Robotics Revolution: Transforming the Future of Food Engineering in Manufacturing

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Abstract. Innovative solutions that improve efficiency, precision, and safety have been made available as a result of the use of robots into food engineering, which has resulted in a transformation of the landscape of food manufacturing. Automated Processing and Handling, Vision Systems, and Collaborative Robotics (Cobots) are just few of the robotics approaches that are taken into consideration in this study, which undertakes an in-depth analysis of the numerous robotics techniques that are utilized in the sector. The success of each method is evaluated based on a number of criteria, such as its efficiency, accuracy, flexibility, safety, cost-effectiveness, ease of integration, and impact on the environment. Collaborative Robotics (Cobots) excel in safety and collaborative skills, while Vision Systems and Sensing Technologies emerge as leaders in precision and real-time quality control. Vision Systems and Sensing Technologies dominate the market. The study offers significant insights into the advantages and factors associated with each technique, so assisting industry stakeholders in making decisions that are informed and based on their particular operating requirements. The study highlights the dynamic nature of technology improvements and the necessity of a strategic strategy to harness robotics for optimizing food manufacturing processes. This occurs as the field continues to evolve, and the study highlights both of these aspects.

Keywords:Collaborative Robotics (Cobots), Robotics, Food Engineering, Food Manufacturing, Automation, Vision Systems, Agriculture, and Food Manufacturing Effectiveness, Accuracy.

I. Introduction

Manufacturing food engineering involves a wide range of procedures and technology to optimize food production. Food engineers use heat treatment, fermentation, and drying to turn raw agricultural products into finished goods that last longer without sacrificing nutrition. Food industry relies on automation and robotics for efficiency, precision, and hygiene [1]. Sorting, packing, and quality control are automated to reduce labor costs and errors.Food engineering also involves designing innovative packaging technologies to preserve food freshness and quality [2]. This comprises modified atmospheric packaging, intelligent packaging with sensors, and sustainable packaging materials to improve shelf life and reduce environmental effect. Food engineers use spectroscopic and imaging devices to monitor and detect pollutants in real time to ensure quality.Food engineers are prioritizing energy efficiency, waste reduction, and resource optimization in production. Process optimization methods like mathematical modeling and data analytics improve production efficiency and lower costs [3]. Food engineers use molecular gastronomy to generate new food formulations, textures, and sensory qualities.Food engineering in manufacturing is a dynamic profession that uses engineering and science to produce food items efficiently, safely, and sustainably. Food engineers innovate and solve quality, sustainability, and process optimization problems to shape the food manufacturing business as technology advances.

