MINI-REVIEW

Development of automated systems for the implementation of food processing

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Abstract: Food and beverage are the main requirements of humans and animals. The more significant population of the world leads to an increase in the necessity of food and beverage. The food industry has a high responsibility to fulfil and satisfy the customer needs and wants with achieving nutrition properties of foods, food security, and safety. According to the current situation, automated systems are urgent in the food industry to carry out food production with maximum accuracy and efficiency and maintain the required quality control of the product. It is generally referred to the science and technology. The use of automation systems in the modern food industry has increased in recent times. Many food industries have already introduced an automated system with high technology into their production line, from raw material selection to serving. The primary aim of the computerized system used for the industry is to carry out the process with maximum accuracy and efficiency. Therefore can be realized more advantages than the use of manual techniques for the food industry. This paper included brief information about the importance of automation systems in the food processing industry, focusing on automation tools.

1 INTRODUCTION

Food processing transforms agricultural raw material into a desirable product for consumption using a commercially accepted variety of methods. The food industry plays an essential role in satisfying consumers' requirements through the raw and processed food supply. The food industry always prioritizes the satisfaction of consumers by improving the availability, distribution, convenience and quality. The food industries adapt their product to meet consumer needs considering that as the primary requirement [1].

In ancient times, most industries used manual processes for food preparation. However, with the increasing population, increasing customer demand for food products, and technological development, the food industry had to develop its machinery for manufacturing processes. Therefore, there are fully or partially automated applications in the food industry. It became an esteemed part of the industry. Thus, at present, fully or partially automated applications are developed in the food industry. Today, robots and automatic processes are considered an integral part of the industry [2]. Supply chain performance became a priority of the food industry as it's a critical step in handling and managing the actual demand rather than the predicted demand. So, ensuring efficiency and supply in enough quantity of food becomes even more critical [3]. Basic reasons for the automated system to the food industry are extreme demands and changes surrounding the process and internal factors concerning the organizational and human resource level

[4].

The automation of the food industry means controlling the machine, and every process needs to maintain by independent systems through various technologies based on computer software or robotics to make it faster [5]. The food processing industry combines with the automated system than any other industrial sector. Robots are used for seeding, spraying water and harvesting, cutting, processing, and packaging food product like in the beverage industry-bottle are cleaned, contend filled and arranged on a conveyer belt automatically, and dairy, chocolate food in [2, 3]. The automation system is driven mainly by the competitive success and safety of the food industry or manufacturing plant. The automated system has several advantages for the food industry, such as improved productivity, product quality and profitability, improved hygiene and safety, and worker safety [6]. Moreover, the use of automated system help to reduce injuries, decrease the cost of labour [2].

Automation is technology-related to applying the mechanical, electronic and computer-based system to operate and control production. The automation technology included; [7]

- Automatic machine tools to process parts
- Automatic assembly machines
- Industrial robots
- Automated material handling and storage system
- Automated inspection system for quality control
- Feedback control and computer process control
- The computer system for planning, data collection and decision making to support manufacturing facilities

The robots and automation systems in the food processing and packaging system cause reduce labour costs and health and safety issues. The most valuable advantage of the automation system is to improve productivity, product quality and profitability [8]. Therefore, plant automation can improve productivity, product quality and profitability [9].

Improved productivity

The quality of the end product manufactured per unit for operating parameters – plant size: Number of workers, time of operation, etc. is considered plant productivity. So productivity is directly related to how efficiently the input resource transforms the raw materials into marketable end products. The automation system is used for improved productivity as that allows for an efficient workflow. Details about the Product can accurately highlight areas for more efficient uses of resources [10].

Improved quality

When considering the food industry, one of the most critical goals is quality assurance and other sectors. A high-quality product can be made using automated systems, which is involved for success in the highly competitive food industry. The high-quality product causes increased customer loyalty and expands the market share to make more profit in the sector than that uses manual systems for food production. The human visual inspection method is used in the manual processing industry for quality assurance of the product. Human visual processes are tedious, tolerant, tightened, .so automated systems became necessary for the food industry to employ automatic methods for quality control of products. Therefore improved the quality of the product is most attention in terms of automation.

Improved profitability

Improvement of profitability is the most important thing for the industry. So the company's profit must be considered an industry improved profitability cause to the ads to shareholder value. But not only that, it

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causes to allows management to invest strategically in expanding plant operation, increasing product lines, further improving product quality and productivity, and both directly improve profitability. The dairy, bakery, beverage like fast-moving consumer goods (FMCG) industries are excellent examples of automation include processing and packaging food products [2].

