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Prototype of Automatic Waste Object Picking Robotic Arm in the Working Room

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ABSTRACT

A robotic arm or robotic arm is a mechanical robot that resembles a human arm programmed with functions similar to a human arm. Robotic arms are widely used in today's modern industrial world. But not many use robotic arms for purposes outside the industrial world. Robots can also be useful for the environment around us, for example, for collecting trash in the workspace. From these problems, the researcher aims to create a prototype tool for a robotic arm that automatically collects garbage objects in the workspace which has several components such as a no-touch sensor to read other sensor data, an ultrasonic sensor to read garbage objects in front of the robotic arm, a proximity sensor to function as a navigation arm. A moving robot, a load cell sensor to determine the weight of a trash object, and a 16x2 LCD to determine the battery percentage, and if the object exceeds a predetermined weight, which is less than 200 grams and functions for **a** *temporary full trash box, the indicator is in the form of a sound buzzer that will sound. This prototype tool can help employees clean their rooms and collect trash at work to make the workspace cleaner and more organized.*

Keywords: *Robotic Arm; Proximity Sensor; Ultrasonic Sensors; Load Cell Sensor; Esp32*

Introduction

Technology is a science that learns about the skills and creativity to create tools to programming methods to help solve various problems and facilitate human work [[1][2]. Experts also have other opinions about technology, mentioning that technology is a collection of tools, rules, and procedures that apply scientific knowledge to a particular work under conditions that allow repetition[3]. One of the technologies now is robots that make much human work easier [4].

The term robot comes from the checkout language "robots" or a worker who never gets tired or bored[5]. A robot is a series of mechanical devices that can perform several activities that replace human tasks in work activities carried out using programs designed using a microcontroller [6][7][7]. Even with the development of modern technology, experts estimate that robots can replace ten jobs that robots will replace in the developmental stage among other journalists and web designers[8]. Researchers have started designing or creating robots based on the shape and model of robots created as needed. Robots consist of two types of robots: robots controlled by human intervention and robots using artificial intelligence. One of the existing types of robots is a robotic arm. The robotic arm can be included in a robot of the artificial intelligence type [[9]. One of the aiAI robots related to waste is a waste transport robot[[10][11].

Waste is one of the problems in our environment. In Indonesia, waste every year, always increases recorded by the Ministry of Environment and Forestry (KLHK). According to data in 2020, Indonesia produced 32.82 million tons of waste, and this decreased by 33.33% in 2021, when Indonesia produced waste, namely 21.88 million tons of [[12][13]. Based on the source, household waste contributed the most piles of waste among other sources, namely 42.23% in 2021 [[14][15]. Sometimes in the workroom, there are garbage objects scattered or dropped off our workbenches without us realizing it when working because we are too focused on work, which causes the room to look unsightly and effectively never cleaned[[16][17].

The research conducted previously by [18][19][20][21][22]entitled "Design and Build a Prototype Robotic Arm Manipulator Using a Microcontroller-Based Servo Motor", then the research conducted by inspiration [19][20][21][22][23][23] entitled "Waste Transport Robot Using Webcams And Ultrasonic Sensors Based On The Internet Of Things. These two studies were conducted in 2022, and the differences between these two studies are in the selection of sensors and the needs and uses of the robotic arm.

Research [24] entitled "Design and Build a [24][25][25] which took the title "Design and Built a Prototype of Robotic Arm Control (Robotic Arm) as an Internet Of Things Based Goods Transfer". These two studies have differences in the control system, where one uses Android as a robotic arm drive, while the other

uses IoT, namely the blink application. Continued research [26] entitled "Control of Robotic Arms for the Process of Moving Goods"[13]. This study was created using Arduino uno, plc, and TCS230, which serve as object readers.

Lastly, the study from [27] entitled "Robotic Arm Controller With Smartphone-Based Arduino Microcontroller" used HC-05 sensors, Arduino uno microcontrollers, and servo as drives. To overcome the above problems, a robotic arm was created to transport waste to minimize messy waste in the workspace and help humans work. Later the robot can detect waste around the area that has been determined by the boundary and put it in the garbage box that has been provided.

