Acta Scientific COMPUTER SCIENCES

Volume 3 Issue 7 July 2021

Research Article

Artificial Intelligence in Food Safety Control

Yasin Ozdemir[1]*, Omer Nuri Cam[2] and Seda Kayahan[1]

[1]Ataturk Horticultural Central Research Institute, Food Technologies Department - Yalova, Turkey

[2]Uludag University Technical Sciences, Vocational School, Bursa, Turkey

***Corresponding Author:** Yasin Ozdemir, Ataturk Horticultural Central Research Institute, Food Technologies Department – Yalova, Turkey.

Received: April 14, 2021

Published: June 09, 2021

Abstract

There is a strong relationship between food poisoning and inadequate personal hygiene of staff in food production. Innovative food hygiene control methods will be beneficial and effective tools for ensuring high food safety and quality. (Artificial intelligence is one of the potential tool to control them.) This review summarizes and explain some uses and future potential use cases of artificial intelligence in some food safety control measurements. Low cost, continuous , objective and real time control may be possible with artificial intelligence uses in the food industry. Future studies should focus on new usage areas of artificial intelligence control tools on food industry. However, in this respect we recommend to perform preventive control measurements rather than final product quality control.

Keywords: Hygiene Control; Food Quality; Artificial Intelligence; Computer Vision; HACCP

Introduction

It was reported that approximately 600 million people (one in ten people in the world) become ill after eating contaminated food and 420,000 people die each year. Diarrheal diseases which were reported as the most common diseases caused by the consumption of contaminated food result in the illness of 550 million people and the death of 230 thousand people each year [1]. Food poisoning was mostly associated with foods consumed in places such as street food producer, restaurants, buffet, catering etc. It was stated that poor personal hygiene in food production chain could increase the risk of food poisoning. Inadequate personal hygiene contributes food poisoning to 27-38% each year. Poisoning caused by the consumption of food contaminated with pathogens from the hands of food workers constitutes 89% of total food poisoning cases [2-4]. In these studies, it has been seen that inadequate personal hygiene and wrong practices are the most important causes of food poisoning. It was also stated in the same studies that providing only education is an inadequate tool in preventing these poisonings.

Often there was a relationship between food poisoning and inadequate personal hygiene of food industry. In addition, author indicated that objective evidence showing the hygiene level and food safety precautions should be kept in food industry to ensure food safety [5]. This situation brings to mind the use of object detection, deep learning or other artificial intelligence technologies as control tools to ensure food safety. In this context, controls to be made with image analyzing by deep learning and artificial intelligence can provide both objective evidence/data (photos) and provide retrospective monitoring by reporting. Ensuring that food production under hygienic conditions is the most important expectation of consumers. It is not possible to use machines in the production of foods

such as bread, pastry, pastry, dessert, cake, vegetable dishes, meat dishes, salads and manual skills are required. Therefore, those food handling personnel can play a first-degree contagious role [6,7]. Although periodic hygiene and food safety trainings are provided, it is important to keep the personnel under constant supervision. In these cases, the use of artificial intelligence will be able to provide the desired continuous control system. This review is aimed to present some uses and potential uses of artificial intelligence in food production and similar areas to help control of food safety.

Artificial intelligence in food safety control

Machine vision is reported to be an automatic, non-destructive and cost-effective technique for monitoring food quality and safety. It is stated that the inspection and production approach based on image processing can be used in a wide variety of food industry and can be applied in different areas [8,9]. In studies, it has been reported that image processing has the potential to examine and classify fruits and vegetables, to determine the quality of grain and other food products such as bakery products, pizza, cheese and pasta, and to evaluate their quality. Since image analysis provides a fast, economical, consistent and objective inspection, its potential for use in many different industries is mentioned. This system makes it possible to develop fully automated processes. These systems can fully respond to increasing production and quality requirements thanks to their high speed and accuracy [8].

