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Potential of Robotics Use in Food Industry and Future Prospects

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Abstract: Global population is incredibly increasing now a days that in turns causes upsurge in consumer's demand about the wider variety of food, their concerns about quality, safety, nutrition & hygiene of food is increasing. Using traditional production and processing methods makes impossible to meet demands and would lead to malnutrition. In order to meet such desires, there is need to develop automated robotic systems which have enhanced economic efficiency, hygiene, quality and are eco-friendly & safe. Robots are part of autonomic system of food industry Which reduce operational cost and time. Such robotic systems require less or no labour and essentially have capacity to transform the processes in food handling, processing, packaging, palletizing as well as food serving. The process parameters, type of industry, size of product and nature of the product either it is fragile, perishable or not have a significant impact on Robotic system specificity. Processing of meat and fish in meat industry, milking in dairy industry and handling of non-rigid food products, harvesting and packaging operations has increased the use of robotics in recent years due to its characteristic like increased production more speed and less chance of error. Such technological advancements have replaced traditional laborious slow processes by enhancing production, food safety and quality. Also, these should be adopted in all type of large- and small-scale industries because they provide a wider range of potential for production, development and commercialization providing healthy, safe & aesthetically pleasing food to the consumers.

Keywords: Robotics, Food systems, Automation, Food safety, Robo-Food.

1. Introduction:

1.1 Robotics

The science and engineering involved in creating, assembling, managing, and utilizing robots is known as robotics. It is a computer system with information processing, control, and sensory feedback capabilities. These technologies are well recognized for creating robots that can simulate human behavior in place of real people. When it comes to labor-intensive or repetitive chores, robots are useful. Cartooning, robots in developing things (such biscuits or other bakery goods), labeling and coding, and robot filling are examples of robotics in action. It is often used in the meat industry for tasks like deboning, splitting, evisceration, hair or hide removal, and dressing [1].

1.2 Robot

Robot is derived from term "robota" of Czechoslovakian language which denotes forced labor. A robot is a self-governing, programmable apparatus made up of mechanical, electrical, or electronic components. In a broader sense, it is a device that performs tasks in lieu of a living being. As to the British

Robot Association, an industrial robot is a programmable apparatus that is intended to accomplish certain production activities by manipulating and/or transporting components, tools, or dexsignated manufacturing implements using variable, programmed motions. A re-programmable, automatically controlled, manipulative, multi-purpose machine with some degrees of freedom, which may be either mobile for use in industrial automation applications or fixed in place" is how the International Standards Organization (ISO) defines a robot. For some jobs, robots are particularly useful because, in contrast to humans, they get never tired, can work in hazardous or uncomfortable environments, can function in an environment without air, cannot get bored with repetition and also cannot be sidetracked from their current task. The robot is strong, dependable, and able to operate in hot environments, where a person could get ill and tired from prolonged labor [2].

Generally speaking, robots can be classified into two main categories: industrial and service. With the exception of manufacturing tasks, a service robot is any robot that carries out tasks that improve the wellbeing of people and other machinery. Industrial robots are capable of carrying out repetitive, accurate, durable, fast, and dependable activities [3].

1.3 Robotics in food industry

The use of robots in the food sector has been expanding constantly because various food materials have varying sizes, shapes as well as more importantly vulnerability to mechanical harm. Designing soft robots for flexible adaptability in material handling throughout diverse food processing procedures has been proposed. In the food processing sectors, robotics is being used extensively to automate labor-intensive activities including material handling and conveyance. Recent research has been preparing the way for the use of robots in the workplace to increase productivity, quality, consistency, and flexibility while lowering ergonomic risks for employees. By guaranteeing dependable operations and preventing operational interruption, automation of the food handling processes presents a significant opportunity for increased profitability. The robot's end effectors perform these functions. In order to create robotic effectors that successfully handle food with minimal harm, considerations such as mechanical qualities, handling challenges, hygiene parameters as well as environmental effects must be made. The mechanism of end effector robots in the food handling process, their classification, design specifications, and possible applications in different food industries are the main topics of this article [4].

In the future, robots will be a far bigger part of everyday life for humans. Specifically, the robot is employed in the food business for a variety of duties, such as splitting chicken breasts. Robotics application is the answer to production process optimization because human labor-intensive old approach is error-prone [5]. Because of the low birth rate and elderly population in industrialized nations, which have further contributed to the labor crisis, service robots have been progressively used in real-world settings based on previous academic research. The automation of traditional industrial applications has gradually moved into commercial services due to the fast development of space perception technology and artificial intelligence. As a result, the use of service robots is being proposed to penetrate the realm of everyday life. The contemporary market is gradually accepting the need for service robot implementation for package delivery, tour guides, and entertainment [6].

