Empirical study on investigation of applications of Artificial Intelligence in Food Safety

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ABSTRACT

The food industry currently place a strong emphasis on food safety. Food safety is important for public health. Looking at data from the World Health Organization (WHO), which predicts that 600 million people (nearly 1 in 10) get sick every year after consuming contaminated food, resulting in around 420,000 deaths, makes it very evident. Food safety is the practices of handling, preparing, and storing food in a way that minimizes the possibility that people would contract a food-borne illness.

In this study we reviewed many applications, comparing their benefits, limitations, and establishments as a guideline for selecting the suitable techniques for increasing AI and food safety-related advances. Additionally, the integration of this system with other devices such as an electronic nose, tongue, and computer vision system, 3D printing, and near-infrared spectroscopy (NIR) is stressed, all of which will benefit both industry participants and consumers.

It has been discovered that by developing and applying artificial intelligence approaches, one may enhance the quality and services of food while also lowering the risks to food safety in a variety of industries, including the dairy, bakery, beverage, fruit, and vegetable sectors.

In light of the Covid-19 outbreak, this study concludes studies on how food is handled from the farm to the workplace and how any neglect can devastate society. Strict regulation, an update to the food handling procedures, and measures to stop the spread of new infectious diseases related to food are all advised by this evaluation.

Keywords: AI, Food industry, Food sensors, Model development guidelines, Covid-19, Farm to fork

1. Introduction

Artificial intelligence (AI) is a branch of computer science (Schroer, 2023) that mimics human thinking processes, learning ability, and knowledge storage. Among the industries that have made use of AI methods are gaming, weather forecasting, heavy industry, process industry, food industry, medical industry, data mining, stem cells, and knowledge representation.AI algorithms include reinforcement learning, expert systems, fuzzy logic (FL), swarm intelligence, the Turing test, cognitive science, artificial neural networks (ANN), and logic programming. (Nidhi Rajesh Mavani, 2021) AI's enticing performance has made it the most appealing tool to use in industries

such as decision making and process estimation, with the objective of reducing overall costs, increasing efficiency, and increasing profitability. Food demand is expected to rise from 59 to 98% by 2050 as the world's population grows. Thus, to meet this food demand, AI has been used in areas such as supply chain management, food sorting, production development, food quality improvement, and proper industrial hygiene.

The AI method provides numerous benefits, and its use in the food industry has been increasing for decades. AI has been effectively used for applications such as sorting fresh produce, supply chain management, food safety monitoring procedures, optimal cleaning in place systems, predicting consumer desire, and new product development, with improved efficiency and cost savings (Isahit).Nonetheless, this paper will focus on the application of AI in food industries beginning in 2015, as there has been a tremendous increase in implementation and innovation recently.

2. Role of AI in Food Safety

AI or machine learning (ML) is a relatively new modeling system that has observed widespread application in real-world problems (What is Machine Learning? Defination, Types, Applications, and more, 2023). AI has been used in a variety of fields, including modelling, classification, and data analysis. In food science and processing, AI has been utilized for sorting, quality control of food samples, and wine analysis. CIP and COP systems help the food industry in maintaining hygiene and maintaining high product standards. Even these systems function with the assistance of AI. These are known as SOCIP (Self-Optimizing Clean In Place). (Mounika Addanki, 2022) AI in agribusiness generally requires data analysis, decision making, and good activity by applying machine power to a early diagnosis of yield sicknesses, and increasing farming inputs and profits.

As AI capabilities advance, food safety professionals will have an influence on the tools and algorithms used throughout the food industry, including the retail sector (Adam Friedlander, 2020). AI can improve food safety, but it will require strategic collaborations across the supply chain, including with technology providers, regulators, and academics, to be successful.

3. Different fields of artificial intelligence

Several artificial intelligence (AI) methods are being used in food safety to improve the efficiency and accuracy of food safety inspections, identify and prevent food contamination, and enable better traceability and recall management. Among these techniques are:

3.1 Machine learning(ML) -

Large volumes of food safety data are being analyzed using machine learning algorithms to identify patterns and trends that may indicate potential food contamination (Cangyu Jin 1 2, 2020). These algorithms can also be used to create predictive models that can help in the detection of potential food safety hazards before they occur.

3.2 Computer Vision (CV) -

Food safety inspections are being automated using computer vision technology, which analyses images and videos of food products to detect potential issues such as contamination, spoilage, or damage. This can aid in improving the precision and efficiency of food safety inspections. (Rijwan Khan, 2021)

3.3 Natural Language Processing (NLP) -

To identify potential food safety issues, NLP techniques are being used to analyze unstructured data such as customer complaints, social media posts, and online reviews. This can enable food safety agencies and businesses in identifying potential issues that traditional inspection methods may not detect. (Noor Sakinah Shaeeali, 2020)

3.4 Internet of Things (IoT) -

Sensors and RFID tags, for example, are being used to collect real-time data on food products throughout the supply chain. AI can be used to assess this data in order to improve traceability and recall management, as well as identify potential food safety risks before they occur. (Jinsong Zuo, 2022)

3.5 Robotics -

Robotics technology is being used to automate food production processes, allowing companies to reduce the risk of contamination while also improving the accuracy and efficiency of food safety inspections. (Damini, 2023)

Overall, these AI methods are assisting in the improvement of food safety by allowing for faster and more accurate inspections, detecting potential risks before they occur, and improving traceability and recall management.