It is reported that having more than one hand washbasin in restaurant kitchens and/or hand washbasins in the field of view of the staff increases the frequency of hand washing. In addition, as a result of the research, it is reported that more than food safety training is required to increase the hand hygiene of food workers [2]. Similar to the results reported in the literature, the inspection of the personnel entrance and the production area with the aid of computer vision suggests that it may be beneficial for the personnel to wash their hands more frequently and effectively. In the early 2000s researchers stated that images could be detected electronically, quickly, economically and objectively to evaluate food safety and quality [10-12]. Optical sensing and machine vision have potential to use for real time and automatically obtain information and/or to control and interpret machines or the production processes [10]. Systems based on computer vision are reported to be used more and more for inspection and valuation purposes in the food industry and agricultural production, as they provide an appropriate fast, economical, consistent and objective evaluation [11]. Traditionally, quality control of agricultural and food products is carried out by people. However, in most cases these manual controls are time consuming and labor intensive. It was also reported that the accuracy of the control could not be guaranteed [8]. On the contrary, computer monitoring of food products has been reported to be consistent, efficient and cheap [13].

Quality is a key factor for the modern food industry as high quality product is the foundation for success in today's highly competitive market. In the food industry, quality assessment is still largely dependent on manual control, which is laborious and costly and easily influenced by physiological factors, leading to subjective and inconsistent assessment results [14]. Especially in quality management systems such as ISO22000 and HACCP, and the internal control or hygiene control forms of the companies, the suitability of a personnel or production area to hygiene is subjectively evaluated by another personnel. Control results in this way are recorded in a concrete and non-provocative way only by marking the forms with a tick or a plus. Unfortunately, it is spoken in the sector that there are control forms that do not reflect the truth or hygiene control forms filled out with a past date. However, developing computer vision and artificial intelligence systems have the potential to be used in this regard. There are already systems that control the use of masks, helmets and/or aprons in different industrial areas and public areas. There are studies on technology and prototype development on the use of visual processing and artificial intelligence for similar purposes.

In parallel with the increasing knowledge and awareness of consumers, greater expectations are emerging on food quality and safety. To meet these expectations, new technological systems are required to improve the quality control of foods [15]. Some artificial intelligence studies aimed to make hygiene, cleanliness and order control in the production area, based on visual indicators. Outputs of these studies could be provide fast, continuous and objective control, which is stated to be an important need for the food industry in the literature [13,15,16]. The general configuration of the artificial intelligence learning system to be used in the project is given in figure 1. Automatic quality control not only provides objective evaluation, but also contributes to production speed and efficiency. In addition to these positive results, there are also decreases in production costs [16].

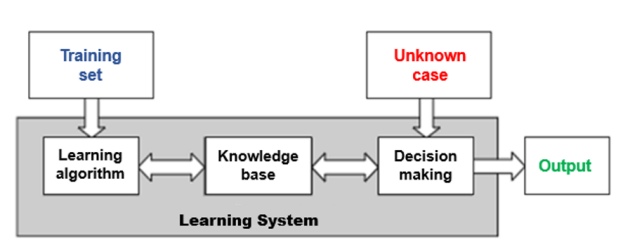

Figure 1: General configuration of the artificial intelligence learning system [14].

Figure 2: Checking the worn helmet on the construction site by image analyzing [19].

Figure 3: Checking whether a mask is worn or not by artificial intelligence [20].

Continuous effective control measures are thought as an important need to ensure food safety. When the studies were evaluated in this field, it was seen that the cleanliness of the food production area/personnel and the behavior of the personnel should be constantly monitored. In today's conditions, these controls are possible thanks to the use of deep learning and machine learning, which are sub-branches of artificial intelligence. It is understood that computer vision is used in order to meet the needs of different work areas other than hygiene and cleaning prepaid. It has been reported that the success rate of correct detection is 91% in the control of employees wearing helmets with artificial intelligence [17]. The photographs of artificial intelligence control of wearing helmets in construction sites are given in Figure 2. In another study, it was reported that a convolutional neural network-based approach to real-time helmet detection will be successful in detecting workers who do not wear helmets in the production/construction site [18]. It is reported that busy and crowded environments reduce the success rate. In fixed working environments, monitoring the wearing of masks, gowns and bonnets can help reduce the need for processing power and increase the success rate of accurate detection.