Research Methods

Stages of Research

The research begins with Literature Studies, Needs Analysis, Device Design, and Device Testing. The research stage of the prototype of the robotic arm taking automatic garbage objects in the workroom can be seen in figure 1.

Figure 1. Flow of research

Literature Studies

This stage is carried out to gain an understanding of scientific studies on the robotic arm prototype that picks up automatic garbage objects in the workroom. Several studies that have been carried out have used many different types of sensors and control devices, so this literature study will determine the type of sensor, hardware, device design, and device testing that suits the needs of this study [28]–[33].

Needs Analysis

This needs analysis was obtained after conducting a literature study. The analysis is carried out to determine the components that will be used by the system, which can be in the form of hardware or software. This analysis includes the needs of input devices, process devices, and output devices. The input devices needed are a no-touch sensor used to read sensor data before the robotic arm works, an ultrasonic sensor used to read the distance of the object from the robotic arm, a proximity sensor combined with an ultrasonic sensor used to regulate the movement of the robot from the object so that the robotic arm is exactly the stopping point and can distinguish garbage objects and wall objects, Load cell sensor used to determine the weight of garbage objects. The processing device required and used on this prototype is the ESP32 for communication between each sensor. The output device consists of a speaker to find out whether the temporary garbage box has been filled or not and also serves to find out if the object exceeds the predetermined weight of 200grams and to signal that the temporary garbage box is fully sidelined, a servo motor as a robotic arm drive, 16x2 Lcd as an indicator that all sensors are running well and to find out whether the object was successfully taken or not, relay module to cut off the voltage source if there is a short circuit or fire or there is damage to the electronic device so that the electronic device is not damaged directly.

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Device Design

Hardware Design

Hardware planning aims to define the block diagram as a whole. This planning includes selecting the components to be used, determining the layout of the components, selecting sensors, schematic circuits, or component layouts, installing components, and finally, finishing. The hardware used is the components used in this design, namely sensors and the Esp32 microcontroller [34].

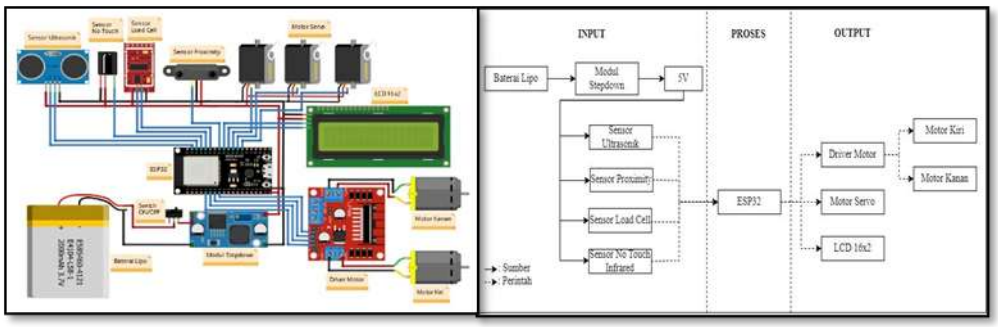

Figure 1. Esp32 microcontroller hardware

Designing Tools

At the design stage, this tool has the aim that during the process of making the tool can run well according to what is expected until the end until the tool can be used perfectly as desired. What is being done now is to create a tool design that aims to determine the layout of components so that components can be installed correctly and regularly. Furthermore, a flowchart is needed to design and build this tool. This flowchart aims to design the step-by-step process of this tool to produce the desired results [35].