The following tools can successfully apply to the optimization of food processing,

- Computer Vision system
- On-line sensors
- Expert systems
- Robot technology
- Computer integrated manufacturing
- Flexible manufacturing systems

2 AUTOMATED APPLICATION IN THE FOOD INDUSTRY

When spending time, the robotic and automation in the food sector offers great potential for improved safety, quality and profitability and motioning and control robotics and automation system in the food industry provide an improvement overview of current. Emerging technologies automation is a very complex thing in the modern industry because it can cover a lot of different ways of manufacturing processes. Automation is a bounded sphere between mechanization and computerization together. Automation is a bonding sphere between mechanization and computerization [11]. When considering the current situation, most food industries have become wholly or partially automated. Primarily robot system is used to pick and place food handling packaging and palletizing, and food is served in a food restaurant [12].

1.   Pick and place

The traditional process is currently happening in the food handling category [13]. Robots are used to pick and place food items and food preparation.

2.   Palletizing robots

The parts of robots are categorized under packing and palletizing of the food industry. Palletizing robot is used for palletizing cookies, beverages, sweets paste, and other food items. The company that applied automated systems for palletizing has entirely removed even wooden pallets from the process. Therefore, it can achieve the advantage of full capacity shipping containers. Another benefit of using that type of robot for the food industry is eliminating the damage of bags. The vision sensors are used to arrange the stack height of individual pallets and the orientation of the cartons in the pallets so, handling both bins and pallets efficiently [14].

3.   Inspection and testing

That type of robot is used for the inspection and testing of food products in the food industry. The inspection is usually done with multiple cameras to verify the desired quality of the finished product. After labelling, robotic used to involve in the inspection operation. The failed item gets rejected and sent to the reached bin, and finished items are sealed over the conveyor belt for final transportation to the market. The camera system to confirm the ensure quality control. Recently, computing platforms are used multiple video cameras to inspect the quality of various food products. Those camera systems are low cost but high performance [15, 16].

4. Cooking robots

These robot's categories focus on cooked food. The harsh and rugged environments may be suitable for chef robots. The clean and tidy handling is done by vision-based actuation control not only that it helps to prevent the human operator from burning their hands in case of accidentally touching hot plates.

5. Serving robots

Recently, robots have been used to fulfil restaurant requirements like guest reception and food distribution among customers [16]. Sometimes not use actual robots but use prototypes to demonstrate real robots in this field [17]. For example, sushi restaurants in Japan have started a fully automated system for food lines to the customers, and it has become more popular now [18, 19].

3 APPLICATIONS OF AUTOMATED SYSTEM IN FOOD PROCESSING

Food industries are doing food processing activities by covering seafood, fresh produce and traditional foods, fruits and vegetables, meats (processed and unprocessed), dairy products, beverages, confectionaries, and grain and cereal [20]. Food processing transforms raw ingredients of animal and plant origin into the desired product suitable for consumption [21]. The most important unit operations used in the food industry are cleaning, separation, size reduction, mixing, and heat transfer, concentration, drying, foaming, and packaging [22].

According to the recent development, robots and automated systems are being used in every task in the food industry. Food Industries are now using cost-effective, profitable automation solutions to get higher production volume than the food industry used in manual systems. As adherence to manual labor is considered a concept now, more preference is given to robotize handling/ manufacturing installing.

The meat processing industry is automated by various robot systems like slaughtering, deboning, cutting, sorting and packaging unit operation and automatic quality detection of the final product of the baking industry. They stir curds, transfer cheese mold, cut portions, packaging, and palletize using automation systems when producing the cheese. When considering the beverage industry, bottles are cleaned, counted, filled, and arranged like unit operation done using automated systems so used conveyor belts via robotic machines [23]. The computer vision camera system is used to inspect and control the quality of vegetables and fruits [24]. Compared with the manual system, the productivity of +25% increased after applying robotics and automated systems for the food industry. However, the speed of the implementation varies in different food sectors [25]. Because of that, several factors affect that, like the level of automation carried out, the number of robots deployed, and product variation due to customer demand changes.

The industry that is deal with egg uses the online egg sorting method. Online poultry inspection uses a multi-camera system and accurately detects and identifies carcasses unfit for human consumption [26]. The camera monitors the quality of the egg passing through the system, and images are analyzed digitally. The advantages of accuracy in identifying defective eggs increase, and the sorting rate is high [27].

