Journal of Soft Computing Exploration

Homepage: https://shmpublisher.com/index.php/joscex

p-ISSN: 2746-7686
e-ISSN: 2746-0991

# Current trend in control of artificial intelligence for health robotic manipulator

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**Article Info**

***Article history:***

Received Nov 26, 2022
Revised Dec 4, 2022
Accepted Dec 14, 2022

***Keywords:***

Artificial intelligence
Robotic manipulator
Control algorithm

**ABSTRACT**

The increasing utilization of artificial intelligence and robots in various services in healthcare makes robots as preferred intelligent agent model. Robotic evolution produces the optimal robotic innovation in the robotic system or its subsystems, morphology, kinematics, and control. An intelligent algorithm is programmed into the control of the robotic manipulator. This paper aims to identify the control of artificial intelligence and identify comparisons of artificial intelligence algorithms control for healthcare robotic manipulators. This study uses a systematic literature review using the Preferred Reporting Items for Systematic Review (PRISMA). The potential for further articles is explored related to the theme of the research carried out. The conclusion obtained many studies have been carried out to optimize the work and tasks of the robotic arm manipulator, specifically developing various types of manipulator control (algorithms) combined with neural networks to get the right and appropriate algorithm.



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## 1. INTRODUCTION

The presence of artificial intelligence (AI) and robots has become a very interesting discussion. Especially in the digital era and the Internet of Things (IoT) where all data is digitized and accessible anywhere in real-time. AI is robotic intelligence or computer that can imitate intelligence, ways of thinking, acting, and behavior like humans [1]. In the next evolution, the functions of AI and robots will exceed human intelligence. The development of AI and robots involves various disciplines, such as computers, science, engineering, biology, psychology, mathematics, statistics, logic, philosophy, business, and linguistics. Advances in AI, robotics, machine learning, and automation caused many human jobs to be replaced or known as unemployment technology [2]–[4]. The increasing utilization of AI and robots in various services makes robots as preferred intelligent agent model, so AI and robots are growing rapidly all over the world.

Robots were created to imitate human activities in order to make activities easier and more efficient. Robots are designed and controlled according to the desired and required characteristics or behaviors. The robot design is adapted to functions that can measure the ability to adapt to the environment, without programming specific behaviors as known as robotic evolution [5]. Robotic evolution produced an optimal robotic innovation in the robotic system or its subsystem, morphology, kinematics, and control. Robotic evolution is in line with machine evolution, electronics, applied technology, and computation such as program evolution, strategy evolution, genetic programming, and genetic algorithm [6], [7]. Robotic evolution leads to dynamic development all over the world.

As a robotic executive mechanism, the robotic manipulator plays an important role in finishing specific tasks. Manipulator is an important chapter from robotic design and robotic manipulator research. Within designing and researching robotic manipulator, control system design is oftentimes inseparable from the overall dynamic performance, especially for controlling the joints of robotic arm, which has been one of the core contents of robotic research [8]. Autonomous robots can substitute humans to complete some jobs, thereby relieve humans from job to carry out other activities.

Progress in robotics, artificial intelligence, and automation have potential to change social human life. However, restructuring of robotic manipulator is complicated and technology is still evolving, robotic infrastructure is expensive, and safety challenges in carrying robots into dynamic environment alongside humans. Currently, the application of robotic manipulator has existed in controlled and semi-controlled environments, with relatively limited human interaction and controls to protect human safety. The comprehensive application form robotic manipulator requires some design of transitional experiment in the sense of a real world context to test and develop the technology [9]. Research on robotic manipulator has been carried out along with the increasing public demand for robotic manipulator [10]–[12]. Robotic manipulator have many advantages, such as high precision, fast moving speed, and multipurpose movement. In advanced application, sensing module was extended, such as vision modules, proximity sensor, or energy sensor, can be integrated with the robotic arm to provide human understanding of the robotic system [13]. The results of the study using an Arduino-based controller circuit built to implement the algorithm, and servomotors are used to undertake joint control independent from manipulator [14].