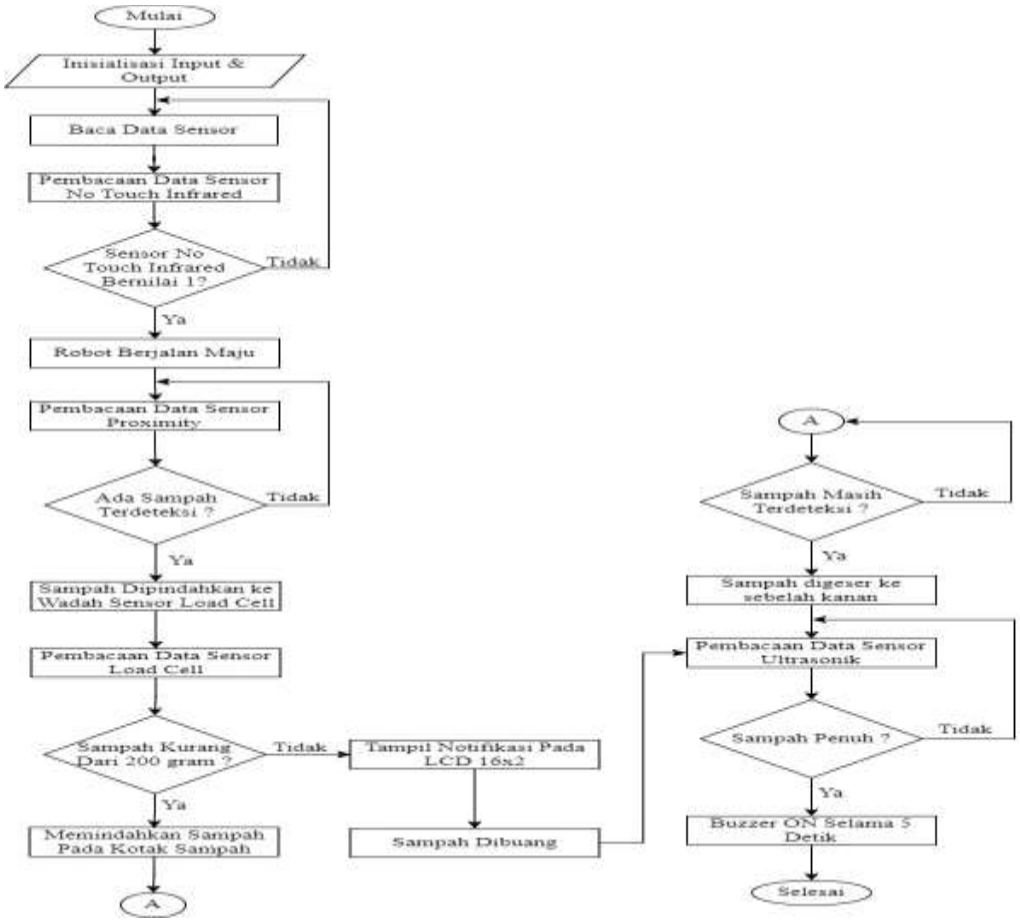

Figure 2. Flowchart Suite of Tools

How the Tool Works

The "Prototype of the Automatic Waste Object Picking Robotic Arm in the Working Room" uses ultrasonic, Proximity, and Load Cell sensors. The main source is to use Li-Po batteries. The tool works as follows:

1. When the tool is turned on from the Li-Po battery source then, the current and voltage will pass through the module step down, then the tool will work if the no touch has been turned on and wait a few seconds for the sensor to read the read data and wait for the sensor to be ready to work.
2. When all the sensors are ready to eat, the robot will move to patrol and become its navigation using ultrasonic and Proximity sensors simultaneously, which distinguish garbage objects or walls. At the same time, the other ultrasonic sensor serves to read the object's distance from the object, where the robot will approach the garbage object until it is 15-20cm away from the object. After that, the robotic arm will pick up the garbage object.
3. Then the robotic arm will place the object on the load cell sensor and will be measured if the weight is less than 200 grams. The garbage object will be returned and placed in a temporary garbage box.
4. If the temporary garbage box is full, the buzzer will sound marked as a garbage box while fully loaded, and the robot will stop patrolling.

Device Testing

Tests are carried out to ensure whether the device corresponds to the desired result. This test is to determine whether the device is functionally running. The tests carried out include; an UltraSonic sensor, Loadcell sensor, and Proximity sensor combined with an ultrasonic sensor.

Results and Discussion

The result of designing the prototype device for the robotic arm to pick up automatic garbage objects in the workspace.

