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The Use of Artificial Intelligence with Mechanisms in Robots in the Linkage of the Manufacturing Industry: Systematic Literature Review

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ABSTRACT

This paper aims to provide an overview of the literature by looking at the use of artificial intelligence with robotic mechanisms in the manufacturing industry. The PRISMA approach is used in a modified framework to consider the inclusion and exclusion criteria. One of the bases for selection is the basic understanding of artificial intelligence technology obtained from the Scopus index database only for 2020, 2021, and 2022. The results were from 1178 articles to 481 contiguous pieces until the selection of 36 articles. The journal description used as the most common reference of Frontiers in Robotics and AI was used to identify these papers in more depth. The most common journal publisher was Frontiers Media S.A., Italy was the country of origin found, and quantitative research was the most common methodology. Research in 2020, 2021, and even 2022 is still a fraction of what is now being discussed. Still, the last three years have seen significant growth in discussions on this topic, creating tremendous opportunities for additional studies.

Keywords: *Artificial Intelligence, Robots, Manufacturing Industry, Systematic Literature Review, PRISMA*

Introduction

The fourth industrial revolution, known as "Industrial Revolution 4.0," is characterized by the rapid advancement of technology, the interconnectivity of technology, and the application of these developments. The emergence of artificial intelligence technology, or what we commonly refer to as "AI," is one of the new developments that has never happened in the previous industrial revolution [1]. Advances in artificial intelligence include learning, self-correction, and reasoning. This approach is comparable to how humans think about options before making a choice [2]. Synthetic intelligence approaches, or AI as it is more commonly known, are currently seen as an optimization technique that may be effective [3].

With the increased use of artificial intelligence-focused applications due to their unique automation and connection, Industry 4.0 is referred to as the era of technological disruption. The application uses robots to replace human labor, making it more affordable, efficient, and effective [4]. These mechanical devices (robots) can perform physical tasks either with human supervision and control or with pre-defined programs (artificial intelligence) that are not tedious or fatiguing and are typically used for repetitive tasks when humans complete them quickly get bored, heavy as people can lift weights, risky if done by people. Some people mistakenly believe that all robots are humanoid machines, but this is not always the case [5].

Other types of robots are used in the industrial sector, and many of them have automated production and manufacturing machines that use robots and artificial intelligence, especially in the manufacturing industry, which is a collection of activities and operations related to the scope of design, material selection, planning, production, quality control [2]. According to [6], the fact that robot sales increased by 12% in 2013 to 178,132 units proves that the use of robots is growing yearly and will likely continue to increase until 2023. In manufacturing, robots are taught to perform simple and complex tasks. According to New Scientist's research on Google's artificial intelligence, artificial intelligence technology allows robots to detect lip movements with an accuracy rate of up to 95%, higher than humans, whose accuracy rate is only 52% [7]. The argument is that robots and artificial intelligence essentially work together to increase productivity in the workplace, particularly in the industrial sector.

While there is a lot of talk about studying different types of robots, there is very little done for and related to industrial manufacturing robots. This literature study can still use studies from various sources of papers that are specific or related to industrial production robots as references. The COVID-19 period in 2020, 2021, and 2022 is still a pandemic until the transition from pandemic to endemic, whether the role of robots in the manufacturing industry sector will replace the part of humans or not. That's what we want to know. This topic is interesting because, in the previous discussion, this robot can exceed human capabilities in addition to other reasons.

The main objective of this paper, which is detailed in the Scopus database for 2020-2022, is the use of artificial intelligence with robot implementation methods in the manufacturing sector. Identify the characteristics of the general approach of various studies conducted on the use of artificial intelligence with

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robot implementation mechanisms in the manufacturing industry, identify the impact of different independent variables on artificial intelligence with robot implementation mechanisms in the manufacturing industry, and identify the role of robots in the human work environment in the manufacturing industry.

