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Developing A Robot to Improve The Accuracy of Ring Retrieval and Throwing at The ABU Robocon Indonesia Robot Competition

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Abstract

This article outlines the creation and application of a technologically improved robot designed to amplify the precision and effectiveness of ring retrieval and projection tasks in the ABU Robocon Indonesia Robot Challenge. The ABU Robocon competition is an annual event that tasks teams with crafting robots capable of accomplishing specific assignments under a predetermined time limit. The ring retrieval and projection task, historically known for its precision requirements, has proven to be quite demanding. Our strategy entailed the incorporation of cutting-edge technologies into the robot's design, encompassing computer vision and machine learning algorithms, to augment its accuracy and performance. We equipped the robot with cameras and sensors for the detection and analysis of ring positions and orientations. Real-time decisions regarding the optimal approach for retrieving and accurately projecting the rings were made using machine learning models that had undergone training. The outcomes of our experiments reveal a marked enhancement in the robot's performance when compared to conventional methods. The tech-enhanced robot consistently exhibited a heightened success rate when performing ring retrieval and projection tasks. This development not only boosts the competitiveness of our robot in the ABU Robocon competition but also underscores the potential of advanced technologies in enhancing the performance of robotics systems when confronted with intricate tasks.

Keywords: ABU robocon , robotics competition, ring retrieval, ring throwing

1 Introduction

The ABU Robocon Indonesia Robot Contest is an annual competition that challenges participants to design and build robots capable of performing specific tasks. One of the tasks in the competition involves retrieving and throwing rings onto designated poles, requiring precision in both ring retrieval and throwing for efficient task completion. In this context, the development of a highly accurate robot becomes crucial to excel in the competition and complete the ring-related tasks swiftly and effectively.

The robot is equipped with sensors that allow it to detect the location of the rings and poles. It uses machine learning algorithms to analyze this data and determine the best trajectory for throwing the rings onto the poles. The accuracy of the observer is proved by the experiments in robotic catching [1].

The development of this robot represents a significant advancement in the field of robotics. By using artificial intelligence to analyze data and make decisions, the robot is able to perform tasks with greater accuracy and efficiency than traditional robots. The proposed control method can gain the high positioning performance for throwing a rigid object with one degree of freedom robot [2]. This technology has the potential to revolutionize many industries, from manufacturing to healthcare.

In this journal, we will explore the development of the robot for the ABU Robocon Indonesia Robot Contest in detail. We will discuss the design of the robot, the algorithms used to analyze data and make decisions, and the results of testing and evaluation. A system for determining the throwing position was developed using the derived method with same preconditions [3]. We will also consider the implications of this technology for the future of robotics and the wider world.

The ABU Robocon Indonesia Robot Contest stands as a testament to the rapid evolution and convergence of robotics and artificial intelligence. Within this dynamic and competitive context, precision-oriented tasks like ring retrieval and throwing have emerged as pivotal challenges that demand not only technical finesse but also innovative solutions. This research was like development for A proposed method to retrieve the balls which are scattered in the Tennis court back to the user is developed on a Python platform [4]. The integration of AI algorithms into robotic systems has redefined the boundaries of achievable accuracy in such tasks. Throwing manipulation enables the robot not only to manipulate the object to outside of the robot's movable range of the robot, but also to control the position of the object arbitrarily in the vertical plane even though the robot has only one degree of freedom [5]. The study pursued the ambitious goal of designing a robot explicitly designed to improve ring picking and throwing precision, with the ultimate goal of excelling in the ABU Robocon Indonesia Robot Contest. As robotics and AI continue to intertwine, the outcomes of this research contribute not only to the specific domain of robotic competitions but also to the broader advancement of AI-enhanced robotics.