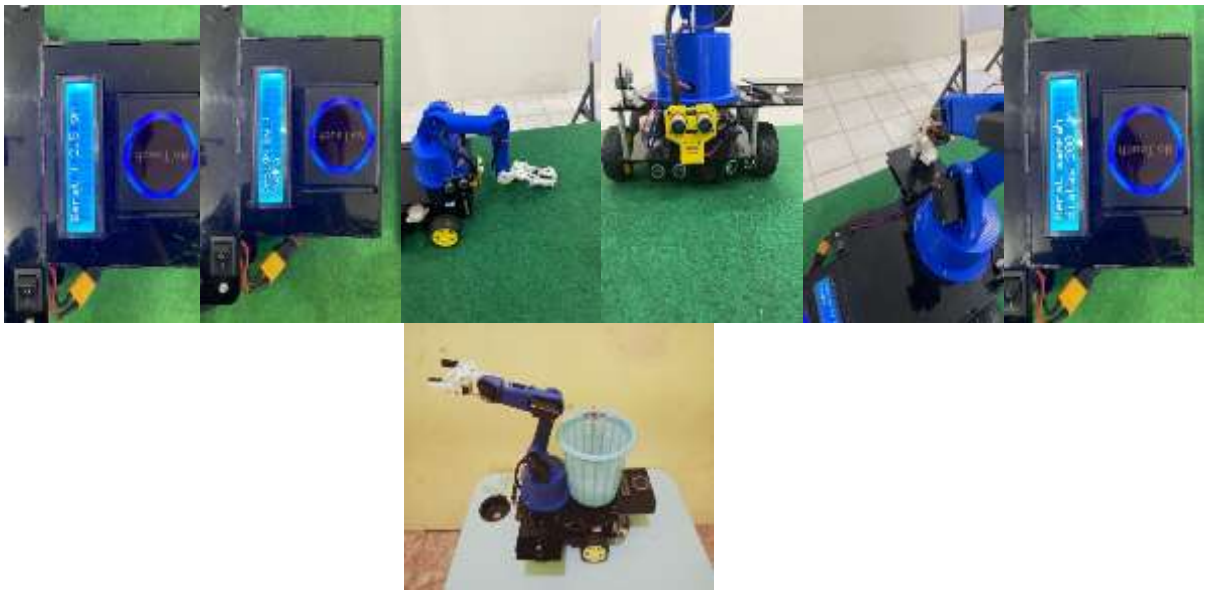

Figure 3. Prototype of Automatic Waste Object Picking Robotic Arm in the Working Room

Ultrasonic Sensor Testing

Suppose the ultrasonic sensor detects a garbage object before the robotic arm. In that case, the robotic arm will approach the object up to 20cm from the garbage object, and the robotic arm will pick up the garbage object[18]. The result of this test is to calculate the time for the robotic arm to move towards the garbage object, a tool used to find the time required using a stopwatch. Ultrasonic sensor testing can be seen in test table 1.

Table 1. Ultrasonic Sensor Test Results

No	Object reading distance (cm)	Time	Succeed	To no avail
1.	10 cm	0	Not	Yes

2.	20 cm	0	Not	Yes
3.	30 cm	3 seconds	Yes	Not
4.	40 cm	4 seconds	Yes	Not
5.	50 cm	5 seconds	Yes	Not
6.	60 cm	6 seconds	Yes	Not
7	70 cm	7 seconds	Yes	Not

This ultrasonic sensor test is by the cold, where this robotic arm has a delay in stopping between 1-2 cm before the robotic arm stops to pick up garbage objects.

Load Cell Sensor Testing

Testing this load cell sensor, the results are displayed on a 16x2 LCD where if the garbage object is less than 200 grams, the robotic arm will insert the garbage object in the temporary trash box[19]. If the garbage object exceeds 200 grams, the robotic arm will pick up the garbage object and put it to the right side of the robot, which we can see the result of the time required for each load of the garbage object is different, the tool used to find out the required time using a stopwatch. We can see the results in table 2.