Research Methods

It serves as a search tool and data source so that the literature study is not too broad and the existing objectives can be more focused on the application of artificial intelligence with the deployment of mechanisms in robots in the manufacturing industry. Only 2020, 2021, and 2022 were considered when selecting articles. To simplify the work of robots in the manufacturing sector, some words were used, such as "arm robot," "handheld robot," "autonomous robot," and so on, all of which are still relevant. The search plan was executed:
1. Subject area boundary (artificial intelligence or mechanical engineering and computer science).
2. Title (robot or robotic or science or AI).
3. Language limit (English) and year limit (2020-2022).

Furthermore, a systematic literature review following the PRISMA Preferred Reporting Items for Systematic Reviews and Meta-analyses) method guidelines will describe the inclusion and exclusion criteria [8].

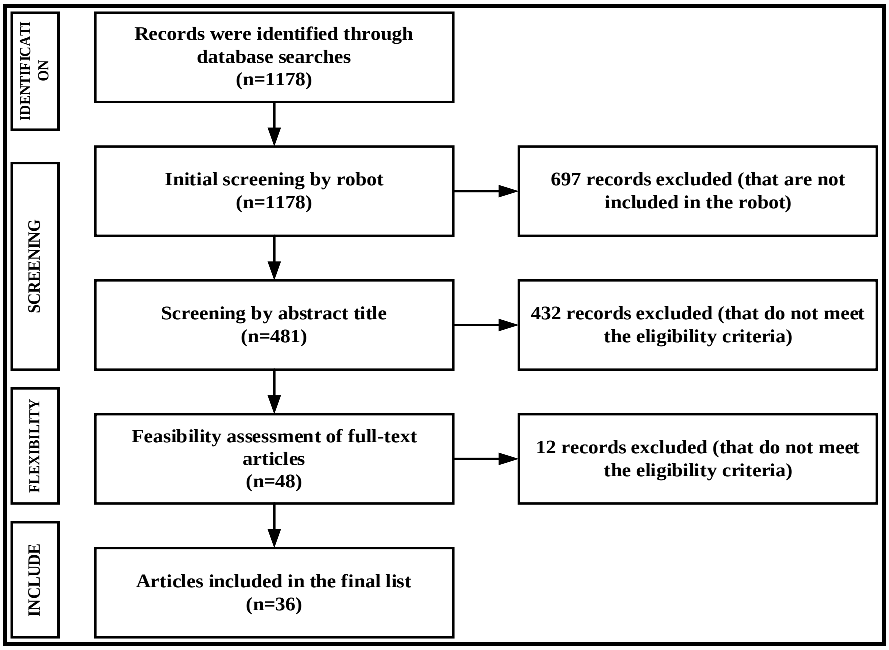

Figure 1. PRISMA Framework

Based on Figure 1, the PRISMA approach has four strategies: identification, screening, eligibility, and inclusion. A total of 1178 articles were collected and recognized from the Scopus database on artificial intelligence journals. In addition, filtering based on relevance at the first level of hierarchy (screening) was conducted, resulting in 481 articles. Forty-eight articles were also selected at the feasibility level of the order. These items are included in the final list of 36 pieces at the bottom of the hierarchy. The following can explain the criteria in Table 1 Inclusion and Exclusion Criteria.

Table 1. PRISMA Framework

Inclusion	Exclusion
Language (English)	Language: Not English
Document (Article (open access))	Document Type: Book
Subject (Computer Science, Engineering, and Mathematics)	Subject Area: Article Review, Secondary Studies, and Editorial
Specialized Subject Areas (Artificial Intelligence, Mechanical Engineering, Control and Optimization, and Computer Science Applications).	-
Specialized study on robots.	Studies Beyond Robots

Based on Table 1, Inclusion and Exclusion Criteria, Exclusion criteria apply when research subjects cannot be a representative sample of the population under study. In contrast, inclusion criteria apply when they do, and so do the details of the applicable provisions.

Results and Discussion

Following the previously described sub-chapter, 36 articles were selected from the initial 305 articles using the systematic literature review model collection method, PRISMA, focusing on 2020 to 2022. because this technology is bound to experience progress that has a significant impact, especially in the field of artificial intelligence, and because we want to understand the difficulties of technology.