In this context, the ABU Robocon Indonesia 2023 Robot Contest serves as a testing ground for innovative robotic systems, demanding intricate tasks to be executed with precision. This journal delves into the conceptualization and realization of an robot tailored for the ABU Robocon Indonesia Robot Contest, focusing on enhancing the accuracy of two crucial tasks: ring retrieval and throwing. These tasks not only require efficient detection and manipulation but also highlight the significance of algorithms in computing optimal trajectories and achieving target accuracy [6][7]. The journal provides an in-depth exploration of the robot's design and an analysis of its performance within the dynamic and competitive environment of the ABU Robocon Indonesia Robot Contest, shedding light on the forefront of robotic innovation and precision engineering.

2 Methods

The development of the robot for the ABU Robocon Indonesia Robot Contest involved several steps. These included designing the robot's hardware and software, collecting and analyzing data, and testing and refining the robot's performance. Below is a more detailed explanation of each of these steps:

A. Designing the Robot: The first step in developing the robot was to design its hardware and software. The robot was designed to have a precise and efficient arm that could retrieve and throw rings onto designated poles. The robot was also equipped with sensors that could detect the location of the rings and poles.

The software for the robot was designed to analyze the sensor data and make decisions about the best trajectory for throwing the rings.

B. Collecting and Analyzing Data: Once the robot was designed, the next step was to collect data on the location of the rings and poles. This involved testing the robot in different environments and collecting data on the position and orientation of the rings and poles. The data was then analyzed using machine learning algorithms to identify patterns and develop models for predicting the trajectory of the rings.

C. Developing the Algorithms: Based on the data analysis, the researchers developed algorithms for the robot to use in analyzing the sensor data and making decisions about how to throw the rings. The algorithms were designed to take into account factors such as the distance and angle between the robot and the pole, as well as the weight and size of the rings.

D. Testing and Refining the Robot: Once the algorithms were developed, the robot was tested in a variety of environments to evaluate its performance. The researchers analyzed the robot's accuracy in retrieving and throwing the rings and made adjustments to the algorithms and hardware as needed. This process continued until the robot was able to perform the task with a high level of accuracy and efficiency.

Overall, the development of the robot for the ABU Robocon Indonesia Robot Contest involved a combination of hardware and software design, data analysis, and testing and refining the robot's performance. Prediction of object movement trajectories has great importance in diverse domains of smart systems [8]. The result was a highly accurate and efficient robot that could perform the task of retrieving and throwing rings with great precision.

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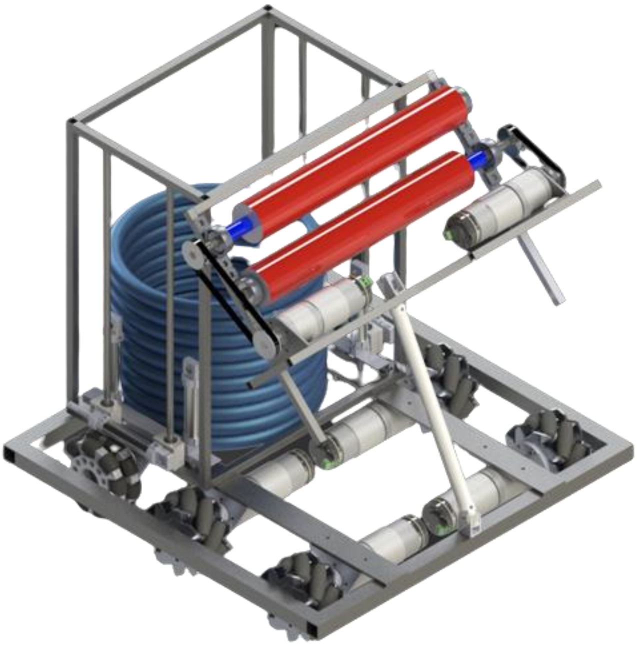

Figure 1. Design robot abu

The combination of a roler system for throwing, a mechanum wheel for propulsion, and a DC motor for throwing, will create an Aburobocon robot that has unique and sophisticated capabilities in dealing with challenges and situations on the playing arena, especially in 2023. With this design, it is hoped that the abu robot will be able to become a robot that can maximize system work and complete robot tasks properly. Robot-catching of in-flight objects is a challenging task, requiring a high-frequency sequence of pose estimation, trajectory prediction, catching point determination, and motion planning [9].