Table 2. Table 2. Load Cell Sensor Test Results

No	Sensor Load cell	Digital scales	difference	Time	Succeed	To no avail
1.	49 grams	50 grams	1	7 seconds	Yes	Not
2.	80 grams	80 grams	0	7.1 seconds	Yes	Not
3.	109 grams	110 grams	1	7.15 seconds	Yes	Not
4.	139 grams	140 grams	1	7.16 seconds	Yes	Not
5.	170 grams	170 grams	0	7.2 seconds	Yes	Not
6.	229 grams	230 grams	1	0	Not	Yes
7.	245 grams	250 grams	5	0	Not	Yes

This load cell sensor test is carried out and calibrated using digital scales to make the data real. The difference in results from load cell sensors and digital scales is about 0.2 grams.

Testing the Merger Between Proximity Sensors and Ultrasonic Sensors

Proximity sensor testing, combined with ultrasonic sensors, is carried out to find out the difference between garbage objects or walls as navigation for moving robotic arms and the dimensions of garbage objects around the robotic arm. This robotic arm has minimal and maximum dimensions that can be taken by the robotic arm, which is measured using a crossbar to find out each dimension of the garbage object. We can see the results obtained in table 3.

Table 3. Testing of Proximity Sensors and Ultrasonic Sensors

No	Weight (grams)	Time	Succeed	To no avail
1.	0.4 x 0.5 cm	4 seconds	Not	Yes
2.	0.5 x 1 cm	4 seconds	Not	Yes
3.	1 x 1.5 cm	4 seconds	Yes	Not
4.	1.3 x 1.8 cm	4.05 seconds	Yes	Not
5.	1.5 x 2 cm	4.1 seconds	Yes	Not
6.	1.8 x 2.3 cm	4.12 seconds	Yes	Not
7	2.1 x 2.5 cm	4.15 seconds	Yes	Not

Testing of proximity sensors combined with ultrasonic sensors is carried out by testing the dimensions of waste objects, which are adjusted to predetermined dimensions based on the table above.

Conclusion

The results of testing and analyzing the prototype of the robotic arm picking up garbage objects automatically in the workspace, the robotic arm runs well according to its function. Ultrasonic sensor testing can read garbage objects, while load cell sensors show weight measurements that are by the original weight of the calibrated object using digital scales. Proximity sensors combined with ultrasonic sensors that function as navigation and differentiator of wall objects and dimensions are going well, the robotic arm patrols according to expectations and can distinguish wall objects and knows that the dimensions of garbage objects are by the limitations of the stamping on the robotic arm. For a temporary garbage box to work properly, if the temporary trash box is filled, then a sound buzzer will activate, indicating that the temporary garbage box is full. The robotic arm will stop to patrol. For a 16x2 lcd, it will display all the information needed to know the object's weight, the time of retrieval, and notification of the object whether or not the robotic arm successfully took the object. The error percentage in each sensor has an error percentage of about 1% - 2% for sensor data readings. It is hoped that further research can be developed using the latest generation of raspberries and a webcam as an object reader and its navigation. In future research, it is hoped that the robotic arm can be called using voice.

References

[1] Y. Jiang, "Composite-Learning-Based Adaptive Neural Control for Dual-Arm Robots with Relative Motion," *IEEE Trans. Neural Networks Learn. Syst.*, vol. 33, no. 3, pp. 1010–1021, 2022, doi: 10.1109/TNNLS.2020.3037795.

[2] A. Zahaf, "Robust fault tolerant optimal predictive control of hybrid actuators with time-varying delay for industrial robot arm," *Asian J. Control*, vol. 24, no. 1, pp. 1–15, 2022, doi: 10.1002/asjc.2444.

[3] W. Bai, "Anthropomorphic Dual-Arm Coordinated Control for a Single-Port Surgical Robot Based on Dual-Step Optimization," *IEEE Trans. Med. Robot. Bionics*, vol. 4, no. 1, pp. 72–84, 2022, doi: 10.1109/TMRB.2022.3145673.

[4] D. Liang, "Fuzzy-Sliding Mode Control for Humanoid Arm Robots Actuated by Pneumatic Artificial Muscles with Unidirectional Inputs, Saturations, and Dead Zones," *IEEE Trans. Ind. Informatics*, vol. 18, no. 5, pp. 3011–3021, 2022, doi: 10.1109/TII.2021.3111655.

[5] W. Yan, "Trajectory planning and low-chattering fixed-time nonsingular terminal sliding mode control for a dual-arm free-floating space robot," *Robotica*, vol. 40, no. 3, pp. 625–645, 2022, doi: 10.1017/S0263574721000734.

