Technical Brief

Artificial Intelligence (AI) and Food Safety

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This technical brief provides a general introduction into the application of artificial intelligence (AI) to food supply chains, with particular focus on food safety.

What is AI?

Mechanisation, automation and image processing is already widely used in food safety systems, e.g. the use of check weighers, thermal cameras, X-ray scanning in meat plants, use of scanning to identify foreign bodies, and metal detection. Electronic noses, or e-noses, have been developed as sensing devices that can detect odours, and e-tongues use chemical sensors to provide taste information.

AI as an all-encompassing term and has been described as the science and engineering that has been combined to make 'intelligence' through using software on its own, or software built into hardware, that can sense, interact, learn and provide feedback or make predictions [1]. It is a term which includes the development of computer systems together with specific data sets, sensors or automated analytical techniques that can be used to solve specific problems. AI can help organisations to collect the appropriate data to implement controls at food safety critical control points (CCPs) or make predictions, independently or with human intervention, about the safety of food [2]. The intelligence aspect is the ability of these systems to perceive (see, hear, smell, touch), move, pick, pack or palletise items (robotics) and the mechanism for bringing data together. Then to provide information and business intelligence, for example, on aspects of food safety, quality or business performance.

What are the uses of AI in food supply chains?

These include:

- substituting human tasks with automated activities to improve efficiency and productivity e.g. colour grading on-line or robotic picking of fruits and vegetables
- performing complex tasks that require a high level of data processing through applying a series of rules to a given problem, and utilising the data being collected to improve the efficacy of the task and the quality of final product, e.g. automating and integrating traceability functions
- performance of tasks that are currently beyond the capabilities of humans with the tools they have available, e.g. accurate crop yield prediction [3].

How can AI be applied in a food context?

The science of AI is complex so only three aspects are considered here:

- analytical tools
- computer vision systems
- natural language processing

Firstly, analytical tools that focus on food safety and food quality. **Machine learning** is a branch of AI and computer science which 'focuses on the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy' [4]. An example is a Bayesian Network Model that has been developed, based on data within the European Commission Rapid Alert System for Food and Feed (RASFF) to predict food fraud [5]. There are a number of commercial systems that are utilising RASFF data to develop prediction tools, e.g. FoodAKAI and 3iVerify, often using product lifecycle management or traceability systems as a basic functionality [6]. Machine learning can also be used to predict food safety risk factors in supply chains, screening of suppliers and real-time detection of food-borne illness, or prediction of antimicrobial resistance within a microorganism population [3]. AI models allow for food safety prediction, e.g. in the development of HACCP plans and food safety management systems, using past data related to known hazards and to consider food safety culture [7]. An example of AI enabled culture assessment tools is CultureAmp [8]. Generative AI, such as ChatGPT uses a form of text-based machine learning via a ChatBot that can create content based on being asked a question. There is interest in the use of ChatBots in developing food safety awareness and knowledge, and there is potential for their use, in combination with augmented reality technology, in food safety training.

Computer vision systems

Computer vision systems use AI applications. They are composed of two key elements: image acquisition and image processing. The former is through a 'camera' or scanner and the image processing manipulates the digital images to forms that can be used within the vision system [9]. The characteristics that might be of interest could be colour, shape, size, depending on the problem that needs to be solved, e.g. grading of cherries for different supermarket specifications. Most attributes may be related to quality rather than safety aspects, such as mould contamination, spray deposits and insect infestation. Image processing involves the selection of the appropriate algorithm and associated parameters, to develop the computational model, in this case cherry quality and safety attributes. The model then needs to be trained using a dataset. The quality of the dataset, relevance to the problem, the varieties of product being considered, and so on, will affect the accuracy of the predictions which the computational model makes. The computational model then needs to be tested for accuracy and repeatability [9]. A recent example is the use of a computer vision-based AI application for identification of allergenic material [10] within a food setting and acrylamide in potatoes during processing [11].

Natural language processing (NLP)

Natural language processing (NLP) combines linguistics, computer science and AI tries to understand the complexity, context and content of human language. Applications include text- to-speech and speech-to-text applications. Named Entity Recognition (NER) recognises specific text e.g. a place, a person or an organisation as an item. Sentiment analysis can determine the positive or negative aspects of language that is used. Text mining is an AI technology that uses NLP to turn free text, which is unstructured into structured data that can then be used by machine learning algorithms. In food recall situations, signals of a food safety problem may come from unstructured data, texts, communications, posts on social media and so forth. Recent research has used text mining and machine learning to identify symptoms of food poisoning in free on-line text e.g. use of words such as sick, vomiting, nausea, stomach, and fever, or combinations of words such as 'hours after eating' or 'diarrhoea and vomiting' [12]. This technology has potential to identify early signals of a foodborne disease outbreak.

Industry4.0 or Agriculture4.0, as a concept, draws together three elements:

- **artificial intelligence or AI** - applications that support the ability to analyse and interpret data that is collected, both real-time and historic
- **big data** - the ability to access vast volumes of data within and across food supply chains, both real-time and historic
- **internet of things (IoT)** - the infrastructure to schedule, measure, monitor and integrate information through technology, devices and human inputs.

Industry4.0 will bring together AI including machine learning, computer systems and NLP to support improving supply chain efficiency, food safety and optimising food quality. These tools could be combined in fruit yield prediction, identification of disease and precision spraying, and the development of digital twins. A digital twin is a virtual representation of a real-life situation e.g. a farm, an orchard, a factory, or a production line. Integrating automation, IoT, computerisation, AI, sensors etc. will provide real-time monitoring of activities and optimisation of processes, within the farm and/or factory. For example, a batch of fresh produce could be monitored through the whole supply chain via Industry4.0 techniques, and this could inform active rather than static shelf-life determination, and identify products that are showing signs of spoilage to be sold more quickly on shelf to reduce food waste.

Summary

This document has been developed to provide an overview of how AI is currently being considered as a tool, within food safety management systems and for public health control. The use of the technology is still new and further applications will develop. For food business operators, understanding how AI is affecting their businesses, and the business environments in which they operate and how they will continue to do so in the future is important.

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