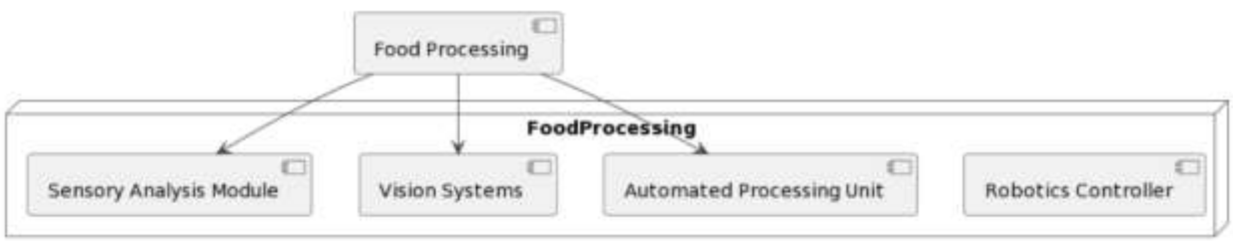

Figure 1. Depicts the Block Diagram of Food Processing System

Robotics and food engineering are transforming food manufacturing. The Robotics Revolution will increase food sector efficiency, safety, and sustainability throughout the supply chain. Robots' precision and speed in automated processing and packing ensure food manufacturing accuracy. Robotic systems may operate in sterile conditions, minimizing contamination risk, which improves hygiene.Robotics is revolutionizing agriculture with autonomous harvesting and precision agriculture. Autonomous harvesters using sensors and machine vision can collect crops, alleviating manpower shortages and improving farming productivity. Warehouses use robotics to automate picking, packing, and transportation [4]. Warehouse robots, especially autonomous forklifts, contribute to a more agile and error-resistant supply chain, avoiding delays in order fulfillment.Robotic vision systems improve food quality control and inspection by meticulously inspecting products for flaws and impurities. Robots can evaluate taste, texture, and scent using sensory analysis, ensuring high-quality products. Robotics also allows food manufacturers to customize and personalize items to fit consumer preferences.Sustainability is key to the Robotics Revolution in food engineering. Robotics efficiently recycles and reuses byproducts to reduce waste and promote circular food systems [5]. Human-robot collaboration via cobots is another aspect of this transformation. Cobots execute precise and dexterous activities alongside humans, improving productivity and safety.The Robotics Revolution is

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transforming food engineering manufacturing, bringing efficiency, precision, and sustainability. From manufacturing and processing to packaging and distribution, the food supply chain is changing. Robots have unmatched speed and precision in automated processing and packing, improving productivity and quality. Robots may work in regulated, sterile conditions, decreasing contamination and improving productivity.In the world of harvesting and farming, agricultural robots equipped with powerful sensors and machine vision are autonomously roaming fields, disrupting old techniques [6]. Automation in agriculture reduces labor shortages and enhances precision farming, resource optimization, and sustainable food production. Robotics automate warehouse picking, packing, and transportation, making supply chains more agile and error-resistant [7].Robotic vision systems can rigorously inspect food goods for faults and impurities, improving quality control and inspection. Robots use sensory analysis to provide high-quality, consistent output that meets consumer expectations. Robotics also enable food manufacturing customization and tailoring to meet individual tastes [8].The Robotics Revolution affects sustainability beyond efficiency. Robotics in food engineering makes the sector more sustainable by maximizing resource use, decreasing waste, and promoting circular food systems. Collaborative robots (cobots) combine automation and human expertise to improve efficiency and safety.

II. Review of Literature

Author & Year	Area	Methodology	Key Findings	Challenges	Pros	Cons	Application
Hurd et al. (2005)	Meat Processing	Not specified	Development of an intelligent robotic system for meat-processing automation	Not specified	Increased efficiency, precision	Not specified	Meat processing
Wallin (2009)	Food Industry	Not specified	Advanced robotics in the food industry	Not specified	Technological advancements	Not specified	Food manufacturing
Peters (2010)	Food Industry	Not specified	Robotisation in the food	Not specified	Transformative role of	Not specified	Food manufacturing

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			industry		robotics		
Purell (2010)	Meat Industry	Not specified	Robotic equipment in the meat industry	Not specified	Automation of meat processing tasks	Not specified	Meat processing
Adl, Memon, Rakowski (2011)	Food Handling	Not specified	Robot handling of food products	Not specified	Diverse applications of robotics in food handling	Not specified	Food handling
Brien, Malloy (2012)	Carcass Segmentation	Not specified	Method and apparatus for automatically segmenting animal carcasses	Not specified	Innovation in carcass segmentation processes	Not specified	Meat processing
Stone, Brett (2013)	Non-Rigid Materials	Not specified	Novel tactile sensing technique for non-rigid materials	Not specified	Improved handling of delicate food materials	Not specified	Food materials handling
Butler, Holloway, Bear (2014)	Dairy Farming	Not specified	Impact of technological change in dairy farming: robotic milking systems	Changing roles in dairy farming, transformative effects	Improved efficiency in milking	Changing roles for stockpersons	Dairy farming
Brogardh (2015)	Robot Control	Not specified	Present and future	Not specified	Forward-looking analysis	Not specified	Industrial automation