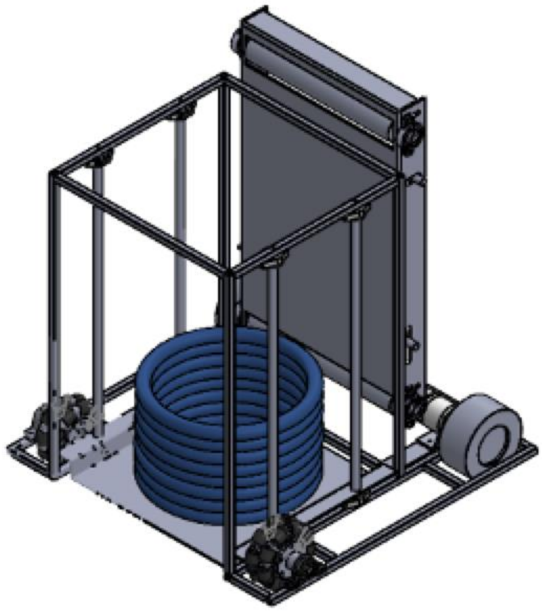

Figure 2. Design robot

The ring transport system on the robot's body uses a lift system that is able to quickly and safely carry the ring from the floor to the throwing robot, which is a very important feature to improve the performance and efficiency of the robot in robotic competitions.

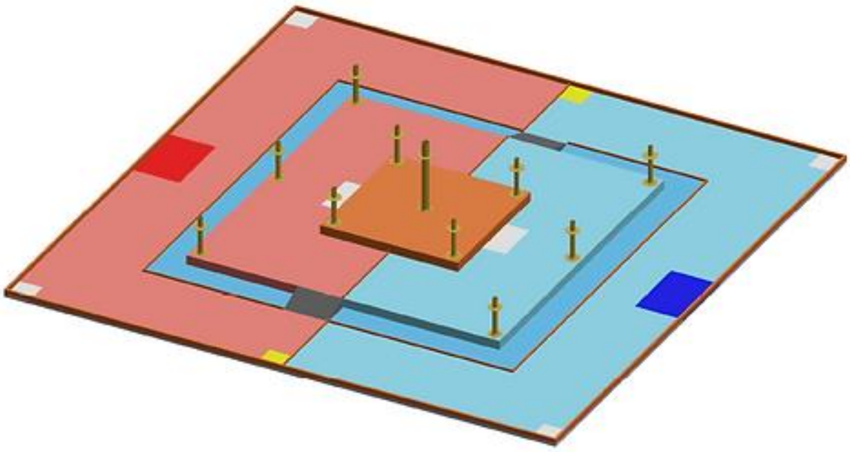

Figure 3. Game field Abu Robocon 2023

The robocon fields measures 12 meters x 12 meters, which is large enough to allow the robot to move freely and perform various tasks. The court has 3 levels of height, each of which is 20 cm high between levels. This level height creates a

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challenge because the robot must be able to move and navigate across height differences, either by using a transport mechanism or special mobility capabilities. With different level heights, the robot is faced with various tasks that must be completed. Robots need to be able to move up and down between levels smoothly and efficiently to complete the specific tasks in each level.

