

Smart manufacturing in the food industry
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Abstract

This paper investigates the Internet of Things (IoT) use in smart manufacturing within the food industry. The potential benefits of the Internet of Things in the food industry include real-time food safety monitoring, reduce food waste, and traceability. Through a review of relevant studies. This essay explores the importance of IoT in the food industry. To demonstrate the advantages of using IOT in the food industry, this paper provides an example of an automated waste system for potatoes. This automated waste system includes, stakeholder users, check weigher, cameras, PC, and waste bins to track and measure waste throughout the production. This data is analysed to provide useful information. The implementation of IOT in the farms offers useful information for farmers including, real-time monitoring of the temperature and humidity and any action that is required within the farms, which helps to improve efficiency and reduce waste. However, this essay acknowledges the potential drawback of the use of this technology includes, including IOT in their early stages of development and requires specialised expertise to be implemented successfully. This research suggests that further studies are needed to develop the Internet of Things technology in the food industry and that data sharing between companies should be regulated to address potential security concerns. To conclude, this paper demonstrates the potential benefits of IOT technology in reducing waste and improving efficiency in the food industry, with an automated waste system for potatoes serving as an example of its successfully implemented.

Introduction:

In the United Kingdom, approximately 10 million tonnes of food and drink are wasted each year, with 2.05 million tonnes wasted before reaching customers in the manufacturing, distribution, and retail sectors. This ultimately results in the misuse of resources throughout the supply chain process. To address this issue, operational improvements are required in production, storage, distribution, and consumption (Estimates of food surplus and Waste Arisings in the UK (2017)). However, in most cases, food waste monitoring is completed manually, which is time-consuming and vulnerable to human errors (Elimelech et al., 2018). Therefore, there is a need for an automated and accurate method to collect data to reduce food waste (Jagtap, S. et al. 2019).

The Internet of Things (IoT) technology, which connects the Internet via radio spectrum recognition and other message detection devices for intelligent identification and management, has the potential to address these issues (N; 2022). The food industry has experienced significant changes over the last few years, and there is a need to adopt new technology, such as IoT, to meet this growth. Additionally, the installation of IoT devices in farms has increased dramatically, with a predicted increase from 30 million in 2015 to 75 million by 2020 (Misra et al., 2022).

The implementation of IoT has provided farmers with a better way to access data and make decisions regarding the installation of more sensors on the farm. This brings significant advantages to the farmers, allowing them to increase profits, as the crop yield has increased with the addition of more IoT sensors. However, the implementation of IoT is still in its early stages, with data sharing between companies causing challenges in the agricultural sector (Misra et al., 2022).

Moreover, food safety has become a major concern for the public, and many researchers have suggested the adoption of a food traceability system that tracks food from the farm to the end customer. IoT enables blockchain to provide solutions for food safety, security, and traceability. For example, when data from pork in China and mangoes in the United States was fed into the blockchain, it took only 2.2 seconds to deliver information, compared to seven days using traditional traceability methods (Kamath, 2018).

Therefore, this essay aims to study smart manufacturing in the food industry by examining the IoT and its applications. The use of the Internet of Things has potential benefits to reduce food waste, increase crop yield, and offer a great solution for food safety, security, and traceability systems.

Keywords: Supply chain, IOT, food safety, Traceability.

Aims & Objectives:

The aim of smart manufacturing in the food industry as follows:

- [1] Reduced food waste
- [2] Increased efficiency.
- [3] Real-time monitoring
- [5] Enhanced traceability

Implementation Methodology Figure 1 provides a demonstration of automated potato waste monitoring. Also, the potatoes move in a single file on the conveyor. In addition, When the potatoes pass under the camera, the image is captured, and the weight is measured by the load cell. The data is sent controller PC via Bluetooth. In the event of an unauthorised potato, the signal will be sent to the computer, which rejects the potato and alerts the rejected arm. As a result, all information related to waste, such as time, date, location, and rejection reason, is automatically displayed on cloud storage. This data is also interpreted to provide useful information that is displayed in management systems.