An intelligent algorithm programmed into the control of manipulator robot is an artificial intelligence in robotic. The control algorithm is designed and programmed on a robot which aims to provide instructions to the robot in executing the job. Furthermore, control algorithm plays a role in connecting electronic and mechanical systems in order to obtain the desired function. Various algorithm of artificial intelligent control for robotic manipulator are widely used by research focused on finding the most efficient optimization algorithm for task-based robotic manipulator. The utilization of optimization algorithm is the synthesis of kinematic structure manipulator is a rather complicated task if an analytical approach is used. The utilization of genetic algorithm is not the only approach used. There are several algorithms including anneling simulation algorithm, heuristic-guided tree hunt algorithm, quasi-Newton deterministic algorithm to find the local minimum of the cost function in designing robotic manipulators [15]–[18]. This paper aims to identify the control of artificial intelligence for robotic manipulator. Robotic manipulator as an autonomous robot execution mechanism, has the characteristics of high operational accuracy and continuous work, which can reduce human's labor intensity and increase labor productivity.

## 2. METHOD

This study uses a systematic literature review using the Preferred Reporting Items for Systematic Review (PRISMA). The research was carried out systematically through appropriate research stages. The data provided is comprehensive, balanced, and aims to synthesize relevant research results. The stages of systematic literature review research include formulating research questions, prospecting literature, screening and selection the relevant articles, screening and selecting appropriate research articles, then analyzing, synthesizing qualitative findings, and preparing research reports [19]. The procedures carried out in systematic literature review research that is writing the background and research objectives, arranging research questions, prospecting literature, article selection, article extraction, assessing the quality of the basic study, and data synthesis [20].

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## 3. RESULTS AND DISCUSSIONS

Systematic literature review is one of the research methods that aims to identify, analyze, and evaluate all the results of previous studies. The research results obtained are in accordance with the stages of the research that has been carried out.

**Formulating Research Question**

The outcome of the formulation of research questions related to the research theme of artificial intelligence control for robotic manipulator can be seen in Table 1.

Table 1. Research Question on Systematic Literature Review

| Code | Research Questions | Motivation |
|---|---|---|
| RQ1 | How the development of artificial intelligence control? | Identify potential articles in the development of artificial intelligence control |
| RQ2 | How the development of artificial intelligence control for robotic manipulator? | Identify the most significant articles in the development of artificial intelligence control for robotic manipulator |
| RQ3 | How the development of robotic manipulator? | Identify potential articles in the development of robotic manipulator |
| RQ4 | How about the application of robotic manipulator? | Identify potential articles about the application of robotic manipulator |
| RQ5 | How the comparison of artificial intelligence control algorithms for robotic manipulator? | Identify the most significant articles in the comparison of artificial intelligence control algorithms for robotic manipulator |

**Prospecting Literature**

Prospecting literature was carried out on relevant articles using keywords *artificial intelligence, robots, robotic manipulators, algorithms, implementation of robotic manipulators, and control algorithms*. Articles are collected from various databases, such as Scopus, Web of Science, and Researchgate. The strategy used to search for articles is the inclusion and exclusion criteria that have been determined previously. This aims to ensure determination in finding the searched article.

Screening and Selection Articles

The screening and selection of articles using inclusion criteria to guide the prospect and selection of research articles in English, full articles published in international journals from 2010-2021, indexed in databases, and has the theme of artificial intelligence control for robotic manipulator (Figure 1). The samples obtained were analyzed to acquire relevant information to the established theme. The extracted articles were analyzed and synthesized to observe, describe, and classify the data obtained. Further data is used to collect the generating knowledge on the themes explored in the meta-synthesis. Through meta-analysis, new concepts can be obtained to turn some qualitative studies into new knowledge and disseminate scientific knowledge.