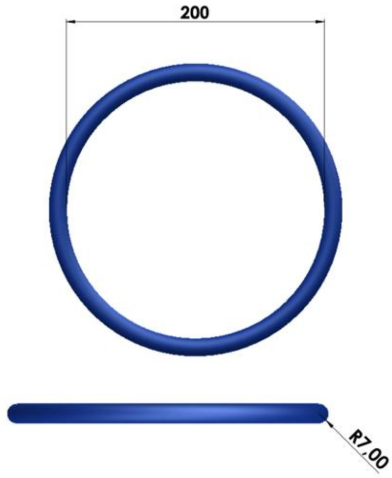

Figure 4. Ring Abu Robocon 2023

The ring material used in the Abu Robocon competition has material from 8 mm twin welding hose and has a ring diameter of 200 mm and a hose radius of 7 mm. A contour-detecting method is proposed to obtain the accurate contours of marker blobs in images [10].

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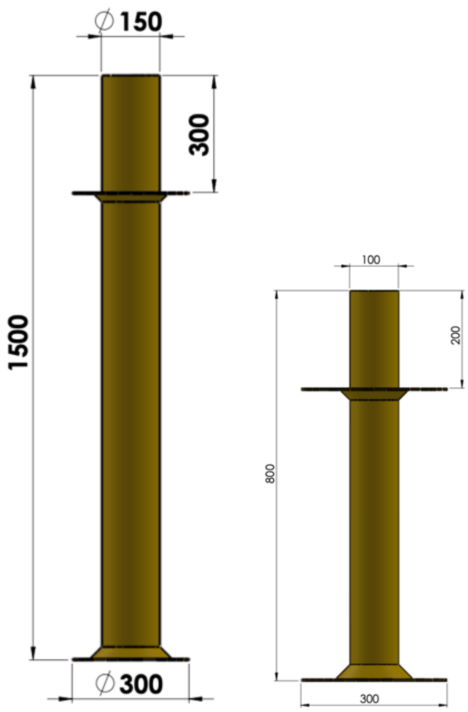

Figure 5. Pole Abu Robocon 2023

The angkor pole material used in the Abu Robocon competition is made of iron pipe and has 2 types of length 1500 mm in diameter of 150 mm ring and the second type has a length of 800 mm in diameter of 100 mm.

3 Design of Controllers

To enhance the accuracy of ring retrieval and throwing in the ABU Robocon Indonesia Robot Contest, a robot can be developed using a combination of machine learning and computer vision techniques.

To design the controllers for the robot, are steps :

1. Identify the requirements: The first step is to identify the requirements for the robot. This includes the size and weight of the robot, the number of motors required, the type of sensors needed, and the algorithms that will be used.

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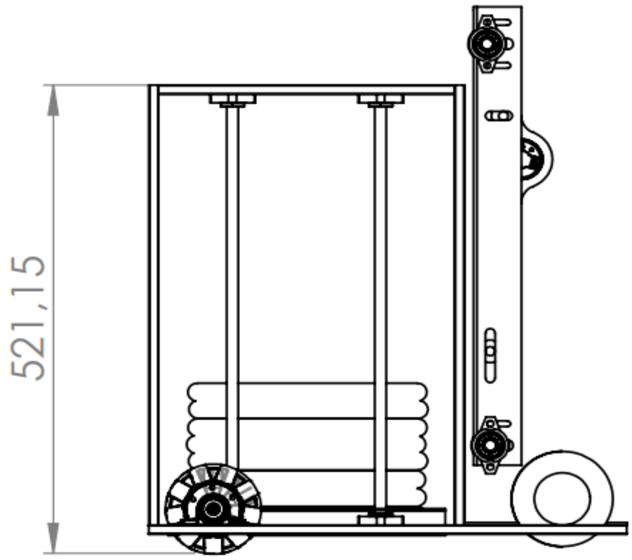