Descriptive Overview

It attempts to provide the information contained therein more straightforwardly and comprehensively. This descriptive overview of journals include a list of specific articles used as references, the publication of each journal, and the country from which it was produced. Table 2. Selected Journals.

Table 2. Selected Journal

Author	Title	Source
[9]	A Methodology for Flexible Implementation of Collaborative Robots in Smart Manufacturing Systems.	Robotics (MDPI)
[10]	Optimizing Cycle Time of Industrial Robotic Tasks with Multiple Feasible Configurations at the Working Points.	Robotics (MDPI)
[11]	Modeling and Analysis of a High-Speed Adjustable Grasping Robot Controlled by a Pneumatic Actuator.	Robotics (MDPI)
[12]	Evaluation Criteria for Trajectories of Robotic Arms.	Robotics (MDPI)
[13]	An Analysis of Power Consumption of Fluid-Driven Robotic Arms Using Isotropy Index: A Proof-of-Concept Simulation-Based Study.	Robotics (MDPI)
[14]	Design, Implementation, and Kinematics of a Twisting Robot Continuum Arm Inspired by Human Forearm Movements.	Robotics (MDPI)
[15]	Low-Cost Sensory Glove for Human–Robot Collaboration in Advanced Manufacturing Systems.	Robotics (MDPI)
[16]	Human–Robot Interaction in Industrial Settings: Perception of Multiple Participants at a Crossroad Intersection Scenario with Different Courtesy Cues.	Robotics (MDPI)
[17]	Safe Robot Trajectory Control Using Probabilistic Movement Primitives and Control Barrier Functions.	Frontiers In Robotics and AI
[18]	Formal Verification of Real-Time Autonomous Robots.	Frontiers In Robotics and AI
[19]	An Accessible, Open-Source Dexterity Test: Evaluating the Grasping and Dexterous Manipulation Capabilities of Humans and Robots.	Frontiers In Robotics and AI
[20]	Learning to Centralize Dual-Arm Assembly.	Frontiers In Robotics and AI
[21]	How to be Helpful? Supportive Behaviors and Personalization for Human-Robot Collaboration.	Frontiers In Robotics and AI
[22]	Automatic Calibration of the Adaptive 3D Scanner-Based Robot Welding.	Frontiers In Robotics and AI
[23]	Implementation of NAO Robot Maze Navigation Based on Computer Vision and Collaborative Learning.	Frontiers In Robotics and AI
[24]	Modal Kinetic Analysis of a Parallel Kinematic Robot with Low-Stiffness Transmissions.	Robotics (MDPI)
[25]	Socially Assistive Robots Helping Older Adults through the Pandemic and Life after COVID-19.	Robotics (MDPI)
[26]	A Novel, Oriented to Graphs Model of Robot Arm Dynamics.	Robotics (MDPI)
[27]	A Method for Health Indicator Evaluation for Condition Monitoring of Industrial Robot Gears.	Robotics (MDPI)
[28]	An Overview of Verification and Validation Challenges for Inspection Robots.	Robotics (MDPI)

Table 2. Selected Journal (Continued)