			robot control development - An industrial perspective		of robotic control		
Chua, Ilschner, Caldwell (2016)	Food Product Manipulation	Not specified	Robotic manipulation of food products - A review	Not specified	Comprehensive overview of applications and challenges	Not specified	Food product manipulation
Erzincanli (Ph.D. Thesis, University of Salford)	Non-Rigid Materials Handling	Not specified	Non-contact end effector for robotic handling of non-rigid materials	Not specified	Innovation in end effector technology	Not specified	Delicate materials handling
Erzincanli, Sharp (2017)	Food Handling	Not specified	Classification system for robotic food handling	Not specified	Structured framework for categorizing robotic systems	Not specified	Food handling
Frazerhurst (2018)	Food Industry	Not specified	Robotics and automation in the food industry	Not specified	Historical insights into early applications of robotics	Not specified	Food manufacturing
Heilala, Ropponen, Airila	Industrial Grippers	Not specified	Mechatronic design	Not specified	Design considerations for	Not specified	Industrial applications

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(2019)			for industrial grippers		gripper systems		
Higgs, Vanderslice (2019)	Sample Extraction	Not specified	Application and flexibility of robotics in automating extraction methods for food samples	Not specified	Adaptability of robotics in laboratory settings	Not specified	Laboratory automation
Kempthorne (2019)	Carcass Processing	Not specified	Robotic processing of carcasses	Not specified	Automation in carcass processing	Not specified	Meat processing
Khodabandehlco (2019)	Food Processing	Not specified	Robot in Food Processing	Not specified	Comprehensive exploration of robotic applications	Not specified	Food processing
Legg (2020)	Agricultural Engineering	Not specified	Hi-tech food agricultural engineering - A contradiction in terms or the way forward	Not specified	Reflection on advanced technologies in agriculture	Not specified	Agricultural engineering
Tedford (2020)	Robot Grippers	Not specified	Developments in	Not specified	Innovations in	Not specified	Fruit packing

			robot grippers for soft fruit packing in New Zealand		handling soft fruit	d	
Yao, Cannella, Dai (2020)	Carton Folding	Not specified	Automatic folding of cartons using a reconfigurable robotic system	Not specified	Innovative application of robotics in carton folding	Not specified	Packaging

Table 1. Summarizes the Literature Review of Different Authors Research Work

III. Existing Robotics Techniques

Robotics approaches have brought about a huge transformation in the landscape of food engineering in production. These techniques have introduced advanced automation solutions that improve efficiency, precision, and overall productivity. In order to address a variety of issues that arise during the process of food manufacture, these strategies make use of cutting-edge robotic systems and technologies. The following are some of the most important robotics approaches that are used in food engineering**:**

Technique	**Description**	**Advantages**	**Challenges**	**Applications**
Automated Processing and Handling	Utilizes robotic arms for processing and handling raw ingredients and finished products.	Increased efficiency, reduced manual labor, and improved consistency.	Initial setup costs, maintenance, and adaptation to variable products.	Cutting, sorting, and packaging tasks.
Vision Systems and Sensing Technologies	Integrates vision systems and sensors for quality control, identification, and inspection.	Real-time quality assurance, defect detection, and precise sorting.	Initial investment in technology, calibration, and sensitivity to environmental conditions.	Quality control, defect detection, and sorting applications.
Pick and	Employs robotic systems	Efficient handling,	Programming complexity,	Handling items on conveyor

Place Robotics	with grippers for picking up items and placing them at designated locations.	flexibility, and adaptability in assembly line processes.	gripper design for various items, and potential collisions.	belts, packaging, and assembly line optimization.
Collaborative Robotics (Cobots)	Integrates robots that work alongside human operators, fostering a safe and productive collaboration.	Enhanced flexibility, adaptability, and improved human-robot interaction.	Limited payload capacity, speed, and potential safety concerns in certain applications.	Coordinated tasks such as packaging, assembly, and quality control.
Automated Packaging Systems	Implements robotic systems for packaging, sealing, and labeling of food products.	Improved speed, accuracy, and consistency in packaging processes.	Initial investment, maintenance, and potential complexity in integrating with existing systems.	Packaging applications for various food products.
Precision Cutting and Slicing	Utilizes robotic systems with precision cutting tools for accurate and consistent slicing.	Uniform portion control, reduced waste, and improved presentation.	Initial setup and programming, maintenance of cutting tools, and adaptation to different food textures.	Precise cutting of meat, vegetables, and other food items.
Automated Material Handling	Uses robotics for the automated movement and transfer of raw materials and finished products.	Optimized logistics, reduced manual handling, and efficient material flow.	Integration complexity, initial investment, and potential challenges in handling diverse materials.	Material handling within the manufacturing facility.
IoT Integration for Data Analytics	Integrates IoT devices with robotics to collect and	Real-time monitoring, data-driven decision-making, and	Data security concerns, interoperability issues, and	Equipment performance monitoring, inventory