[6] Y. Ouyang, "Actor–critic learning based coordinated control for a dual-arm robot with prescribed performance and unknown backlash-like hysteresis," *ISA Trans.*, vol. 126, pp. 1–13, 2022, doi: 10.1016/j.isatra.2021.08.005.

[7] N. Lv, "Dynamic Modeling and Control of Deformable Linear Objects for Single-Arm and Dual-Arm Robot Manipulations," *IEEE Trans. Robot.*, vol. 38, no. 4, pp. 2341–2353, 2022, doi: 10.1109/TRO.2021.3139838.

[8] T. Chen, "Design and Control of a Novel Leg-Arm Multiplexing Mobile Operational Hexapod Robot," *IEEE Robot. Autom. Lett.*, vol. 7, no. 1, pp. 382–389, 2022, doi: 10.1109/LRA.2021.3127639.

[9] H. Hu, "Adaptive variable impedance control of dual-arm robots for slabstone installation," *ISA Trans.*, vol. 128, pp. 397–408, 2022, doi: 10.1016/j.isatra.2021.10.020.

[10] W. Kornmaneesang, "Contouring Control of an Innovative Manufacturing System Based on Dual-Arm Robot," *IEEE Trans. Autom. Sci. Eng.*, vol. 19, no. 3, pp. 2042–2053, 2022, doi: 10.1109/TASE.2021.3073423.

[11] D. HAN, "Capture and detumbling control for active debris removal by a dual-arm space robot," *Chinese J. Aeronaut.*, vol. 35, no. 9, pp. 342–353, 2022, doi: 10.1016/j.cja.2021.10.008.

[12] V. Girbés-Juan, "Combining haptics and inertial motion capture to enhance remote control of a dual-arm robot," *J. Multimodal User Interfaces*, vol. 16, no. 2, pp. 219–238, 2022, doi: 10.1007/s12193-021-00386-8.

[13] M. Deng, "Nonlinear Intelligent Control of Two Link Robot Arm by Considering Human Voluntary Components," *Sensors*, vol. 22, no. 4, 2022, doi: 10.3390/s22041424.

[14] K. Kronhardt, "Adapt or Perish? Exploring the Effectiveness of Adaptive DoF Control Interaction Methods for Assistive Robot Arms," *Technologies*, vol. 10, no. 1, 2022, doi:

