm to find out what people think, both good and bad. These days, most people find a restaurant online, either via Google or some other search engine. Based on a user's location and ratings, AI is using this data to recommend a café or restaurant

that they would like [45]. Notifying consumers about local specials, events, and special deals is another function of these AI assistants.

4.2. Machine Learning in Food Delivery: Delivery route selection, raw material supply, demand forecasting, logistics planning, and other related challenges may be efficiently addressed with the use of machine learning (ML) [48]. Machine learning (ML) may solve the delivery route problems by coordinating the agent's position with current or future traffic conditions and then providing them with real-time advice on the best route. When timely and efficient delivery is guaranteed, it is easier to regularly fulfill orders and handle problems like running out of delivery staff or getting late supplies. Another benefit of ML is that it allows for the gradual accumulation of data, which, when processed using different algorithms based on artificial intelligence, may lead to a more intelligent system overall. This examination might be carried out using advanced AI-based technologies such as deep learning (DL), which provide users a competitive advantage.

Voice Assistants (4.3): About a quarter of people said they would rather use voice search than the more conventional method of typing in a search query. Consequently, a new speech commerce platform similar to Amazon's Alexa has been developed, and voice-based searching is being integrated into all e-commerce sectors, including food. For new eateries, this means they can take rapid orders using voice commerce apps without having to look up details [46].

4.4. The Functions of Food Vending Machines: Building a reliable system to provide its services to the public online is the next step for a food-selling firm after selecting its menu and marketing strategy. Either a web-based platform that allows for expedited ordering and suggestions or an app with extra features like an AI-based system may constitute this system. Because of the proliferation of food-based e-commerce apps, adding one's food-selling organization to their repository is a fantastic decision [44]. The business may still be motivated to construct it by the amount of commission paid by the e-commerce, but it allows them to have the greatest functionality of these apps without spending more money on creating them themselves. With the use of AI, the business may automate customer care processes such as staff assignment, report generation, and customer complaint resolution.

A System for Collecting Customer Feedback Utilizing Artificial Intelligence (4.5): These days, the food service industry offers a plethora of apps that help with inventory forecasting, order amount and type prediction, and more. You may use this data to scientifically analyze the quantity of food and guests needed over time [43]. This information is derived from a combination of sources, including past encounters with customers, their meal preferences, routines, complaints, and the delivery of essential items at that period. Applications based on food service may increase their client loyalty via increased meal orders from current and future customers thanks to the results of data collection and analysis. On top of that, it helps with addressing the shortcomings and complaints that enhance the reliability and security of these apps [44]. The features of the food-service apps are enhanced by other apps, such as those for managing the restaurant, accepting payments, storing huge data in the cloud, and even scheduling tables at restaurants. Using a numerical equation as a guide, the method's particles, which stand in for potential solutions, are moved around the chosen search area at varying speeds and positions. Conventional wisdom is that the particle's local best-known location in the search space has the most bearing on its motion.

Figure 6: Machine Learning Application in Restaurant Businesses

5. UTILIZATION MACHINE LEARNING TO IMPROVE THE SECURITY OF FOOD

Robotic technology is highly accepted in the food processing industry because of how sterile it is. This characteristic significantly lowers the incidence of disorders connected to eating. Stricter sanitary requirements have been developed by the Food Safety Modernization Act (FSMA), and they apply to entire supply chain systems. Cereals, spices, and other foods that do not require refrigerators and are located in areas that are most vulnerable to contamination are the root of the problem. Such food goods were formerly free from contamination, but the situation has now altered. AI-based solutions can undoubtedly aid in the solution of challenges of this nature. They cannot spread diseases the way that humans can. However, an AI-based system's upkeep is quick and easy. Additionally, there are some fresh, ground-breaking developments in food safety methods that employ artificial intelligence that are expected to gain popularity shortly. Their main goal is to reduce the incidence of food-borne illnesses.

5.1. Food waste management: According to a survey released by the American Department of Agriculture, between 30 and 40 percent of the nation's food supply is wasted. According to this estimate, which was based on figures from the USDA's Economic Research Service, there were approximately 133 billion pounds and $161 billion worth of food lost at the retail and consumer levels in 2010. The effects of this waste on society are extensive. By 2030, AI will be able to handle these kinds of problems and save a significant proportion of food waste, claims McKinsey. By implementing additional regenerative leisure farming practises, such startling numbers can be achieved [51]. It demonstrates that people are not effectively using the resources at their disposal. The more intelligent farming techniques can take the place of the conventional ones. Different sensors are installed in this to get the data. Following the processing of the data using ML

algorithms, the proper decisions are made. Farmers can make the most rapid and precise selections by utilising these.

5.2. Electric noses and next-generation sequencing: Next-generation sequencing (NGS) and electronic noses (ENs) are the two most exciting developments in the food sector. Very soon, NGS replaces the DNA method in the field of food security. Data capture and lab-oratory trials are now developed more quickly and correctly than ever thanks to the development of AI-based automated tools and workflows. Hazardous inclination can be promptly and effectively found using the NGS. Additionally, it can stop illness epidem-

ics before a significant number of people become impaired. ENs are typically used in manufacturing environments as a substitute for a person's muzzle. There are certain sensors set up that can accurately distinguish between various odours. These sensors only pick up smells from their surroundings, and the collected data is sent to a data centre where ML algorithms may access it [49, 50]. An warning signal is sent to the manufacturing units in accordance with the choice reached by the machine learning system. Consequently, EN may represent the future of food product safety.

6. THE FUTURE OF ML IN THE FOOD INDUSTRY

Following a review of the food industry literature, it is clear that there is a significant demand for investment in the food processing and manufacturing industries. methods that use AI can discover numerous challenges in food production more easily than human-based methods. It has also been observed that researchers are heavily involved in this field. Gayama, a Swiss agrotech firm, is an excellent example of one such firm, having received $3.2 million for an artificial-intelligence- driven project. The technology is built on hyperspectral cameras that can detect slight changes in water intensity, nutrients, vermin, and agricultural yields. The artificial intelligence algorithm then detects potential intimidation and sends alert signals to farmers, allowing them to plan accordingly. The artificial intelligence method will also suggest convincing actions that farmers must do in order to make the most use of available resources. Satellite data can also be used to analyse the Earth's surface using ML and deep learning approaches [52, 53]. The major goal is to find areas where the government or its shareholders can provide assistance in improving the crop and therefore improving the outcome. It has also been observed that farming is static and outmoded in many parts of the world. It may be phased out in the near future by smart farming. AI has the potential to adopt smart farming and solve the current crisis in the future. Smart farming might increase yields by at least 60% if implemented successfully. Although ML and AI are promising tools, there will be a plethora of options to eliminate waste in food producing businesses.

7. CONCLUSION

The research provided a wealth of information in a precise way to show how AI may benefit food businesses. Now even the most rudimentary kind of AI is being used by the food business. The ability of AI to enhance sanitation, food safety, and waste management systems is elevating its position in these fields. Because AI can deliver fair and healthier productivity for workers and consumers, it will change the food processing industry in the future. Already, artificial intelligence (AI) and machine learning (ML) are improving the food production and restaurant operations sector by decreasing human mistake in manufacturing and, to a lesser degree, remaining surplus. Reduced packaging and delivery expenses, increased customer happiness, accelerated service, voice search capabilities, and more customized purchases are all benefits of this technology. Even major food enterprises may profit from these business aspects, and they will pay off in the long run.

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