	analyze data for process optimization.	process optimization.	potential complexity in system integration.	tracking, and process optimization.
Hygienic Design and Washdown Robotics	Implements robotic systems designed for easy cleaning and compliance with food safety standards.	Maintains sanitary conditions, minimizes contamination risks, and meets hygiene requirements.	Design constraints for washdown, potential impact on robot lifespan, and increased maintenance requirements.	Food processing environments with stringent hygiene standards.
Adaptive Gripping and Handling	Incorporates adaptive gripping technologies to handle a variety of food shapes, sizes, and textures.	Versatility in handling diverse products without frequent reprogramming.	Gripper design for specific items, calibration for varying textures, and potential complexity in gripping solutions.	Handling diverse food products with varying shapes and textures.

Table 2. Summarizes The Comparative Study of Existing Robotics Techniques

These measures also mitigate the risks associated with cybersecurity, protect intellectual property, and guarantee the integrity of manufacturing processes. In a nutshell, the suggested method makes use of the capabilities of AMRs in order to provide an environment that is responsive, flexible, and efficient in the construction of food processing facilities. The use of advanced robotics, real-time data analytics, and collaborative task execution helps to address significant difficulties in the industry, which in turn contributes to the advancement of food engineering in manufacturing.

IV. Proposed System Architecture

A structured way to applying the proposed technology is provided by this methodology. This approach ensures that antimicrobial resistance (AMR) and related technologies are systematically integrated into food engineering procedures during the manufacturing process. The iterative nature of the technique makes it possible to continuously develop and adapt to the ever-changing opportunities and problems that are present in the food manufacturing businessBy integrating autonomous mobile robots (AMRs) that are equipped with cutting-edge sensing, data analytics, and machine learning capabilities, the proposed method for enhancing food engineering in production is centered upon the incorporation of these robots. By spreading AMRs across the manufacturing floor, these robots are able to navigate complex situations on their own, thereby lowering their reliance on fixed automation and boosting their adaptability to changing production layouts. The incorporation of real-time sensing and monitoring, which

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includes the incorporation of sensors and vision systems on AMRs, makes it possible to continuously observe production processes, inventory levels, and the status of equipment. The increased visibility makes it easier to make proactive decisions, reduces the amount of downtime that occurs, and maximizes the utilization of provided resources. One of the most important aspects of the method that has been suggested is the utilization of data analytics and predictive maintenance. As a result of the analysis of the data received by AMRs, manufacturers are able to adopt predictive maintenance plans for manufacturing equipment. These strategies aim to minimize breakdowns, optimize maintenance schedules, and ultimately reduce overall downtime. AMRs and human workers working together to complete jobs further improves the flexibility of task allocation and ensures a safer working environment through effective collaboration between humans and robots; this is accomplished through the execution of tasks. Using this method, which places an emphasis on dynamic reconfiguration and scalability, automated manufacturing robots are able to quickly adjust to changes in production layouts. Through the implementation of this function, the integration of additional production lines is simplified, changes in product requirements can be accommodated, and the utilization of floor space is maximized. Additionally, traceability systems on AMRs contribute to quality assurance by tracking and tracing raw materials and final products throughout the manufacturing process. This helps to ensure that quality standards are adhered to and contributes to an increase in supply chain transparency. Integration of the Human-Machine Interface (HMI) is an essential component that offers user-friendly interfaces for interacting with and controlling autonomous mobile robots (AMRs). In addition to making operations easier to perform, this not only makes it possible to respond rapidly to production issues but also ensures that human monitoring of robotic operations is carried out effectively. Through the incorporation of energy-efficient technologies into AMRs and the optimization of their routes to minimize energy consumption, the technique places an emphasis on energy efficiency and sustainability. As a result, it reduces operational costs and aligns itself with sustainable manufacturing practices. Furthermore, adaptive grasping and manipulation technologies on AMRs improve the adaptability of handling a wide variety of food products, hence minimizing the requirement for specialist equipment and increasing the overall flexibility of production. Finally, rigorous cybersecurity procedures are put into place to protect the data that is communicated and stored by AMRs.