Figure 6. Design robot high

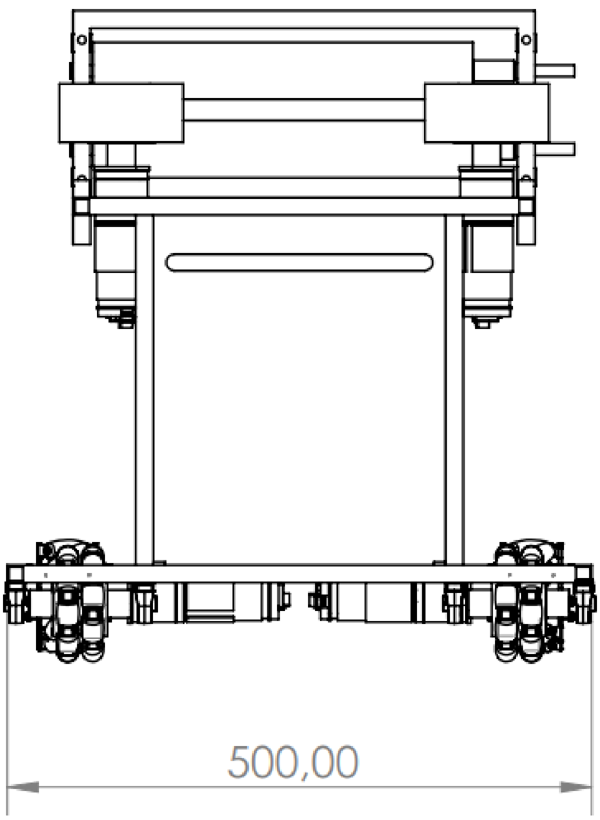

Figure 7. Design robot width

A heavy-duty robot weighs less than 23 kg and requires 4 DC motors as its drive.

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2. Choose the hardware: Once the requirements have been identified, the hardware for the robot can be chosen. This includes the motors, sensors, and other components required for the robot.

Figure 8. DC motor planetary gear

Motor DC planetary gear refers to a DC motor that is combined with a planetary gear system. A planetary gear system is a type of gear system that uses gears in a configuration similar to the solar system, where a central gear (sun gear) is surrounded by smaller gears (planet gears) that rotate around it. This configuration provides a high gear reduction ratio in a small package, making it suitable for applications where high torque and compact size are required. [11]

DC motors combined with planetary gear systems are often used in robotics, automation, and other applications that require precise control of motion and high torque in a small space. The planetary gear system allows the motor to provide a high torque output while maintaining a small size, which is important for many robotic applications where space is limited.

3. Develop the software: The software for the robot can be developed using a combination of machine learning and computer vision techniques. This includes training the algorithms using large datasets of ring retrieval and throwing scenarios.

    a) Define the problem: The first step in developing the software is to define the problem clearly. In this case, the problem is to improve the accuracy of ring retrieval and throwing using a robotic system.

b) Collect data: To train the machine learning algorithms, a large dataset of ring retrieval and throwing scenarios will be needed. This can be collected using a camera and sensor system that captures data from the robot as it performs the task.

c) Preprocess data: Once the data is collected, it will need to be preprocessed to remove noise and irrelevant information. This may include image processing techniques to extract features from the images and filtering techniques to remove unwanted data.

d) Train the machine learning models: With the preprocessed data, machine learning models can be trained to recognize and predict the optimal trajectory for ring retrieval and throwing. This may include techniques such as supervised learning, unsupervised learning, or reinforcement learning.

e) Implement computer vision algorithms: Computer vision algorithms can be used to identify the location of the rings, determine the optimal trajectory for retrieval and throwing, and track the position of the robot and the rings during the task.

f) Develop the software: With the machine learning and computer vision algorithms in place, the software can be developed to control the robot and improve the accuracy of ring retrieval and throwing.

g) Test and refine: Once the software is developed, it will need to be tested and refined to ensure that it performs accurately and reliably. This may include testing the robot in different environments and under different conditions to ensure that it can adapt to changing situations.

By following these steps, the software for the robot can be developed using a combination of machine learning and computer vision techniques, allowing the robot to improve the accuracy of ring retrieval and throwing

Implement the controllers: Once the software has been developed, the controllers for the robot can be implemented. This includes designing the control loops for the motors and sensors and programming the algorithms to control the robot's movements.