4 REQUIREMENT OF AUTOMATED SYSTEM INSTEAD TO MANUAL SYSTEM

When considering the, A Comprehensive analysis of the food industry requirement with comparing manual system it is an essential requirement for developing a general-purpose robot and automated system [28]. These requirements are intended from various aspects, including kinematics dynamics hygiene, productively, worker safety, cost and ease of operation and maintenance [29, 30]. So automation system and industrial robot specially designed to fulfil the set of presents below.

1. Food hygiene

Food hygiene is the condition to ensure the safety of food from production to consumption. Food can become easily contaminated at any point of unit operation like slaughtering or harvesting, processing, storage, distribution, transportation and preparation.

Food safety means supplying accessories and consuming food safely; the most crucial thing is hygiene factors when dealing with food items. The food-grade robot can conveniently achieve food safety (cleanliness) when producing whatever food product and beverage than using a manual system. Such strength requirements are satisfied by using automation, and robotic manipulators, vision systems and especially end affecters or grippers require unique hygienic design as an approach in the food industry [31].

But when using the robot, the fundamental problem is the robot should be working in a wet environment. So it is possible to by extensive use of stainless steel to produce robotic and automated types of machinery. Another option can be to use shields and seals to make the waterproof condition, which is practically a daunting task. The hygienic robot design must ensure that the food particles do not strike and retain and cause bacteria growth. When considering the automated system, specially specified joints near the gripper are more facilitated to this problem. All of the external parts must be visible for inspection and accessible for manual cleaning. The robotic grippers do food handling, and they are washed down with industrial detergents and pressurized hot water for cleanness [32].

And other things are the surface of the robot and machinery should be designed with smooth and easy to rinse off the surface and lubricant-free joints that are resistant to most corrosive. If it is not smooth can retain the particle of food it causing contamination of the food product. Another feature is gripper design its must behave to the ability of food handling softly (with moderate force) without damaging the food product. The cleanliness and sanitation requirements are the highest essential things overall in the production [33].

2. Cost

The large scale production line may offer a low-cost production system by using automated systems and provide flexibility in the production system. Therefore, it is more Beneficial than a manual system because the cost of the labour which needs to be paid is reduced. The initial cost of installing the automated system is high, but the operation cost will trade-off to get the higher profit.

3. Worker safety

The central concept of worker safety is to isolate automated systems from human work. The mixed working environment is highlighted for improvement in the efficiency of industrial robots [34]. However, the concept has a technical execution point of view. The new images, including recording current activities and considering the context and applicable situation, access the risk potential to which a worker could be exposed because of the robot's movement [35]. Other standard features in the food industry are user-friendly interfaces for billing, product changeover support, and recipe handling.

4. Ease of operation and maintains

For easy operation, the robot must be of suitable size in terms of its footprint and available workspace for reachability to fulfil required tasks. The enormous footprint is not ideal as it takes ample factory floor space. The factory units of food production are smaller in size. So small scale modular robotics is the most solution for maintaining space facility and those can be activated by the programmed system. Programming

of robot configuration must be designed to facilitate user [36]. Programming robot configuration through better process control and maintenance ensures the reliable operation of robots and automated systems. It obtains the ultimate objective discontinuity in the function of food factories from the maintained scheme [37]. The recent concept is the maintenance repair for a range of motion (ROM) of the robot while is working to execute required operations [37].

5 CHALLENGES AND OPPORTUNITIES
Some of the challenges in automated processing are listed below [38].

1.   Augmented intelligence
Augmented intelligence is vital in today's world of the food and beverage industry robot instead of intelligent work. Still, robots are mainly used for "heavy work "in the industry, such as packaging, palletizing, and repacking tasks. According to the stranded level, packaging like tasks can be done using this type of robot, and it is relatively easy than the manual process.

2.   Food safety and hygienic
Food safety and automated machines are highly modern systems used to satisfy the stringent hygienic requirements of the food industry that meet the relevant cleaning and disinfection protocol. The machinery can be the source of corrosive properties, so need to control the environmental conditions to decrease the corrosion of robots.

3.   Controlled environments using food robots
Food robots are considered easier to operate in a controlled environment as compared to their human counterparts.

4.   Cost-effective production cycle
The wide range of production demand with extensive product ranges in the food industry needs flexibility at various levels to allow highly variable space and performance specifications. The main requirement is face to challenges to maximize efficiency and decrease the cost of production.

6 POSSIBLE SOLUTIONS AND OPPORTUNITIES
Typically food industry that uses manual systems has critical issues, and these problems are solved by using automated robotics technology with high precision and accuracy [39].