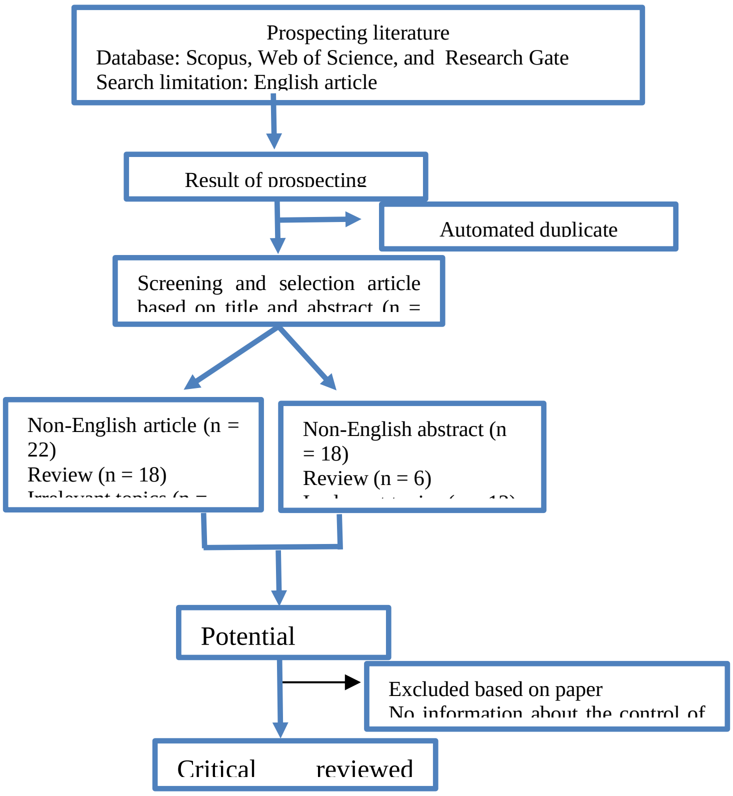


Figure 1. PRISMA flow chart on systematic literature review

Data Extraction, Primary Study Quality Test, and Synthesis

Data extraction aims to collect data in order to answer the research questions. The research quality test plays a role in determining the interpretation of the synthesis of the findings and arranging the conclusions described. Data synthesis aims to collect evidence from selected research to answer research questions.

**Discussion**

Prospecting articles on three databases have been successfully carried out and 301 articles were obtained. The results of screening and selection articles obtained 150 potential articles that fulfill the inclusion criteria. The theme "artificial intelligence control for robotic manipulator" was used as the new statement theme from meta-analysis of 150 articles. On these theme which discusses artificial intelligence, robotic manipulator, with their various advantages and disadvantages. Today's artificial intelligence has a dramatic impact on necessity and public marketing. Future manifestations of artificial intelligence are expected to bring greater change results and delivering the realization of the 4$^{th}$ industrial revolution. The current and potential impact of artificial intelligence on the increasing necessity of the industrial public [21]. Intelligent production systems require innovative solutions to improve the quality and sustainability of manufacturing activities while reducing costs. In this context, artificial intelligence driven technologies utilized by I4.0 Key Enabling Technologies (e.g. Internet of Things, advanced embedded system, cloud computing, big data, cognitive systems, virtual and augmented reality), ready to generate new industrial paradigms [22]–[24].

Artificial intelligence is the science and manipulations of creating intelligence machines, especially intelligence computer programs. In general, the term of artificial intelligence is used when machines simulate functions that humans associate with other human minds, such as learning and solving problems. In the 21st century, artificial intelligence has become an important research area in all fields, such as engineering, science, education, medicine, business, accounting, finance, marketing, economics, stock market, and law [25]. The scope of artificial intelligence has grown rapidly since machine intelligence with the capabilities of machine learning has created a huge impact on business government and society [26], [27]. They also influence the larger trends in global sustainability. Artificial intelligence can be useful to be solved. The development of Machine Learning as a chapter of artificial intelligence very fast at present. Its application has spread to various fields, such as machine learning, which is currently used in intelligent manufacturing, medical science, pharmacology, agriculture, archaeology, games, business, and others. Thus, artificial intelligence subfields, such as machine learning, natural language processing, image processing, and data mining, are also important topics for giant technology at present. The topic of artificial intelligence generated considerable interest in the scientific community [28]–[30].

Artificial intelligence in robotic manipulator shows various aspects of human intelligence. Artificial intelligence in robotic manipulator is an industrial revolution that is in line with other transformative technologies [31]–[33]. Transformative technologies, such as three-dimensional printing and the internet are expanding connectivity to devices such as security systems and electrical equipment to provide the ability to send and receive information over the internet. Many companies are substituting employees with artificial intelligence, some customers are choosing artificial intelligence-based services over alternative employee-based ones and all person are using previous artificial intelligence technologies [34], [35]. Artificial intelligence and robotics can enhance human potential, increase productivity, and progress from simple reasoning to human-like cognitive abilities. Artificial intelligence technology is used in a variety of services, from healthcare, manufacturing, financial services, banking, transportation, energy, advertising, management consulting, and government agencies. The level of intelligence of robotic manipulator can be measured by the capacity to predict the future [36]–[39]. The extensive use of manipulator robots around the world is being used to do jobs that cannot be done by humans.