Author	Title	Source
[29]	I am validating Safety in Human–Robot Collaboration: Standards and New Perspectives.	Robotics (MDPI)
[31]	A Holistic Approach to Human-Supervised Humanoid Robot Operations in Extreme Environments.	Frontiers In Robotics and AI
[32]	Detachable Robotic Grippers for Human-Robot Collaboration.	Frontiers In Robotics and AI
[33]	Characterizing Continuous Manipulation Families for Dexterous Soft Robot Hands.	Frontiers In Robotics and AI
[34]	OUTPUT: Choreographed and Reconfigured Human and Industrial Robot Bodies Across Artistic Modalities.	Frontiers In Robotics and AI
[35]	A Scooping-Binding Robotic Gripper for Handling Various Food Products.	Frontiers In Robotics and AI
[36]	Hierarchical, Dense and Dynamic 3D Reconstruction Based on VDB Data Structure for Robotic Manipulation Tasks.	Frontiers In Robotics and AI
[37]	Acceptance of Industrial Collaborative Robots by People with Disabilities in Sheltered Workshops.	Frontiers In Robotics and AI
[38]	An Open-Source ROS-Gazebo Toolbox for Simulating Robots with Compliant Actuators.	Frontiers In Robotics and AI
[39]	A Virtual Sandbox Approach to Studying the Effect of Augmented Communication on Human-Robot Collaboration.	Frontiers In Robotics and AI
[40]	A Soft Five-Fingered Hand Actuated by Shape Memory Alloy Wires: Design, Manufacturing, and Evaluation.	Frontiers In Robotics and AI
[41]	FMG- and RNN-Based Estimating Motor Intention of Upper-Limb Motion in Human-Robot Collaboration.	Frontiers In Robotics and AI
[42]	Robotic Development for the Nuclear Environment: Challenges and Strategy.	Robotics (MDPI)
[43]	On the Trajectory Planning for Energy Efficiency in Industrial Robotic Systems.	Robotics (MDPI)
[44]	An Analysis of Joint Assembly Geometric Errors Affecting End-Effector for Six-Axis Robots.	Robotics (MDPI)

Based on Table. 2 Selected Journals, only two robotics journals, and frontiers are listed. A total of 36 papers or publications were selected in the field of robotics and AI, some of which were included following the inclusion criteria and had relevance to the manufacturing sector. Due to failure to meet the inclusion requirements involving robots relevant to the manufacturing business, some journals were excluded. The source journals robotics, published by Multidisciplinary Digital Publishing Institute (MDPI), and Frontiers in robotics and AI, posted by Frontiers Media S.A., contained a total of 36 balanced articles that were referenced, with 18 articles appearing in each issue. Next, Figure 2. Year of Journal Distribution.

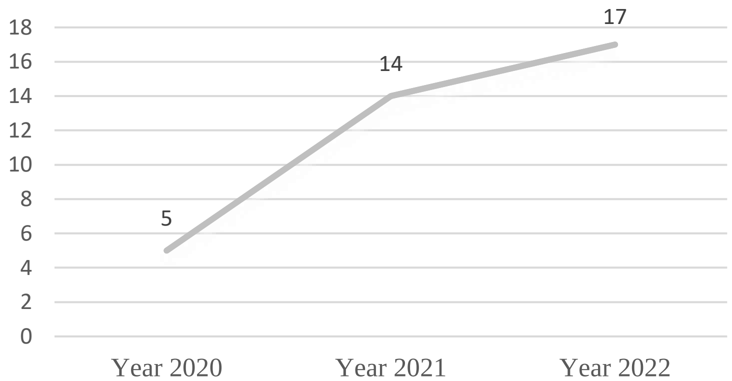

Figure 2. Year of Journal Distribution

According to Figure 2, research on AI in robots related to the manufacturing sector was published predominantly in 2022 with 17 articles. There will likely be more articles in 2023. The following is Table 3—distribution by Region, which presents the frequencies and percentages in more detail.

Table 3. Distribution by Region

Region	Number of Countries	Number of Articles	Percent (%)	Country Name	Total
				Iraq	1
Asia	2	4	11,11	Jepang	2
				Thailand	1
Afrika	1	1	2,78	Afrika Selatan	1
				Inggris Raya	3
				Bulgaria	1
				Italia	9
				Irlandia	1
				Jerman	6
Eropa	9	27	75	Kanada	3
				Portugal	1
				Prancis	2
				Selandia Baru	1
				Slovakia	1
				Slovania	1
Amerika Utara	1	4	11,11	Amerika Serikat	4
Total	13	36	100		

Table 4 explains that of the 17 total articles selected, there were 16 different countries represented in 3 continental regions, and most studies were conducted in Italy, where there was a total of 9 studies. Europe has the most studied continental Region, with 27 studies, and the percentage is 75%. With a calculation of 1 research and a rate of only 2.78%, South Africa and the African continent had the fewest studies. Following Figure 2 Research Methods.