1.4 The industrial robots selection methodology for food industry

The Food Industrial Robots Methodology (FIRM) was developed to determine the best IR physical configuration and end effector mechanisms for a given application by analyzing the production needs and food qualities. FIRM uses four processes that navigate the examination of eight different elements in order to do this.

The first stage is to describe the foodstuff and categorize its components by determining the source of each ingredient. Users of the FIRM must be completely informed on the nutritional facts of the food they are researching. This step consists of three tasks: determining the type, condition, as well as state of the foodstuff.

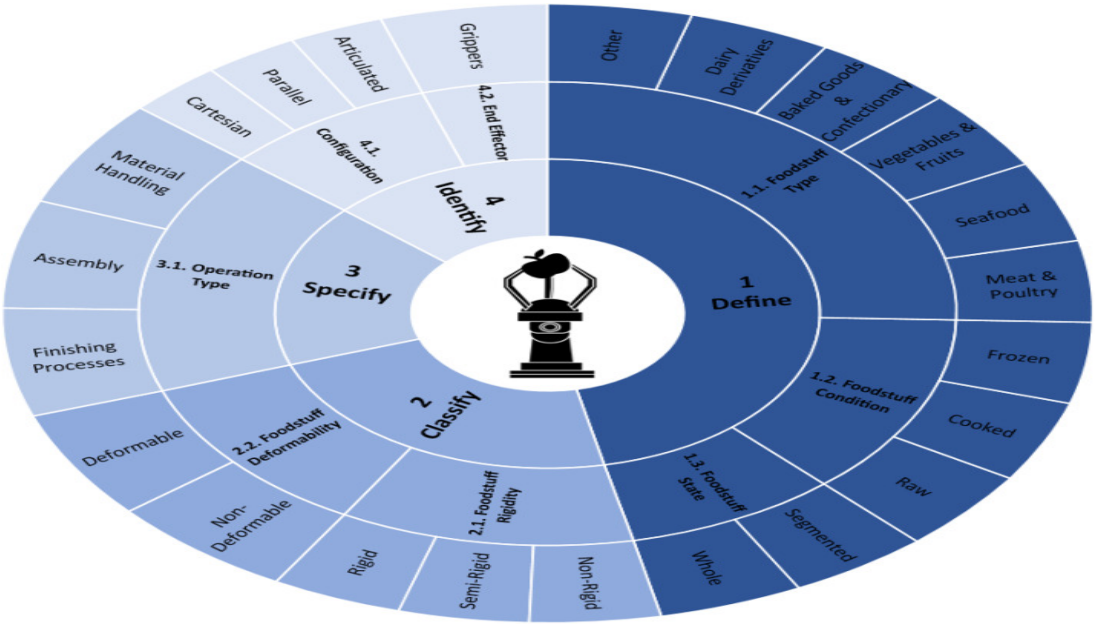

Figure 1. FIRM (Food Industrial Robot Methodology) for food manufacturing applications [7].

1. The second phase of FIRM is essential for outlining the food's handling requirements, which are the primary determinants of the IR solution. This is predicated on the stiffness and deformability of food.
2. The third stage is all about outlining the tasks that IR must complete in order to process food. These actions may consist of several tasks or just one action.
3. Based on data gathered in the first three steps, the fourth and final step of FIRM targets on identifying physical factors that determine the best IR configuration and end effector for a food production application.

2. Benefits of using robots in food industry

2.1 Effective speed

Another advantage of artificial intelligence for the food industry is faster manufacturing. But now that artificial intelligence and automated machinery have advanced, machines can produce more items faster and with higher quality. Thus, this benefits the company and raises revenue [8].

2.2. Easy material handling and sorting

Many industrial processes require the handling and sorting of materials; yet, physical handling involving human labor is a labor-intensive undertaking, particularly when dealing with a big volume of items. The manufacturing sector is now able to meet higher production rates, boost production efficiency, and lower production costs due to automation [3].

2.3 Quality control

Food quality inspection is a difficult process that requires precision. However, quality is rarely compromised or disregarded when food and other products are produced in big amounts. However, this is not a disadvantage if robots with AI assistance are in charge of the production process. To ensure quality, AI tools and algorithms can be trained and adjusted to look at multiple factors. This specific task can also be completed with fewer errors because machines only accept certain traits. Artificial Intelligence (AI) has

multiple applications, including product classification (based on size and shape), microorganism detection, defect detection, and food quality assessment [9].