Optimal control of the robotic manipulator to reach the desired trajectory point requires continuous research. The optimal control in this study is the handling of objects or workpieces in certain positions, where the robotic manipulator can determine the angle with a small error to reach the pre-determined target [40]. Optimization of the robot trajectory is required to ensure a good quality product and to save energy, and this optimization can be provided by proper modeling and design [8], [41], [42]. The result of mathematical modeling and non-linear control of the manipulator is that the DH parameter is used to derive the kinematics of the model, while the dynamics is based on the Euler-Lagrange equation. Two modern control strategies, $H\infty$ and predictive control models (MPC), were investigated to develop control laws. For an optimal performance, the controller has been well-tuned through simulations performed in the MATLAB/Simulink environment. The designed control laws are subject to various inputs and tested for their effectiveness in transient parameters such as settling time and overshoot as well as steady-state error. The simulation results confirm the effectiveness of the developed controller by tracking the motion of the reference precisely on the trajectory [8], [43], [44].
Development of soft manipulators, the overall technological maturity will be gradually increased [45], [46]. At present, the application of soft manipulator located mainly in the fields of land rescue, underwater grabbing, medical operations, assistance treatment, human-machine interaction, space manipulation and others. Application fields, such as origami soft manipulators, biomimetic soft micro-robots, self-healing soft robots, space soft manipulators and others, present new opportunities and challenges for soft manipulators. The robot can be modeled mathematically with a computer program where the results can be displayed visually, so that it can be used to determine the input, gain, attenuate and error parameters of the control system. Furthermore, the robot's motion control system, to reach the target point, must require research to get the best trajectory, so that the robot's movement can be more efficient. Soft manipulator is a kind of special manipulator which uses soft material or flexible structure to perform manipulation task through continuous motion control under the action of certain continuous drive mode. The definition of a soft material is based on the tendon's biological modulus of elasticity (about 1 GPa), which can be considered a soft material if it is less than 1 GPa [47].
In the industrial world, robotic manipulator perform repetitive movements. The task of the robot is controlled by a robot program, which is a path robot consisting of a set of robot positions (either a link position or a tool center point position) and a set of corresponding motion definitions between each of the two adjacent robot positions [48]. Many studies have been carried out for the optimization problem of robotic work cell design. Several approaches have been taken to optimize the work and job position of the robot by selecting the appropriate type of control. Computed Torque Controller (CTC) is a good non-linear control and is widely used in controlling robotic manipulator. CTC is designed according to feedback linearization, using dynamic motion, and calculating the torque of the manipulator robot arm [49]–[51].

In the design process of industrial robot, there are several stages, that is: 1) robot specification (payload, workspace, etc.), 2) structural CAD design, 3) kinematic chain design, 4) selecting and checking the drive system, 5) simulation-modelling with beam (Block Digital Simulation), 6) finite element analysis (FEM) of components and assemblies (static and dynamic), and 7) modeling and simulation of robots as multibody systems (Multi Body Simulation MBS), 8) virtual prototyping and analysis, 9) integration of control in virtual prototype simulation (Coupled Control), 10) validation of virtual prototype, and 11) alteration of real prototype [52]. The robot that has been designed to have parts of a manipulator robot arm has a function analogous to the features of a human arm and is named shoulder, elbow, and pad (Figure 2).

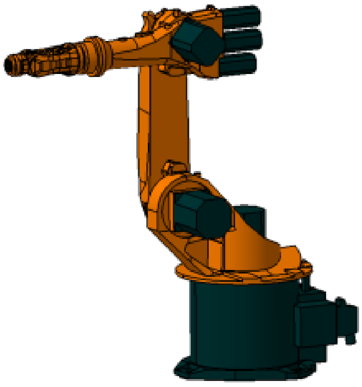

Figure 2. 3D robotic manipulator

The whole system is based on two parts, a mechanical part with a working arm and a signal processing part. The signal processing part will process the computational language uploaded to the microcontroller and the mechanical part is a design concept using mechanics [53]. To control the robot, a special Advanced Control Language (ACL) controller is used. This controller is combined with the software on the PC via a USB connection. Thus, with the support of this software, a control program can be written which is then sent to the controller for further manipulation of the robot. Initially, the Scorbot-ER 9 Pro could only be controlled manually but this research and development was carried out in terms of adding a sight source that leads to the operation of the robot automatically. For this purpose, software programs such as Matlab, Visual Basics, and Scorbase are used. There are several steps that must be implemented before the robot can move and perform operations. The initial stage is object image processing which is carried out through Matlab coding with a camera connected to a PC [54].