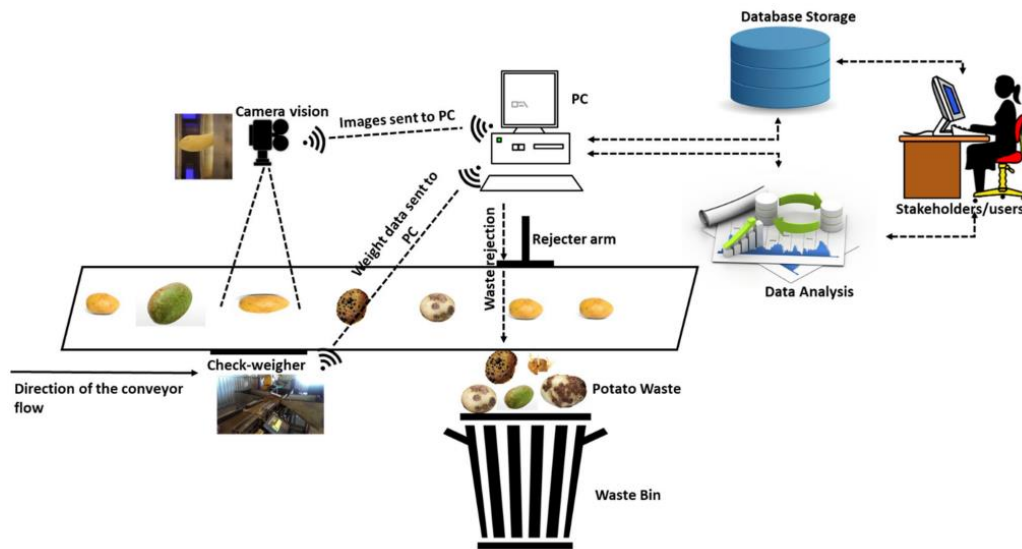


Figure 1 demonstrates a schematic diagram of the automated waste system (Jagtap, S. et al. 2019).

Check the weigher system.

The check weigher systems contain a load cell that records the potato weight and activates the rejected arm in the event of a damaged potato, as shown in Figure 2. The personal computer uses 0/1 language to communicate with the programmable logic controller (PLC), where one represents the pass results and zero represents the failure results, to trace the quality of the potatoes. If the potato does not meet the standard, then it will be rejected by the rejected arm and disposed of in the potato waste bin as can be seen in Figure 1. When a potato is rejected, the system records the weight, data, and time automatically.



Figure 2 explains the check-weigher systems (Jagtap, S. et al. 2019).

hardware and software set-up:

This section will look at the hardware and software involved in the potato waste tracking system being developed by architecture. The system was divided into three layers, as shown in Figure 2. The sensor, which collects image and weight data via the camera, is the first layer. The network layer collects them through the load cell and then transfers them into the service layer via Bluetooth hardware. The images were interpreted in the service layer to provide valuable waste information, which was then presented to management systems (Jagtap, S et al.2019).

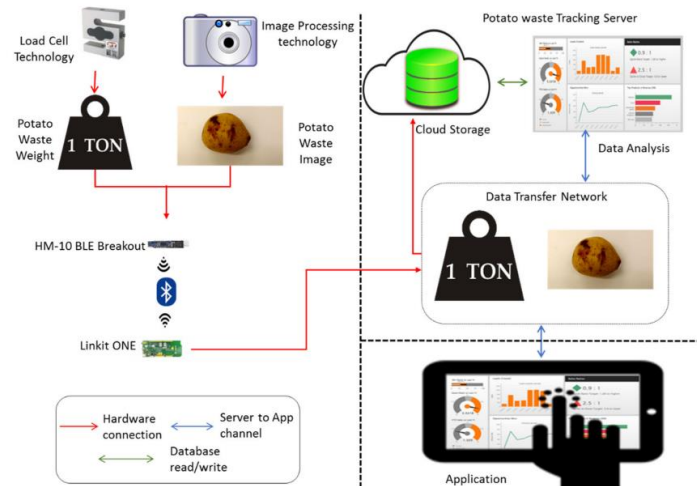


Figure 3 shows the architecture Real time potato waste tracking system (Jagtap, S. et al. 2019).

Image processing:

The image processing can be used for online monitoring of blade sweep and angular velocity tracking. Comparably, Figure 4 discusses the potato image that was taken by the camera. There are many signs indicating potato faults were highlighted in green. There were various signs that could be used to identify the faults of potatoes, such as blackening, cracking, disease, and so on, which would be considered waste. The next step is to provide information on rejections (Sujatha et al. 2018).

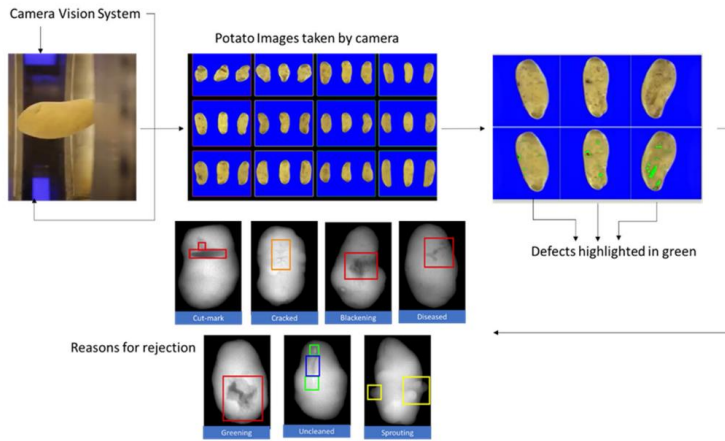


Figure 4 depicts the identification pathway for potato waste.
(Sujatha et al.,2018)