Control of wearing masks in public areas due to corona has gained speed with image processing (Figure 3). In this way, continuous and real-time inspections can be done without the need for control personnel. Convolutional Neural Network (CNN) derivatives are used in the aforementioned studies and in the object recognition stages as the algorithm that will serve as the basis for this study.

Singh., *et al*. [20] investigated the identification of people wearing masks and those not wearing masks using two state-of-the-art object detection models, YOLOv3 and R-CNN. The authors trained artificial intelligence on both models on a dataset of images of people in two categories with and without masks. As a result, it has been reported that the software they developed can be used with high accuracy and precision in any work environment or in any public area such as station, corporate environment, streets, shopping malls to identify unmasked persons [20]. In a similar research, a hybrid model that uses deep and classical machine learning for face mask detection was studied. In a study conducted on three different data sets, it was reported that the correct detection rate ranged from 99.49% to 100% [21]. In a study where deep learning techniques (224x224 pixel resolution and 25,000 images) were used to distinguish whether the person was wearing a face mask in

real time depending with alarm system, it was stated that the data set was detected with 96% accuracy [22]. An algorithm based deep learning study was developed for the detection of helmet use, it was shown that the rate of correct identification is quite sufficient in terms of sensitivity success and rapid decision-making. It has been reported that the method developed can facilitate security auditing and reporting [23]. In another study construction worker were determined in image sequences through very deep residual networks under different poses and in a changing background, the success of accuracy, precision and sensitivity was reported as 94.3%, 96.03% and 98.13%, respectively [24].

Images of worker protective equipment (safety helmet, safety goggles, safety masks and safety headphones) were processed and analyzed with the Convolutional Neural Network (CNN) method by a study. In the real-time application of the test result of this study, it was reported that the accuracy percentage was 85.83% [25]. It was reported that the application, developed in a study where deep learning was used in real-time detection of personal protective equipment in order to ensure occupational safety in the production area, can be detected in the construction site with an accuracy of 72% [26]. Computer vision system-based neural networks were used to determine whether personal protective equipment was worn or not, it was reported that the system could distinguish workers who do not wear protective equipment with an accuracy of 80%, a warning can be generated in the presence of workers who do not wear protective equipment and this system can be applied in production places [27].

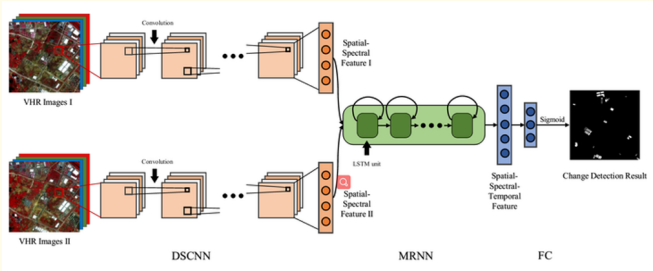

Figure 4: Perceiving the difference (s) between the two pictures with the Siamese neural network [28].

In the light of the above mentioned literature, siamese neural network have been seen to detect changes. (appropriate and inappropriate situations) So that can be use as related to cleanliness and order in the warehouse or work area. An example of this control system for this purpose was given in Figure 4. In the literature, it is used as a preferred algorithm for images that were monitored remotely and where change is followed. In addition, it is reported that this algorithm is suitable for instant analysis because it works fast [28].