The development of a robotic arm manipulator prototype for industry has developed along with the development of artificial intelligence (Table 2). Robotic manipulator with 2-DOF swivel arm using fuzzy-logic control has been developed [55]–[57]. A robotic manipulator with a 3-DOF swivel arm has been developed [58]–[60]. This method makes it possible to obtain an analytical solution of the form, taking into consideration all the nonlinear components of the system of differential equations. Software packages for studying nonlinear mathematical models are developed and implemented. 3-DOF robot-manipulator electric drive software control problem.

Tabel 2. Robotic arm manipulator prototype

| Robotic arm manipulator prototype | Design and modelling |
|---|---|
| 2-DOF | [14], [16], [56], [61], [62] |
| 3-DOF | [63]–[65] |
| 4-DOF | [28], [48]–[52] |
| 5-DOF | [54]–[56] |
| 6-DOF | [64], [65] |

Robotic manipulator developed is a three-degree-of-freedom (DOF) swivel arm, which has three links terminated with end-effectors [14], [62]. This structure will be used to derive the kinematics and moment arm equations. Furthermore, designed a 4-DOF robotic manipulator with optimized algorithms for inverse kinematics [66]. The robot has four degrees of freedom (DOF) considered sufficient for the end goal. The first, DOF has a rotation joint at the base, allowing for 360-degree inward motion for increased workspace, followed by three rotational joints. AllDOF will function to position the robot at the desired point and using linear and

nonlinear interpolation will build a path for the robotic arm without considering obstacles. In this study obtained a mathematical equation that describes the inverse and direct kinematics.
Design, implementation and verification of practical visual servo control systems for 5-DOF robotic manipulator to handle the proposed pick-and-place task. Visual servoing schemes are also inspired by sensing and reaction behavior, but are very different from fuzzy logic-based approaches. The proposed visual servo system is a hybrid switching control architecture consisting of image and position based visual servoing approaches, but adopts a reactive based control strategy to calculate the final effect of speed using only vision information without computation of inverse interaction matrix, fuzzy modeling, and basic learning fuzzy rules [63], [64], [67]

6 Degrees of Freedom (DOF) robotic arm kit generated by Robo Analyzer software. Furthermore, this visual simulation consists of mathematical elements that can revive the motion mechanics of robotic manipulator. Besides, the parameters for carrying out simulations can solve the advanced kinematics of the robot in the form of a 3D model that can determine a suitable motor with sufficient power and torque that can be used by each joint. This Robo Analyzer uses the first geometric approach, using the Denavit Hartenberg parameters to determine the final effector. Furthermore, the Robo Analyzer used forward and backward dynamic analysis to obtain torque values. The simulation results clearly demonstrate the effectiveness of the Robo Analyzer software to generate simulated coordinates for each joint, joint parameters, and connection torque required to select the appropriate motor with sufficient torque. Utilization of Robo Analyzer, users can estimate the hardware simulation results before being applied in real situations because visual stimulation can turn on the robot's movement from the beginning to the last position [59], [61].

Utilization of inverse kinematic equation, as a hybrid method, the individual joint angle values are obtained to reach a certain point in the Cartesian airplane. The hybrid method (or algorithm) for inverse kinematics used is suitable for a combination of numerical and geometric methods. A combination of these methods is used to make more efficient and accurate angular resolution of each joint. The results show that the algorithm has a suitable performance with a relatively short computational execution time. Thus, using the algorithm it is possible to get the compilation of corner values that locate the effector point is the resolution of a certain location. Although it could be assumed that the time required to generate a virtual path. Research on the development of application design and optimization of robotic manipulators has been carried out [35], [65], [68]–[71]. A simplified control chain for an arm articulation robot is illustrated in Figure 3.