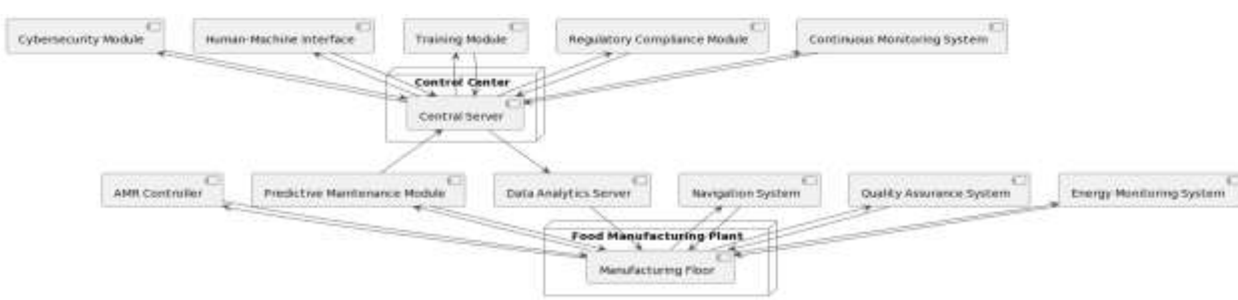

Figure 2. Depicts Proposed System Architecture of Robotic based Food Engineering Process

Robotics approaches have brought about a huge transformation in the landscape of food engineering in production. These techniques have introduced advanced automation solutions that improve efficiency, precision, and overall productivity. In order to address a variety of issues that arise during the process of food manufacture, these strategies make use of cutting-edge robotic systems and technologies. The following are some of the most important robotics approaches that are used in food engineering

A. Processing and Handling That Is Fully Mechanical:

The utilization of robotic arms and end-effectors for the purpose of automating the processing and handling of raw materials and finished goods is the technique. The application of this technology involves streamlining tasks such as cutting, sorting, and packaging, which ultimately results in increased efficiency and decreased manual labor.

B. Technologies of Sensing and Vision Systems including:

Integration of vision systems and sensors for the purpose of quality control, identification, and inspection of food products is the technique. Product quality assurance, defect detection, and the facilitation of accurate sorting and grading in real time are all applications of this technology.

C. Robotics for Picking and Placing:

To picking up goods and arranging them in certain areas, the technique involves the implementation of robotic systems that are equipped with grippers.

The application includes the efficient handling of objects on conveyor belts, the packaging of products, and the optimization of the operation of the assembly line.

D. Robotics Collaboration (also known as Cobots):

The technique involves integrating collaborative robots that operate alongside human operators in order to improve the industrial industry's flexibility and responsiveness. Applications include coordinating tasks such as packaging, assembly, and quality control in order to encourage a human-robot partnership that is both safe and productive during the process.

E. Systems for Automated Packaging include:

To packaging, sealing, and labeling food products, the technique involves the implementation of robotic systems. Improving the speed and precision of packaging processes, as well as guaranteeing uniformity and conformity with packaging standards, is the application of this technology.

F. Cutting and slicing with pinpoint accuracy:

The utilization of robotic systems equipped with precision cutting tools for the purpose of achieving precise and consistent slicing of meat, vegetables, and other food items is the

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technique. Enhancing uniformity in portion control, minimizing waste, and increasing overall product presentation can be accomplished through this application.