2.4 Packaging

Packaging provides containment & complete protection from the external environment, physical, chemical and biological harm as well as alterations in packaged food product. Only robotic intervention can achieve all these parameters of food safety, hygiene, environmental alterations, and packaging precision. Every aspect of the food processing industry, including the extraction of edible oil, beverages, sugar mills, dairy products, fruits and vegetables, meat processing, bakeries etc. has greatly benefited from the use of robots [10].

2.5 Hygiene

Food safety is a major concern in order to prevent the spread of diseases and germs through food so food as well as beverage items must be processed without human contact. In the food business, hygienic design of robotic manipulators, vision systems, and end-effectors or grippers is essential due to these strict standards. Robot grippers used in food handling applications are cleaned with pressured hot water and industrial detergents [11].

2.6. Productivity

In the food handling, preparation and production industries as well as the food serving business, there is a greater need for productivity. PKM robots are mostly focused on handling and preparing food. The combination of integrated control methods and highly agile robotic structures allows for fast operational pick and place speeds. Robotics adoption has outpaced the rate of operator-based manual production [11].

2.7. Workers' safety

Standardizing risk hazards is vital in prospective of hybrid Human Robot Interaction (HRI) environment. The general idea is to cut off human worker access to the robot system entirely. The robot needs to be able to evaluate the risk scenarios where the use of smart sensor integration is necessary [11].

3. Application of Robotics in dairy industry

Developed in Europe, Automatic Milking Systems (AMS), often known as robotic milkers, were first made accessible there in 1992. In the US, this technology was first used in 2000. With robotic milking, the cow has the autonomy to determine her own milking schedule because it is a voluntary system. After a brief period of training, cows are milked with little to no human contact. Every cow on a dairy that uses robotic milking is equipped with an electronic tag that enables the robot to recognize her. The robot cleans the cow's teats, attaches the milk cups, and starts the milking process when she enters. When the milking is done, the cups disconnect and the cow leaves the robot. Her ID tag is read upon entry, and she receives a feed reward based on her production level. Milking happens all day and all night [12]. There are many benefits to utilizing robots for milking, including:

Economic benefit: The two main benefits that current robotic milker users mentioned were labor flexibility and the elimination of the requirement to oversee contractor labor.

Increased milking frequency: While milking can occur up to three times a day, it usually occurs no more than 2.5 times. Given that less milk is typically stored, this may lead to reduced strain on the udder and greater comfort for the cow. A higher milk output per cow is produced by more frequent milking.

Management benefit: It is possible to improve the efficiency of herd management. The robot computer will make a farmer who has never properly managed his cows do so. It informs him of the yield every quarter, conductivity, and blood in the milk.

Cow health and welfare benefits: When producers switched to robotic milking, they saw an increase in the health of their cows and a decrease in mastitis cases. This was ascribed to improved access to information about their cows and reduced stress levels in the cows. Benefits from milking udders quarter by quarter, for instance, can help lower the incidence of udder infections.

3.1 Role of robotics in cheese manufacturing

Cheese packing, cheese slicing, curd slicing, and other tasks are also performed by robots. Robots are used in the manufacture of cheese to turn, slice, portion, package, palletize, and stir curds. They also transport cheese molds. Complex operations can be implemented simply with the help of integrated sensors and measuring devices. Cheese blocks are delivered to the robot picking area on wooden planks. The cheese blocks can be selected and put onto a conveyor for additional processing with the help of a unique gripper [12].

3.2 Drawbacks of using robotics in food industry

Lack of funding, high initial costs, reduction in jobs, adaptability issues, a lack of human interaction, frequent updates, vulnerability to cyberattacks, and other issues are some of the problems linked with robotics and automation [13].

4. Conclusion:

The use of robotics in the food industry is rapidly expanding to meet the growing demands of an increasing global population. Robotics offer economic efficiency, improved food safety, and enhanced quality while reducing the need for manual labor. Various sectors within the food industry, including meat processing, dairy, and cheese manufacturing, have witnessed notable improvements due to robotics. The Food Industrial Robots Methodology (FIRM) provides a structured approach to selecting the most suitable robotic configurations and end effectors for specific food production applications. Robotics in the food industry offer benefits such as increased speed, material handling efficiency, quality control, precise packaging, enhanced hygiene, higher productivity, and improved worker safety. Despite these advantages, challenges like initial costs, job displacement, adaptability, and cybersecurity concerns need to be addressed. As the industry continues to advance, collaboration among researchers, manufacturers, and policymakers is crucial to harness the full potential of robotics while mitigating their associated challenges. The future promises even greater integration of robotics in the food industry, driven by ongoing technological advancements and innovation.

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