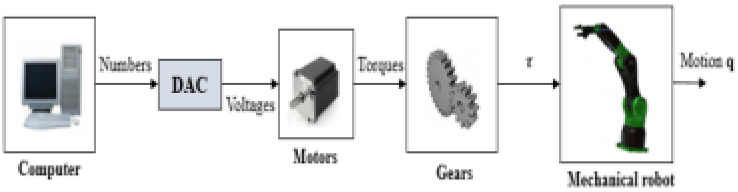


Figure 3. Control chain for manipulator arm

Control techniques for serial rigid robots in free and confined space to control the 6 axis (DOF) manipulator arm using classic PID control will be highlighted. The results of the comparison between the open-loop and closed-loop systems will prove the efficiency of the method to maintain the desired trajectory of the robotic arm. The main purpose of the control chain is to calculate the joint torque vector applied to the input of the mechanical system, which allows getting the joint position vector q as an output, as shown in Figure 3, this chain consists of a "Computer" which calculates the numerical value of N, this " Number" will be converted into analog electrical signal by Digital - Analog - Converter (“DAC”) block. This analog signal represents the "Voltage" required for the "Motor" to produce a "Torque" actuation through the "Gears" block, which represents the gear ratio to be generates the final joint torque value for “Mechanical robot” to perform “q movement” [72].

According to [52], [73] in constructing the design concept the robot must always be mized through CAD and FEM with effective lightweight construction and high torque and flexural rigidity to ensure good dynamic performance with high resistance to vibration. The six-axis industrial robot design model is developed using the general configuration and the exterior of the industrial robot design using handling, assembly, adhesive, machining applications, etc. An integrated CAD/CAE/CAM system for robot manipulators is developed. Coordinate D–H (Denavit–Hartenberg) transformation method is used to perform robot position analysis, according to the transformation matrix, we use Matlab to calculate robot position analysis. Pro/ENGINEER (Pro/E) was used to create parametric solid models of robot manipulators, Pro/Mechanica was used to simulate dynamic and workspace simulations, MasterCAM was used to implement cutting simulations, and prototypes were produced using CNC milling machines.

Based on the results of the analysis in the article [74], [75] can be identified about the evolution of artificial intelligence control algorithms for robotic manipulator. The evolution of algorithms is a growing trend and is widely used by researchers for optimization of robotics design. The evolution of the excellent algorithm in adapting to more optimization and non-continuous search space. One of the first robot design problems was solved by using an evolutionary algorithm and producing a robot capable of walking, jumping, and swimming. Beginning in 1990, various multi-objective evolution algorithms have been developed. Evolutionary algorithms are widely used for the entire system structure design to robot reconfiguration, controller design and in various domains, such as cooperative robotics and mini-invasive surgery [76], [77]. Many algorithms are created every year and many new applications are generated by researchers. Algorithm evolution aims to optimize robotics design, path optimization planning, and optimization of controller parameters or identification of robot manipulator parameters. Robots can be managed using integrated sensors or computer programs in the form of algorithms. Robot is an evolution of an individual algorithm consisting of an element from a collection of robotic manipulator segments (shape and joint boundaries) [78]–[80]

Based on the results of research that has been carried out by researchers for the optimal design of robotic manipulators, it can be seen the evolution of artificial intelligence control algorithms for manipulator robots [81]. The evolution of algorithms for industrial robot design aims to minimize joint torque across a given trajectory. The evolution of the algorithm involves establishing the robot design problem as a multi-objective optimization problem. The results show that the genetic algorithm gives the best results in terms of torque minimization, with differential evolution also giving relatively good results and simulation annealing giving relatively weak results while providing a smoother torque curve [82]. Genetic algorithm is an optimization algorithm that mimics the process of biological evolution using crossover and mutation mechanisms.