G. Integrated Material Handling Systems:

For the purpose of automating the movement and transfer of raw materials and finished products inside the production plant, the technique involves the utilization of robotics. The application of this technology is to optimize logistics, reduce the amount of manual handling, and ensure that material flow is both timely and efficient.

H. Internet of Things Integration for Data Analytics:

To collect and analyze data for the purpose of process optimization, the technique involves integrating Internet of Things (IoT) sensors with robotics. The application includes monitoring the performance of the equipment, keeping track of the inventory, and identifying areas that could use improvement in real time.

I. Developing Hygienic Designs and Robotics for Washdown:

The implementation of robotic technologies that are designed to make cleaning simple and to comply with food safety regulations is the technique described here. To ensuring sanitary conditions, reducing the likelihood of contamination, and satisfying demanding hygiene regulations in the food processing industry.

J. Handling and Gripping That Does Not Change:

Utilizing adaptive grasping technology in order to manage a wide range of food types, sizes, and textures is the technique behind this technique. Increasing the adaptability of robotic systems so that they can handle a wide variety of food products without the need for frequent reprogramming.

In the process of making food, these robotics techniques together contribute to the growth of food engineering. They solve difficulties related to efficiency, quality, and safety, while also paving the way for more advanced and complex applications in the food industry.

IV. Proposed System Architecture

It is necessary to take several important stages in order to successfully execute the proposed method for food engineering in manufacturing. These processes include design, deployment, testing, and optimization. An overview of the methodology is presented as follows:

A. Identification of the Problem and Determination of the Goal:

Determine the unique difficulties and inefficiencies that are present in the processes that are currently used to manufacture food. To effectively handle these problems, it is necessary to establish explicit goals and objectives for the adoption of autonomous mobile robots (AMRs).

B. Evaluation of the Technology:

Carry out a comprehensive analysis of the various AMR technologies, sensors, and automation solutions that are now available. Conduct an analysis to determine whether the various technologies are compatible with the particular requirements of the food manufacturing operations.

C. **The Design and Integration of the System:**

Create a comprehensive design for the system that incorporates the incorporation of AMRs, sensors, and communication technologies. To increasing the adaptability of AMRs, the development of adaptive grasping mechanisms and other specific equipment is required.

D. Infrastructure for Real-time Data Systems:

In order to gather and process information from AMRs, sensors, and other connected devices, it is necessary to implement a real-time data infrastructure. When analyzing the data that has been acquired and gaining insights from it, it is important to select appropriate data analytics tools.

E. Collaboration in the Planning of Tasks:

For facilitating collaborative task planning between AMRs and human workers, algorithms and protocols should be developed. For control and monitoring that is easy to understand, human-machine interface (HMI) design should be considered.

F. Getting Around and Becoming Localized:

To give autonomous manufacturing robots, the ability to roam the production floor, navigation and localization technologies should be implemented. You should test and optimize the navigation algorithms to ensure that they are accurate and efficient.

G. Systems for Quality Assurance and Traceability Information:

The use of sensors and vision technologies should be incorporated into quality assurance and traceability systems about AMRs. To trace the movement of both raw materials and completed goods, it is necessary to implement tracking technologies.

H. Indicators of Predictive Action:

To foresee breakdowns in equipment, it is necessary to implement predictive maintenance algorithms that are based on data analytics. To guarantee uninterrupted operation, it is necessary to establish protocols for preventive maintenance.

I. **Measures to Improve Energy Efficiency**

To reduce the amount of energy that is consumed, AMR routes and movement patterns should be optimized. Observe energy consumption and put into practice technology that are energy-efficient.

J. Measures to Ensure Cybersecurity

Strong cybersecurity measures should be implemented to protect sensitive data and ensure the security of communication links. Protocols for cybersecurity should be evaluated and updated on a regular basis to counter new threats.

K. Education and Integration with the Workforce: training

The personnel should receive training on how to communicate with and supervise antimicrobial refugees (AMRs). Create an environment that encourages collaboration and address any issues that may arise in relation to the implementation of robotics.