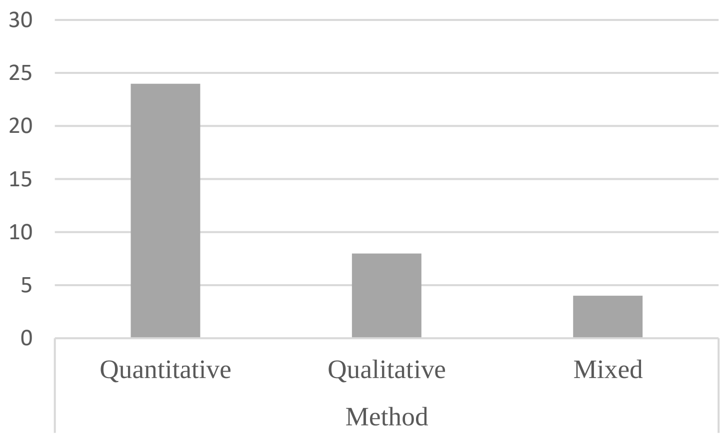

Figure 3. Research Methods

Based on Figure 2, 24 studies used quantitative methods, 8 used qualitative methods, and four mixed strategies, which are most likely to use such practices because they are tough to detect. As a result, quantitative data methods are becoming the most popular because system modeling, programming, track configuration, simulation, and other tasks that require exact numbers to be further processed or interpreted as robots or software applications to be further processed are more important in discussions about the use of artificial intelligence with mechanisms on robots about the manufacturing industry.

Variabel Relationship

This process is used to determine whether there is a relationship between the independent variables and the manufacturing industry robot. This relationship can be positive, negative, significant (large effect), or insignificant (small effect). Table 4 shows the relationship between Variables and Industrial Manufacturing Robots (General).

Table 3. Distribution by Region

No	Independent Variable	Influence on the Robots Manufacturing industry				
		Positive	Negative	Not Significant	Significant	Total
1	Simplifying the Process	1			1	2
2	Considering Configuration	3			1	4
3	Programming Modeling	1			1	2
4	Trajectory	7		2	5	14
5	Simulation	4			1	5
6	Continuum Arm	1		1		2
7	Collaboration	9	2	3	6	20
8	Formal verification (proofing)	1			1	2
9	Manipulation	4			1	5
10	Automatic Calibration	1			1	2

Based on Table 4 explains, in general, how the independent and dependent variables (industrial robot manufacturing) relate to each other. Initially, there are 12 independent variables in total, but upon closer inspection, it turns out that only ten dependent variables have transparent relationships and descriptions. Collaboration and trajectory are the variables that have the most or explain the relationship between industrial robot manufacturing, and the relationship reaches 20 and 14 times out of 36 articles, respectively. However, the remaining collaborations have adverse and insignificant effects or vice versa, and their use is almost evenly distributed. Specifically, this collaboration allows humans and robots to collaborate on joint production operations in a manufacturing environment. If a trajectory is optimized, it must be followed, and the order of tasks is important because it will affect the cycle time of manufacturing industry robots (how long it takes to complete a job) [15][16].

Discussion

The science of implementing artificial intelligence in the form of robots is intertwined, with artificial intelligence serving as the brain and robot operations as the output. To implement collaborative robots as one of the potential technologies as we enter the industrial revolution 5.0, a balance between integration and performance must be achieved in the early stages of technology development [9]. Investing in robots conveniently shows that the economic perspective must also be considered. The findings show that investing in robots with small or medium batch sizes can create new opportunities for collaborative robotics. [11]. A lot of research has been done over the past three years on the creation and analysis of linkage robots for the manufacturing sector, especially arms or hands and autonomous robots (using computer vision which is one of the disciplines of artificial intelligence). [12]. According to [13][14], thought to update these robots due to the lack of standardized criteria, techniques, or tools to measure agility.