The results of research on a 4-degree-of-freedom serial robotic manipulator using four optimization algorithms, which is genetic algorithm, Particle Swarm Optimization algorithm (PSO), Quantum Particle Swarm Optimization algorithm (QPSO) and Gravity Search Algorithm (GSA). This algorithm was tested with two different scenarios for the movement of the end-effector manipulator. The results showed that QPSO can be used effectively for the inverse kinematics solution of the developed manipulator [82]. Comparison of the performance of the DR algorithm, that is the Deep Deterministic Policy Gradient (DDPG) and the Distributed Distribution Deterministic Policy Gradient (D4PG) algorithm. The results show that the D4PG algorithm achieves a higher learning success rate than the DDPG algorithm and demonstrates the potential application of DRL for controlling robot manipulators [83]. One method that can be used to obtain the best path is SOM (Self Organizing Maps) neural network. Research proposed the use of SOM in combination with PID control and Fuzzy-PD to find the optimal path between source and destination [84]. The SOM neural network process is able to guide the robot manipulator through the target points. The presented results emphasize that satisfactory trajectory tracking precision and stability can be achieved using a combination of SOM Neural network with PID and when using Fuzzy-PD=2.225% and when using PID=1.965%.

Reinforcement learning (RL) algorithms have been increasingly adopted by the robotics community over the past few years to control complex robots or multi-robot systems or provide end-to-end policies from perception to control. The RL algorithm bases their knowledge acquisition on the rewards agents obtained when they act in certain ways given different experiences [85], [86].

Compared to other optimization methods, Genetic Algorithm method (GA) is a Metaheuristic-based optimization algorithm approach to solve difficult optimization problems, by simulating biological evolution and the principle of the most suitable elements in the natural environment. Here, a genetic perspective algorithm (GA) to find the optimal control structure for the time horizon is presented and thereafter tested on a control problem [82], [87]. For this proposed approach and to achieve this controller we have to solve two problems, the first is the elimination of the chatting phenomenon, and the second is to find the best parameter value of this controller. The robotic manipulator is a MIMO system with combined non-linear dynamics and parametric variations. Implementation of various control laws requires determination of various control parameters. Metaheuristic optimization method that is Genetic Algorithm to find optimal non-linear parameters for

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controllers. Numerical simulation using a dynamic model of the two-link planar rigid robot manipulator shows the effectiveness of the proposed optimal control strategy based on SMC and GA approaches in regulation and trajectory tracking problems [88].

The solution of the inverse kinematics problem is fundamental in controlling robots. Many solutions to traditional inverse kinematics problems, such as geometric, iterative, and algebraic approaches, are inadequate for redundant robots. Recently, a lot of attention has been focused on the solution of neural network-based inverse kinematics problems in robotics. According to [89], [90] the accuracy of the results obtained from neural networks requires improvement for certain sensitive tasks. Neural networks and genetic algorithms were used together to solve the inverse kinematics problem of a six-joint Stanford robotic manipulator to minimize errors in end-effectors [91], [92]. The proposed hybrid approach combines the characteristics of the neural network and the evolutionary technique to obtain a more precise solution. Three Elman neural networks were trained using separate training sets because one set obtained better results than the other two [93]. The floating-point portion of each network is placed in the initial population of the genetic algorithm with the floating-point portion of the solution generated at random. The positional error of the end-effector is defined as a fitness function, and a genetic algorithm is implemented. Using this approach, the floating-point portion of the neural network result is increased to ten significant digits using a genetic algorithm, and the error is reduced to micrometer level. These results were compared with studies in the literature and found to be significantly preferable. A genetic algorithm is implemented to optimize the parameters associated with the selected motion track profile [94]. These optimized results are then taken as training data to train the artificial neural network which is used to get the task time, speed, acceleration and torque required by each motor to perform a given task. The method adopted in this study can be applied to any redundant serial or non-redundant manipulator having rigid links and known kinematic and dynamic models with motion or free movement along a certain path with obstacle avoidance. Kinematic and dynamic robot models and optimization methods were developed in MATLAB [95]–[97]

A method called the radial basis function genetic algorithm variation method, which is based on a combination feedback controller, is proposed to solve the optimal control problem. We propose a combined feedback with a linear part and a non-linear part. We reconstruct the kinematics and dynamics model of the manipulator with control feedback. In this model, the optimal path, which is solved by the variation method, is considered as the desired output. Improved genetic algorithm radial basis function neural network model. The optimal trajectory is solved quickly using the desired output and a genetic algorithm that enhances the radial function of the neural base network [98]–[100]. This method can greatly increase the calculation speed and guarantee real-time performance while ensuring accuracy.

## 4. CONCLUSION

The conclusion obtained is that many studies have been carried out to optimize the work and tasks of the robotic arm manipulator, that is developing various types of manipulator control (algorithms) combined with neural networks to obtain the right and appropriate algorithm.

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