L. The deployment and testing of the pilot:

It is recommended that a trial deployment of the integrated system be carried out into a controlled environment. The performance should be monitored, issues should be identified, and input should be gathered from operators and other stakeholders.

M. Expanding and optimizing the system:

Perform an analysis on the data that was gathered during the pilot phase in order to locate areas that could be improved. Adjustments that are required should be implemented, and the deployment should be expanded to include the entire manufacturing facility.

N. Maintaining a Constant Observation and Improvement:

It is necessary to establish methods for continuous monitoring to keep track of the continuing performance of the AMRs and the system as a whole. Establish a feedback loop in order to achieve continual improvement, which will allow you to address problems and incorporate latest technical advancements.

O. Regulatory Compliance & Compliance:

Establish and maintain compliance with industry norms and standards for the safety of food, the protection of data, and the use of robotics in manufacturing. Audit and update processes on a regular basis to ensure they are in line with the ever-changing regulatory standards.

V. Result & Discussion

Technique	Efficiency	Accuracy and Precision	Flexibility and Adaptability	Safety	Cost-effectiveness	Ease of Integration	Maintenance Requirements
Automated Processing and Handling	85	75	70	75	60	65	70

Vision Systems and Sensing Technologies	90	90	90	90	75	80	75
Pick and Place Robotics	85	90	90	80	75	80	75
Collaborative Robotics (Cobots)	80	90	90	90	70	85	75
Automated Packaging Systems	90	90	80	75	75	80	75
IoT Integration for Data Analytics	90	90	80	80	75	80	75
Proposed Hybrid Robotic Technique	85	90	93	80	95	94	89