Artificial intelligence in quality management system of food industry

HACCP is the most widely used system for the control of food safety. This system can be used effectively only if basic/general hygiene conditions are under control with systems such as prerequisite programs and good manufacturing practices (GMP) [29]. From this point of view, hygiene/cleanliness/order controls to be made with artificial intelligence had potential for increasing the efficiency of the HACCP system as in the pre-requisite program and/or GMP. Artificial intelligence uses also make important contributions to the recording of the prerequisites of the HACCP system and the implementation of the HACCP system. Development of new control systems related to personal hygiene and production area cleaning may help prevent food poisoning [30]. The two most important concepts in meeting the expectations of customers in the food industry are the safety and quality of food. The most frequently used systems to meet these requirements in the food industry are ISO 9001 for quality and HACCP for food safety. The application of these two systems together increases the synergy between them and positively affects the performance of the organization [31]. In this regards, artificial intelligence-based control should be integrated with quality management systems. In this way, it is thought that the synergetic effect mentioned in the literature will be similar and that it will create synergy with the current management systems.

It is reported that foot slipping/falling due to slippery floor, falling due to messy materials and falling materials from above are the most common work accidents in the food production area [32,33]. Artificial intelligence control was considered to be important in preventing personnel slipping/tripping due to such lack of cleanliness/order and not wearing appropriate workplace shoes. In this context, making the floor cleaning and production place layout control with artificial intelligence in the production area can also contribute to the ISO 45001: 2018 Occupational Health and Safety System.

Conclusion

This review present possible future and current uses of artificial intelligence in food industry. It also provides information about basic methodology, working principle and applications of artificial intelligence for food processing or similar areas. Results showed that continues, objective and cost effective controls are possible for both safety and quality control during processing with correct indicators and artificial intelligence. Although these control possibilities have the potential to be widely used for the food industry, there are limited studies on pilot planning and scaling up. So that the pilot planning of control with artificial intelligence and the realization of scaling up in food production places in order to eliminate this deficiency.

Food industry, which is considered as one of the industries with the most important socioeconomic effects and stands out as an activity which includes many sub-branches. It is thought that the self-monitoring of the food sector which is important for economic development. Developing new artificial intelligence technologies is a need not only to prevent food poisoning but also to prevent the waste of resources. If artificial intelligence control systems will be integrated with ISO quality management systems, that will be increase their uses and effectiveness extensively. Future studies should focus on new uses areas of artificial intelligence control tools on food industry. However, in this respect we recommend to perform preventive control measurements rather than final product quality control.

Conflict of Interest

Declare if any financial interest or any conflict of interest exists.

Bibliography

1. WHO. "Food safety". Key facts (2020).
2. Green L R., *et al.* "Factors related to food worker hand hygiene practices". *Journal of Food Protection* 70 (2007): 661-666.
3. Olsen S L., *et al*. "Surveillance for foodborne disease outbreaks—United States, 1993- 1997". *Morbidity and Mortality Weekly Report* 49 (2000): 1-51.
4. Guzewich J and Ross M. "Evaluation of risks related to microbiological contamination of ready-to-eat food by food preparation workers and the effectiveness of interventions to minimize those risks" (1999).
5. Adane M., *et al.* "Food hygiene and safety measures among food handlers in street food shops and food establishments of Dessie town, Ethiopia: A community-based cross-sectional study". *PloS one* 13 (2018): e0196919.
6. Ali A I and Immanuel G. "Assessment of hygienic practices and microbiological quality of food in an institutional food service establishment". *Journal of Food Processing and Technology* 8 (2017): 2-8.
7. Trafialek J., *et al.* "Street food vendors' hygienic practices in some Asian and EU countries-A survey". *Food Control* 85 (2018): 212-222.
8. Patel K K., *et al.* "Machine vision system: a tool for quality inspection of food and agricultural products". *Journal of Food Science and Technology* 49 (2012): 123-141.
9. McAllister P., *et al.* "Combining deep residual neural network features with supervised machine learning algorithms to classify diverse food image datasets". *Computers in Biology and Medicine* 95 (2018): 217-233.
10. Zuech N. "Understanding and Applying Machine Vision". 2nd eds, Vision Systems International Yardley, Pennsylvania, Marcel Dekker, Inc., (2000): 1-336.
11. Sun D-W. "Inspecting pizza topping percentage and distribution by a computer vision method". *Journal of Food Engineering* 44 (2000): 245-249.
12. Vithu P and Moses J A. "Machine vision system for food grain quality evaluation: A review". *Trends in Food Science and Technology* 56 (2016): 13-20.
13. Lukinac J., *et al.* "Computer vision method in beer quality evaluation—a review". *Beverages* 5 (2019): 38-47.
14. Du C J and Sun D W. "Learning techniques used in computer vision for food quality evaluation: a review". *Journal of Food Engineering* 72 (2006): 39-55.
15. Brosnan T and Sun DW. "Improving quality inspection offood products by computer vision—a review". *Journal of Food Engineering* 61 (2004): 3-16.
16. Sun DW and Brosnan T. "Pizza quality evaluation usingcomputer vision—Part 1 Pizza base and sauce spread". *Journal of Food Engineering* 57 (2003): 81-89.