The assessment of this study is based on the previous explanation that various (independent) factors affect industrial production robots. There are 13 variables, with 10 being the primary or dominant variables. More specifically, five variables were used approximately twice, one variable four times, two variables five times, one variable 14 times, and one variable 20 times. Linkage robots used in the manufacturing sector are influenced by specific findings that can be drawn from the dominance of collaboration and trajectory variables. In implementing robots in manufacturing, some stages start from training the operators who will supervise the robot and end with the robot's readiness to process further the same product to be manufactured. Collaboration is increasingly needed to simplify the programming process (interactive enhancement) while maintaining high flexibility [20][21]. Human-robot partnership offers a safe co-production setup where humans and robots can coexist in a manufacturing work environment [17].

In safe co-production settings, human-robot collaboration enables the coexistence of humans and robots in manufacturing work environments [29]. Furthermore, the model must accurately depict the underlying robot system to produce valid and meaningful verification findings. Consequently, it should consider all potential behaviors of the robot software under real-world hardware and operating system restrictions [32]. Based on the review, it has been established that cooperation is still needed for the use of robots in human work environments in the manufacturing sector [41]. In addition to maintaining operator performance, avoiding close contact between operators and other people in the workplace, keeping them away from potential hazards on site, and creating new challenges, the Covid 19 pandemic approach makes surveillance and robot need even more necessary. These factors together create new challenges that require the collaboration of artificial intelligence, robots, and Humans to be able to integrate [25].

Most of the included studies evaluated the effects of manipulating robot factors on humans. Still, few clarified the impact of human factors on system attributes or performance after examining areas suggested for future research in the article [45]. Future research should investigate whether sufficiently accurate models can be trained through verbal instructions or user demonstrations and how these assumptions apply in different application areas. Future opportunities for additional linking will be centered on validating the results of the simulation studies discussed in this research by using an experimental setup consisting of several hydraulic actuators. This research can be used to determine the best course of action for a particular task based on reduced power consumption. Future possibilities imply that human-robot collaboration systems require task sharing and physical workspaces. If overall worker safety can be ensured and achieved, then human-robot collaboration systems can be implemented. A robot framework can be created consisting of three integrated levels of coexistence, collaboration, and Safety between robots and human workers. The potential opportunity for a robot to move autonomously and display polite gestures whenever it meets a person while performing its task highlights the need to develop the necessary algorithms.

Conclusion

Regarding this study, it turns out that the most frequently raised linkage in the review, presentation, and comparison of various manufacturing-related robots developed in 2022 that can grip and interact. Walk is with the type of arm robot. In addition, 1178 articles from the Scopus database were selected from 36 papers that passed the journal screening based on their relevance to robots, based on their title or abstract, and the eligibility of full-text articles. Since it deals with system modeling, programming, trajectory configuration, and simulation using fixed numbers, most of the research was conducted in countries (Italy, the United Kingdom, and the United States) and mainly used quantitative methods. Including independent variables simplifies the process, with beneficial effects on formal verification, manipulation, simulation (power usage), and automatic calibration. Collaboration and trajectory are the most significant and frequently used factors that have a beneficial influence. For collaboration, some drawbacks must be considered in industrial production robots. In addition to last year due to limited free access, the COVID-19 period in 2020, 2021, and 2022 is still a pandemic until the transition from pandemic to endemic when the role of robots in the industrial manufacturing sector will replace the part of humans or not, that is what we want to know. Since collaborative robots (modern factories) are one of the significant changes in the manufacturing industry and are developing rapidly, the role of robots will be maximized if they work together with humans.

In the articles used, this literature review encountered some obstacles. Due to the limited data in Scopus and the relatively broad field of artificial intelligence and industrial robot manufacturing mechanisms, the area is further limited by the keywords "robots that have linkage mechanisms with the manufacturing industry," such as "standard types" (robot arms and autonomous robots). In addition to working with robots, further study of artificial intelligence can be done by implementing the Internet of Things (IoT), as research on manufacturing industry-linked robots was scant in 2020, 2021, and 2022, so there is now a greater need for this field of study than ever before.

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