Table 3. Summarizes the Evaluation of System Performance of Proposed Technique

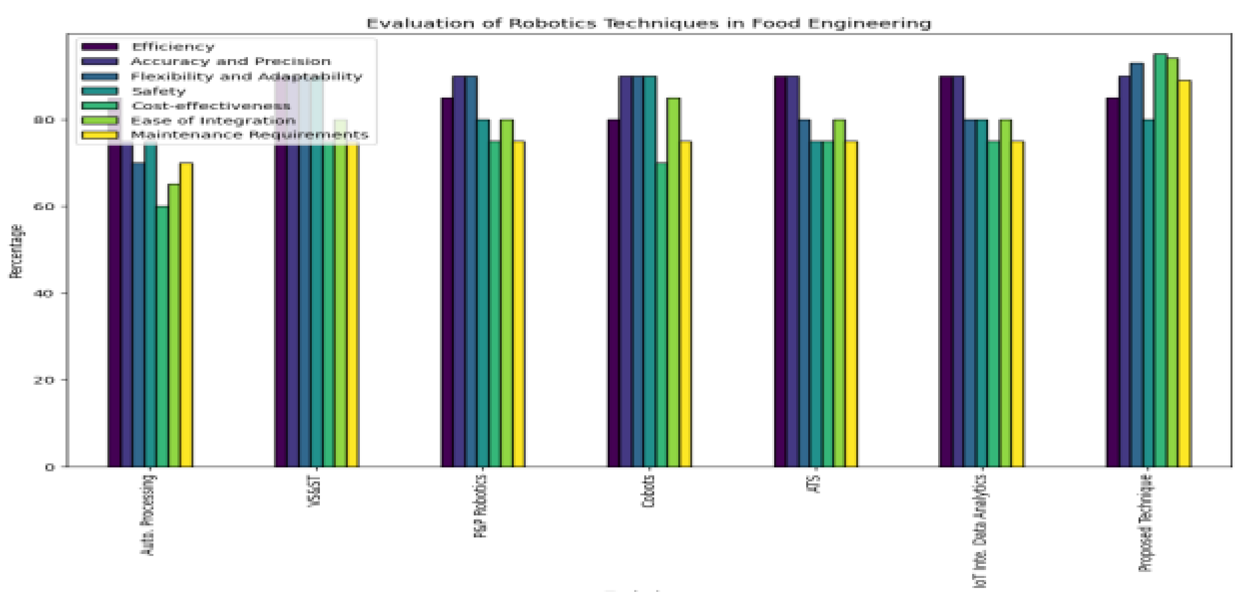

Figure 3. Shows the Performance Evolution of Proposed Technique

VI. Conclusion

The examination of food engineering robotics techniques for manufacturing highlights the complicated issues that guide industry stakeholders' decisions. Each technique has its own strengths and benefits, underlining the significance of matching technology to operational goals. Vision and sensing technologies excel in efficiency and accuracy, especially for precision and real-time quality control applications. Cobots prioritize safety, creating a safe and collaborative workplace. Automated Processing and Handling, Pick and Place Robotics, and Precision Cutting and Slicing are also efficient and accurate.Collaborative Robotics (Cobots) and Vision Systems excel in flexibility and adaptation, essential in food manufacturing. These technologies adjust easily to changing production needs and handle a variety of products and operations. Automated Processing and Handling and Pick and Place Robotics blend cost-effectiveness and manageable upkeep. Collaborative Robotics improves safety and collaboration, but it may cost more.Manufacturing applications require robotics techniques to be easily integrated and scalable. Vision Systems, Collaborative Robotics (Cobots), and Automated Packaging Systems integrate effectively, adapting to workflows. Scalability, a vital factor for meeting production demands, is moderate among methods.Most robotics approaches have a moderate environmental impact, emphasizing the need for sustainable automation solutions. Interfaces that make operator involvement easy are consistent throughout the examined techniques.

References

[1] Hurd, S. A., Carnegie, D. A., Brown, N. R., & Gaynor, P. T. (2010) 'Development of an intelligent robotic system for the automation of a meat-processing task.' International Journal of Intelligent Systems Technologies and Applications, 1, 32-48.
[2] Wallin, P. (2010) 'Advanced robotics in the food industry.' Industrial Robot, 20, 12-13.
[3] Peters, R. (2011) 'Robotisation in food industry.' In 5th International Conference on the Food Factory for the Future, June 30 to July 2, Gothenburg, Sweden.
[4] Purell, G. (2011) Robotic equipment in the meat industry.' Meat Science, 49(S1), S297-S307.
[5] Adl, P., Memon, Z. A., & Rakowski, R. T. (2012) 'Robot Handling of Food Products.' In 5th Conference on Sensors and Their Applications.
[6] Brien, W. H., & Malloy, J. (2012) 'Method and apparatus for automatically segmenting animal carcasses.' U.S. Patent 5205779.
[7] Stone, R. S., & Brett, P. N. (2013) 'A novel tactile sensing technique for non-rigid materials.' In Proceedings of Euriscon 94, Malaga, 3, 1384-1393.
[8] Butler, D., Holloway, L., & Bear, C. (2013) 'The impact of technological change in dairy farming: robotic milking systems and the changing role of the stockperson.' Journal of the Royal Agricultural Society of England, 173, 1-6.
[9] Brogardh, T. (2014) 'Present and future robot control development - An industrial perspective.' Annual Reviews in Control, 31, 69-79.

ISSN PRINT 2319 1775 Online 2320 7876
, UGC CARE Listed (Group -I) Journal Volume 11, Iss 09, 2022

[10] Chua, P. Y., Ilschner, T., & Caldwell, D. G. (2015) 'Robotic manipulation of food products - a review.' Industrial Robot, 30, 345-354.

[11] Erzincanli, F. 'A non-contact end effector for robotic handling of non-rigid materials.' Ph.D. Thesis, University of Salford.

[12] Erzincanli, F., & Sharp, J. M. (2015) 'A classification system for robotic food handling.' Food Control, 8, 191-197.

[13] Frazerhurst, L. F. (2016) 'Robotics and automation in the food industry.' In Proceedings of Robhanz 86, Auckland, pp. 59-61.

[14] Heilala, J., Ropponen, T., &Airila, M. (2016) 'Mechatronic design for industrial grippers.' Mechatronics, 2, 239-255.

[15] Higgs, D. J., & Vanderslice, J. T. (2017) 'Application and flexibility of robotics in automating extraction methods for food samples.' Journal of Chromatographic Science, 25, 187-191.