4. Applications of artificial intelligence in food safety

4.1 Sorting Fresh Produce -

One of the most difficult challenges that food processing plants face is the inconsistency of feed-stock availability. (Adams, 2018) Manual sorting is used in food processing plants to sift and sort vegetables, resulting in inefficiency and increased costs. Food processing companies can achieve significant automation for food cataloging by combining cameras, lasers, and machine learning to enable more efficient food sorting. For example, by deploying Artificial Intelligence involving sensor-based optical sorting solutions, the time-consuming processes of sorting fresh produce can be eliminated, resulting in higher yields with better quality and less waste. AI is being used to better calibrate machines in order to manage multiple product sizes while reducing waste and costs.

4.2 Food Processing -

Many food processing plants are not fully automated. Artificial intelligence is helping the food processing industry with everything from sorting foods to maintaining health and safety

compliance's, developing new products, and improving the supply chain. Essentially, technology is assisting in the streamlining of work processes, making employees' jobs easier and operations more efficient (Agbai, 2020). By automating as many of their processes as possible, the food processing industry can ensure complete hygiene and high food quality.

4.3 Anticipating Consumer Preferences -

Food manufacturers use artificial intelligence-based solutions to clearly anticipate and model their target consumers' flavour preferences, as well as predict their response to such new tastes. Predictive analytic based on artificial intelligence will assist food manufacturers in developing new food products that are closely aligned with consumer tastes and preferences.AI 3D printing can be used to customize food products for specific consumers to improve food safety. Companies can reduce the risk of contamination or allergen exposure by creating products that cater to specific dietary needs or preferences.

In the COVID-19 era, 3D food printing becomes a significant turning point for non-face-to-face and personalized businesses. (Lee, 2021) 3D food printing is a technology that allows for the direct production of small quantities by means of 3D digital design and personalized nutrition data. However, due to the printing characteristics of various food groups, the current development stage of 3D food printing technology is only at the level of making a product with a simple form or only one material, and separate material processing is required to achieve an appropriate level of print quality.

4.4 Food Production -

AI is being used in advanced applications to improve the efficiency, safety, and profitability of food production. It has enormous potential for optimizing production and identifying the best operating points for manufacturing facilities.

The electronic nose, or E-nose, is a device designed to detect odors or flavors in the same way that the human nose does. (J.S. Kauer, 2009) It is composed of a network of electronic chemical sensors capable of detecting both simple and complex odors. Furthermore, controlling product quality is critical in the food industry. It has been used as an environmental protection tool as well as for explosives detection due to its ability to detect complex odors.

4.5 Food Packaging -

AI-powered robotic equipment can perform complex human tasks like packaging with precision. Near-infrared spectroscopy (NIRS) is a technology that uses AI algorithms to examine the near-infrared light wavelengths reflected or absorbed by food items. (Weixin Ye 1, 2022) By analyzing spectral data, AI NIRS can detect potential contaminants or quality issues in food products. Early detection of these issues enables businesses to take action to prevent contaminated goods from entering the food supply chain, thereby improving food safety. By analyzing the chemical composition of food products, AI NIRS can be used to authenticate their origin and quality. This can aid in the prevention of food fraud and ensure that consumers receive the products they expect.

4.6 Efficient Supply Chain Management -

With the increasing demand for transparency, supply chain management is a top priority for all food companies. To meet consumer demands, the food industry must supply markets with high-quality food products at reasonable prices. AI-powered supply chain management systems can be used to monitor and control the entire supply chain. AI can be used to reduce delays and increase profit margins by closely monitoring every supply chain operation. AI also aids in the efficient and transparent tracking of produce from farm to consumer, leading to increased consumer confidence. (Bonanni, 2019)

4.7 Robotics -

Robots are widely used in the food industry, but they are only available to large corporations and are still out of reach for small and medium-sized businesses. Robots are used for everything from seeding, water spraying, and harvesting to cutting, processing, and packaging food products. (Anas Mathath, 2017)

5. The Challenges to AI Adoption in the Food Industry -

AI implementation in the food and beverage industry enables fewer human errors, less waste of abundant products, cost savings, happier customers, process optimization and automation, and more personalized orders. While there are numerous advantages to using AI in the food industry, there are some drawbacks. AI has yet to become widespread due to cost constraints and a scarcity of skilled experts. The high cost of large-scale deployment in the sector limits the market's ability to grow. It is never easy to integrate new technologies, such as AI into food companies. While AI technology is still in its infancy, there is a growing demand for specialized skill sets in data collection and analysis. The technology can essentially work alongside humans to improve operational efficiency. (Spd.group, 2021)

6. Conclusion -

In conclusion, AI has played a significant role in the food industry for a variety of purposes such as modeling, prediction, control tool, food drying, sensory evaluation, quality control, and solving complex problems in food processing. Aside from that, AI can improve business strategies by predicting sales and increasing yield. The applications of AI, their benefits and limitations, as well as the integration of the algorithms with various sensors such as E-nose, NIRS, and 3D printing in the food industry, are critically summarized. While AI holds great promise, the future depends on collaborative efforts among the food industry, policymakers, and technologists. (Roy, 2018)

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