CNN architecture:

According to (Jagtap, S. et al. (2019)), the neural network has nine layers, including six convolutional layers and three fully connected layers, as shown in Figure 5. To represent three classes, the final layer employs a three-way SoftMax. To down-sample the convolution values, max-pooling layers are added after the convolutional layers. Every convolutional and fully connected layer's output is subjected to the Rectified Linear Unit (ReLU) nonlinearity.

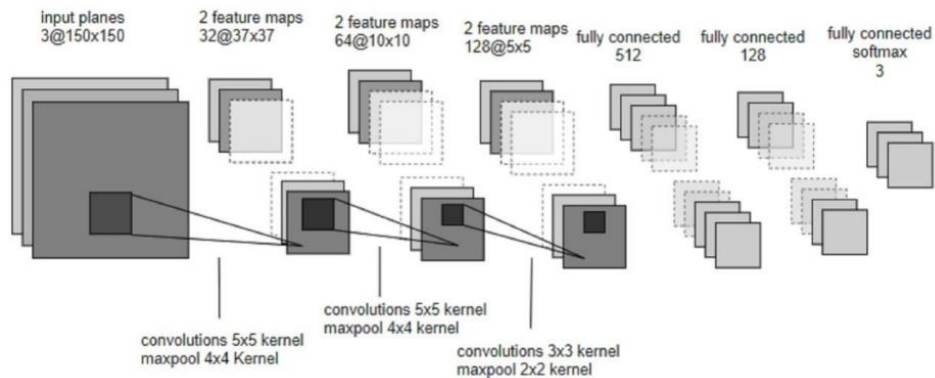


Figure 5 shows a Convolutional Neural Network model (Jagtap, S. et al. 2019)

Experimental parameters:

For the evaluation, there 100kg of potatoes were mixed with potatoes that have not meet the customer's requirements, and then fed into the system. In the final analysis, the system was able to identify unwanted potatoes, if it ran at a rate of two potatoes every three seconds. A 16-megapixel charge couple device camera was used. Two 6400 k fluorescent lamps were used to brighten the area around the camera. The conveyor speed, the timing at which the image of the potato tuber is captured, and the image processing time all play critical roles in the system's smooth operation (Jagtap, S. et al. 2019).

Background Research:

The purpose of this literature review to provide a guidance for the researcher to explore the use of IOT in the food industry and their applications.

Digital technologies have an ability to perform transactions and be completed faster and more efficiency. According to (Brewer et al., 2019) the new technologies such as the internet of things and artificial intelligence brought new level of efficiency in terms of machine communication with each other directly. The author suggests that these developments help solve the challenges in the food production supply chain, by offering traceability, sustainability, and reduce the waste. Similarly, (Ashton, 2018) argues that internet of things (IOT) is a technology that digitally connects many devices with machines. In the food industry, IoT refers to the use of remote sensors to gather information generated by machines to make better decisions and increase efficiency. An example of an IOT application in the food industry is potatoes baking factory, according to (Jagtap et al., 2019) reported that they successfully developed a potato monitoring waste system that able to speed up the process of tracking the potato waste without human intervention, which helps to achieve without errors. Consequently, a lower cost was achieved, and unwanted potatoes were reduced in the food production. Overall, the system was able to process one potato very 1.5 second at the speed of 99.79%, which is more promising when it compared with manual processing. During large scale operations, the authors found that this percentage of testing accuracy was reduced by 81.25% despite the system's significant benefits. Besides, Augmented Reality or known as (AR), This technology has been reported by Chatzopoulos et al. (2017), it is now possible to have AR technology on a mobile device. This research conclude that the customers have a more personal engagement with the product, as they can see the entire process as if it were in front of them. Therefore, the authors stress the benefit of using this technology as it provides information about customer behaviour and feedback without having to conduct a survey.