1.   Maintaining hygiene – food-grade robots
A challenge arises with the use of robots in food production because robots need to work directly with food. When food production, safety and hygienic factors are the main requirements, so must prevent contamination and sanitary requirement must be satisfied. By using cleaning in properly and using the standard procedure of disinfecting forget proper cleaning robots. A variety of solutions are being carried out to maintain the hygienic design of food robots. Especially "wash-down robots" are introduced with IP65, which can be washed easily [40]. When producing the robots for the food industry, Chosen protective coatings are used in their design, e.g.:- epoxide or stainless steel based technique. Because stainless steel does not chemically react with cleaning agents/acid or alkaline present in food materials, food-grade lubricants are used with these robots [41].

2.   Cyber-physical system (CPS) in the food industry
A recent trend is to apply the CPS concept in the food industry. CPS is a method based on the internet of Things (IoT) that can clear supply change in the food sector. CPS method is crucial because it can play its role to achieve the highest level of certainty in food safety [42]. Raw material transforms into a final food product is done in the food processing industry. This transformation supplies a modular approach for

optimized performance. Simulation design to effectively generate scenes and solutions to the problem of sensing data fusion and communicating through a network and physical robots are presented by complete CPS [42].

The food industry is one of the sectors performed as a priority expected to impact the future significantly. An essential event of CPS is involved for the food industry to:

1. Sensors development are done to scan for diseases raw materials to access products freshness, so CPS involve in improved food safety.
2. Autonomous machines are used as hygienic assistance.

Those are involved for short term events and the food industry as well as in the long term. The whole production and supply chain in the food industry is evidence of intelligent food labels to give a depth understanding of where the food is coming from [43]. Also, in the future food industry will be beneficiated by cloud robotics, as highlighted In CPS [44]. When considering the supply chain of the production, poor quality and unsafe products are can be manufactured. CPS based food traceability system can minimize those problems [45]. The concept of CPS is now being used to introduce factors that indirectly influence food quality, such as contaminated water entering into food production, drinking water management systems [46].

3. Sensor interfacing

The food industry represents significant challenges to the components (like sensors) used in food processing technology. However, the requirement for sensors interfacing is improved with time. Many sensors are needed to automate processes in the future. The demand for sensor interfacing Comes from various aspects like CPS, DOF, application, human-robot interaction and safety concepts [47]. Pressure, temperature, flow, and level are essential values are should be detected in the food industry. CPS, DOF, application, human-robot interaction, safety concepts like all these technology areas have specific areas that should be required to sense requirements [48]. According to the CPS needs vision, mapping systems are used for robotic and machine automation. That robot can estimate the position of the human worker. Safe operation in a hybrid environment can provide by this type of CPS. With the 2D vision-based guidance, product quality, manufactures can accurately track products, improve supply chain management, diagnose faults, optimize production and significantly expand the use of robotics automation. Therefore using automation systems and guided robotics can save time, money and resources.

4. Dependable software

When developing robotics and automated system in the product line, software solutions are an integral part. The software must be robust in food industry applications because of rapid changes in product type [49]. Designing optimal and low-cost power solutions is always a necessity to implement such systems [50]. The energy consumption of the robots in the industry is reduced by using the different methods mentioned above [51].

5. Other Requirements

The supply of the power requirement for industrial processes is one of the challenging areas because when working with giant payload capacity robots, the power requirement is increased. It should control the power requirement by avoiding wastage of power analysis of energy requirement. The study of its kinetics and dynamics that used robotics and a condition of the targeted application, placement of objectives in robots workspace and efficiency of path planning algorithm is studied profoundly to reduce the wastage of power [52]. When the robots manipulate, kinetics and dynamics dictate that energy consumption is affected by the inertia lessor of each link and the required torque on each joint of robots.

7 CONCLUSION

There are many usages of robots and automated systems in the food industry to fulfil their needs. Mainly pick and place robot is used to select and identify somewhere of a food item without any damage. Palletizing robot is used to pack and palletize the food item to maintain the accurate quality and safety of the foods.

Inspection and testing robots are used to impaction and testing robots are used to impaction and testing the food item. Accurate observation can be obtained by using that type of robot. Because they have no problem around the environment, they can get the ideas with higher accuracy by using their camera system than the people. As well as serving robots are available in the modern food industry. They can serve the food item to the customer similar way that humans do.

At the same time, robots and automated systems are used for harvest to serve in most of the unit operations of the food industry. According to the recent development, robots and automation are being used in every task in the food industry.

The paper has described the robotic and automated systems used in the food industry based on food handling and processing, pelletizing and packaging, and food serving. The robots and automation systems have incredibly increased the manual systems.

Hence the automation and robotic system have a significant application for the food industry.

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