10.3390/technologies10010030.
[15] H. Fu, "Asynchronous resource-aware control for uncertain semi-Markov jump systems with application to robot arm," *Optim. Control Appl. Methods*, vol. 43, no. 3, pp. 925–942, 2022, doi: 10.1002/oca.2864.
[16] A. Zhu, "Compliance Control of Dual-arm Space Robot Capture Satellite Based on Barrier Lyapunov Functions," *Zhongguo Jixie Gongcheng/China Mech. Eng.*, vol. 33, no. 24, pp. 2997–3006, 2022, doi: 10.3969/j.issn.1004-132X.2022.24.011.
[17] N. J. Ramadhan, "Pattern recognition based movement control and gripping forces control system on arm robot model using LabVIEW," *J. Mechatronics, Electr. Power, Veh. Technol.*, vol. 13, no. 1, pp. 1–14, 2022, doi: 10.14203/j.mev.2022.v13.1-14.
[18] G. Xin, "Loco-Manipulation Control for Arm-Mounted Quadruped Robots: Dynamic and Kinematic Strategies," *Machines*, vol. 10, no. 8, 2022, doi: 10.3390/machines10080719.
[19] H. Hu, "Practical Tracking Control for Dual-arm Robot with Output Constraints," *Int. J. Control. Autom. Syst.*, vol. 20, no. 10, pp. 3264–3273, 2022, doi: 10.1007/s12555-021-0605-z.
[20] G. A. Waltersson, "Planning and Control for Cable-routing with Dual-arm Robot," *Proceedings - IEEE International Conference on Robotics and Automation*. pp. 1046–1052, 2022. doi: 10.1109/ICRA46639.2022.9811765.
[21] J. L. Ramón, "Trajectory Optimization and Control of a Free-Floating Two-Arm Humanoid Robot," *J. Guid. Control. Dyn.*, vol. 45, no. 9, pp. 1661–1675, 2022, doi: 10.2514/1.G006828.
[22] X. Wang, "Robust control of a dual-arm space robot for in-orbit screw-driving operation," *Acta Astronaut.*, vol. 200, pp. 139–148, 2022, doi: 10.1016/j.actaastro.2022.07.048.
[23] S. Hayashi, "Implementation of Remote Control of a Robot Arm by Hand Gestures," *Communications in Computer and Information Science*, vol. 1581. pp. 18–25, 2022. doi: 10.1007/978-3-031-06388-6_3.
[24] W. Ren, "Research on Dual-Arm Control of Lunar Assisted Robot Based on Hierarchical Reinforcement Learning under Unstructured Environment," *Aerospace*, vol. 9, no. 6, 2022, doi: 10.3390/aerospace9060315.
[25] Q. Liu, "Minimum disturbance control based on synchronous and adaptive acceleration planning of dual-arm space robot to capture a rotating target," *Ind. Rob.*, vol. 49, no. 6, pp. 1116–1132, 2022, doi: 10.1108/IR-12-2021-0291.
[26] H. Heyu, "Impedance control method with reinforcement learning for dual-arm robot installing slabstone," *J. Mech. Sci. Technol.*, vol. 36, no. 5, pp. 2547–2558, 2022, doi: 10.1007/s12206-022-0436-8.
[27] V. Kumar, "Kinematics/Dynamics Analysis with ADAMS/MATLAB Co-simulation of a SolidWorks Designed Spatial Robot Arm with Control and Validation of Results," *Lecture Notes in Mechanical Engineering*. pp. 1197–1209, 2022. doi: 10.1007/978-981-16-0550-5_114.
[28] Z. O. Ilhan, "BENCHMARKING VARIOUS NONLINEAR CONTROL DESIGN TECHNIQUES FOR A TWO-LINK PLANAR ROBOT ARM," *ASME International Mechanical Engineering Congress and Exposition, Proceedings (IMECE)*, vol. 7. 2022. doi: 10.1115/IMECE2022-95524.
[29] H. Wang, "Robust tracking control of unknown models for space in-cabin robots with a pneumatic continuum arm," *Complex Intell. Syst.*, 2023, doi: 10.1007/s40747-023-00980-1.
[30] H. Hu, "Prescribed time tracking control without velocity measurement for dual-arm robots," *Inf. Sci. (Ny).*, vol. 629, pp. 533–550, 2023, doi: 10.1016/j.ins.2023.02.005.
[31] D. Lim, "Sliding Mode Control of a Heavy Duty Dual Arm Robot with Hydraulic Systems to Improve Motion-Following Performance," *J. Inst. Control. Robot. Syst.*, vol. 29, no. 2, pp. 147–154, 2023, doi: 10.5302/J.ICROS.2023.22.0113.
[32] T. Seghiri, "Fractional order adaptive MRAC controller design for high-accuracy position control of an industrial robot arm," *Int. J. Adv. Mechatron. Syst.*, vol. 10, no. 1, pp. 8–20, 2023, doi: 10.1504/IJAMECHS.2022.10047818.
[33] Z. B. Hazem, "Joint Control Implementation of 4-DOF Robotic Arm Using Robot Operating System," *2022 5th International Conference on Theoretical and Applied Computer Science and Engineering, ICTASCE 2022*. pp. 72–77, 2022. doi: 10.1109/ICTACSE50438.2022.10009733.
[34] D. T. Tran, "Adaptive Synchronous Sliding Mode Control for Dual-Arm Robots," *Lecture Notes in Networks and Systems*, vol. 567. pp. 542–555, 2023. doi: 10.1007/978-3-031-19694-2_48.
[35] H. Kato, "Partial Depth Estimation with Single Image Using YOLO and CNN for Robot Arm Control," *2022 IEEE International Conference on Mechatronics and Automation, ICMA 2022*. pp. 1727–1731, 2022. doi: 10.1109/ICMA54519.2022.9856055.