Additionally, the author purposes that technology companies have started using IOT based solutions for precision agriculture (PA) with sensors enable them to measure environmental conditions in different locations within the farm, and using cloud-based systems that collect and integrate data. As a result, farm managers can receive notifications over the internet about the farm conditions. One example of IOT in the food industry as described by (Misra et al., 2022), is the use of temperature and humidity sensors and GPS location tracking to accurately monitor the food trucks in the virtual supply chains. This helps to relocate the truck where there is food shortage in certain areas. The authors proposed that in the event of temperature fluctuations, the truck can be delivered to nearest market to sell whether in in less price or discount. Hence, the IOT technology prevents the food wastage and save money. Also, the food waste was addressed by (Aktas et al., 2018) demonstrate that every year one third of the total world food is wasted, which is count around 1.3 billion tones. The author proposed food preservation and storage strategies to minimise the food waste. Continuing the authors explain the benefits of implementation Internet of Things (IOT) in farming, farmers will be more efficient and connected, in terms of feeding huge information to be analysts regards crop yield, and animal health. Further, the internet of things is extremely important for monitoring the food production according to (Kodan et al., 2019) study the effect of IOT technology in the food production, the study suggest that without the use of IOT technology would be extremely difficult to track food production. To simplify, the transformation of the food using refrigerated that has a temperature sensor that enables to monitors the food conditions in case of the failure, the supplier can receive a message automatically informing for potential losses. Thus, ensure the food presented to the market in a good condition. Additionally, the Internet of Things could help with smart maintenance. according to (Saini & Raj, 2022) discussed the issue that most stores use complex equipment, for instance, refrigerators. According to the authors, failure of this equipment could be predicted in advance. Therefore, the potential benefits of IOT food safety, are cost-effectiveness, and energy efficiency.

While internet of Things technology (IOT) can bring a numerous benefit to the food industry, there are also some potential disadvantages to consider. According to (Jagtap et al., 2021) The IOT is not fully utilised for efficiency because it is only applied with a single goal and to only one actor in the food supply chain. As evidence, a majority of Internet of Things (IOT) applications are subject to food traceability. Again, the authors stress the challenge of IOT implementations required expertise from both food industry and internet of things developer. In addition, the authors study the complexity of food supply chains and the finding that food products have varying shelf lives and properties, as well as varying consumer demands. As a result,

many food businesses have not yet adopted IOT as part of their business approach. Additionally, (Srivastava et al., 2019) described the risk of the continued growth of the IOT based data sharing in the food industry with the absence of government regulation, which could result in security and privacy concerns. Furthermore, according to (Misra et al., 2022), study the challenge of the implementation of IOT and conclude that this technology is still in a very early stage, as it has been noted that, the supply chain involves data sharing between the companies. This causes challenges in the agricultural sector. As the farms and large manufacturers are depending on outsourcing, which means there is a third party holding all the data. In addition, the authors suggest that there is a lack of awareness in some companies, in particular the company under the development stage (Misra et al., 2022).

Overall, the review highlights the benefits of the Internet of things in the food industry by offering a solution to tackle the challenge in terms of traceability and food waste. Also, this review provides many examples of IOT applications, such as precision agriculture, monitoring food trucks, and reducing food waste. Moreover, the IOT provides food safety, cost, and energy. On the other hand, this review also acknowledges the potential drawback of the IOT implementation, for example the complexity of the food chain that required expertise in both food industry and developers. Moreover, this review addresses the risk of the continuous growth of Internet of Things without any regulations regarding data sharing. This raises concerns for society. It is important for future researchers to explore more advantages and disadvantages of using the Internet of Things in the food industry. Despite the challenges, this review concludes the potential benefits of IOT in the food industry.

Conclusion:

This paper started by introducing the issue of food and drink waste in the UK. This results in the mistreatment of the supply chain resources. Also, food waste monitoring is completed manually, which is time-consuming and often exposed to human errors. Furthermore, this paper suggested that the use of IOT would have better results in meeting customer requirements, reducing food waste, and food safety. The aims of this paper were stated clearly. The implementation methodology of food monitoring of potato waste was discussed. Figure 1 explains how the system identifies the potatoes that meet customer requirements from unwanted potatoes. The hardware and software were studied referred to in Figure 2. Moreover, the image processing as discussed in Figure 4 shows various signs of distinguishing potato faults. Furthermore, the experiment showed that the system was able to identify unwanted potatoes for every two potatoes only takes three seconds.

The literature review shows that there is a lot of work ongoing to develop the food industry using the Internet of Things and its application to achieve food safety and traceability. However, the review acknowledges the challenge of implementation of IOT in the food industry such as the complexity of this technology, and security concerns. Overall, smart manufacturing in the food industry has the potential to address food waste and increase efficiency with real-time monitoring and enhanced traceability.

Recommendations:

There are many recommendations that would be beneficial in smart manufacturing in the food industry utilising IOT and its applications. One of these is to invest in IOT research and development as the Internet of Things technologies are still in the early stage. For example, more research is needed to develop the sensors.

Furthermore, there is a concern about data sharing in the supply chain between the companies. This issue suggested that the government should address this issue by introducing tougher regulations. Moreover, effective communication between stakeholders in the food industry includes farmers, food manufacturers, distributors, and retailers. As a result of effective communication, it means the success of the implementation of the Internet of Things.

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