17. Wu J., *et al.* "Automatic detection of hardhats worn by construction personnel: A deep learning approach and benchmark dataset". *Automation in Construction* 106 (2019): 102894.

18. Filatov N., *et al*. "Development of hard hat wearing monitoring system using deep neural networks with high ınference speed". In 2020 International Russian Automation Conference (2020): 459-463.

19. C Jagadeeswari., *et al.* "Hard Hat Detection Using Deep Learning Techniques". *International Journal of Advanced Science and Technology* 29 (2020): 1292-1298.

20. Singh S., *et al.* "Face mask detection using YOLOv3 and faster R-CNN models: COVID-19 environment". *Multimedia Tools and Applications* (2021): 1-16.

21. Loey M., *et al.* "A hybrid deep transfer learning model with machine learning methods for face mask detection in the era of the COVID-19 pandemic". *Measurement* 167 (2021): 108288.

22. Militante SV and Dionisio N V. "Real-time facemask recognition with alarm system using deep learning". In 2020 11th IEEE Control and System Graduate Research Colloquium (ICSGRC) (2020): 106-110.

23. Fang Q., *et al.* "A deep learning-based method for detecting non-certified work on construction sites". *Advanced Engineering Informatics* 35 (2018): 56-68.

24. Son H., *et al.* "Detection of construction workers under varying poses and changing background in image sequences via very deep residual networks". *Automation in Construction* 99 (2019): 27-38.

25. Pradana R D W., *et al.* "MIdentification system of personal protective equipment using Convolutional Neural Network (CNN) Method". In 2019 International Symposium on Electronics and Smart Devices (2019): 1-6.

26. Nath N D., *et al.* "Deep learning for site safety: Real-time detection of personal protective equipments". *Automation in Construction 112* (2020): 103085.

27. Zhafran F., *et al.* "Computer vision system based for personal protective equipment detection, by using convolutional neural network". *International Electronics Symposium* (2019): 516-521.

28. Chen H., *et al*. "Change detection in multisource VHR images via deep Siamese convolutional multiple-layers recurrent neural network". *Transactions on Geoscience and Remote Sensing* 58 (2019): 2848-2864.

29. McMeekin T A., *et al.* "Information systems in food safety management". *International Journal of Food Microbiology* 112 (2006): 181-194.

30. Michaels B., *et al.* "Prevention of food worker transmission of foodborne pathogens: risk assessment and evaluation of effective hygiene intervention strategies". *Food Service Technology* 4 (2004): 31-49.

31. Topoyan M. "Analysis of hazard analysis and critical control points (HACCP) and ISO:9001:2000 quality management system relations in food industry". Dokuz Eylül University Institute of Social Sciences, Master's thesis (2003): 153.

32. Kurt, E. "Investigation of work accidents in dried fruits factory". *OHS Academy* 2 (2019): 88-118.

33. Utlu Z and Yılmaz G. "Occupational health and safety impact of technological developments in the food manufacturing sector". *Anadolu Bil Vocational School Journal* 44 (2019): 1-6.

Volume 3 Issue 6 June 2021