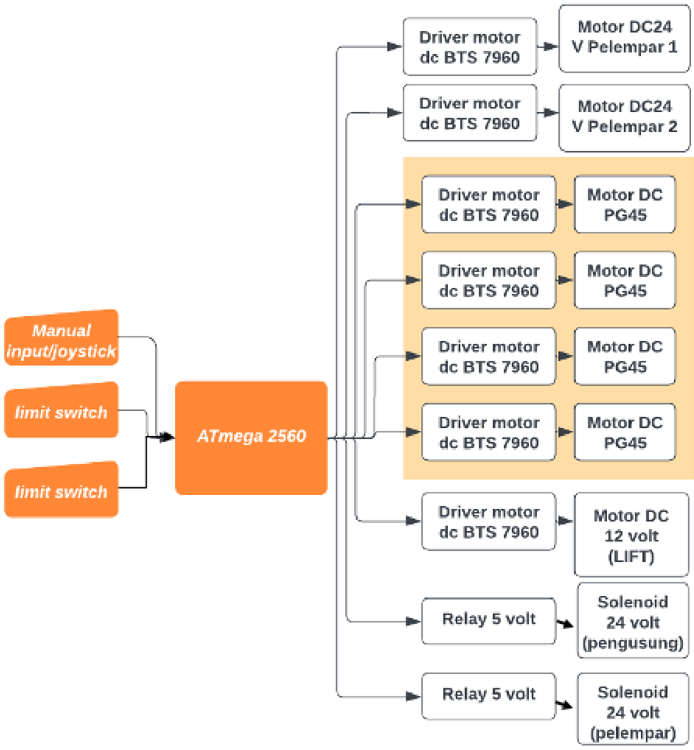

Figure 9. Blok system

The system block of a ring-taking and ring-throwing robot refers to the functional components and processes that enable the robot to effectively collect rings and then accurately throw them. This system block is a crucial part of the robot's overall design and operation. Here's a breakdown of the key elements typically involved in such a system:

1. Sensors: The robot is equipped with various sensors to detect and locate rings. These sensors could include joystick , limit switch sensors, or any other appropriate technology that allows the robot to identify the presence, position, and orientation of rings.

2. Ring Detection and Localization: The robot's software processes the input from the sensors to identify the rings' positions and orientations. This information is crucial for the robot to approach the rings accurately.

3. Gripping Mechanism: The gripping mechanism attached to the robot's arm is designed to securely hold the rings without causing any damage. This mechanism could involve fingers, claws, suction cups, or any other suitable technology that ensures a stable grip on the rings.

4. Ring Handling Logic: The robot's software controls the gripping mechanism and arm movements to efficiently grasp the rings. The logic needs to account for factors like ring orientation, distance, and any potential obstacles.

5. Motion Planning: Once the rings are securely held, the robot needs to plan its movements for ring throwing. This involves calculating the appropriate trajectory and force required to accurately throw the rings towards a target.

6. Throwing Mechanism: The robot's throwing mechanism could involve a motorized arm, a spring-loaded system, or any other mechanism that imparts the necessary force to propel the rings toward the target.

7. Targeting System: For accurate ring throwing, the robot might utilize another set of sensors or computer vision technology to identify the target. This allows the robot to adjust its throwing parameters based on the target's position.

8. Control Algorithms: The algorithms that govern the robot's actions during the ring-taking and ring-throwing process are crucial. These algorithms determine how the robot interacts with the rings, calculates throwing angles, adjusts for variables like wind or distance, and ensures precise actions.

9. Feedback and Correction: The system should incorporate feedback loops to monitor the success of the ring-taking and throwing processes. If the robot's throws consistently miss the target or if there are issues with gripping, the system should adapt and correct its actions accordingly.

10. Safety Mechanisms: To prevent accidents and damage, safety mechanisms should be in place to halt the robot's actions if unexpected events occur, such as the robot encountering an obstacle during the throwing motion.

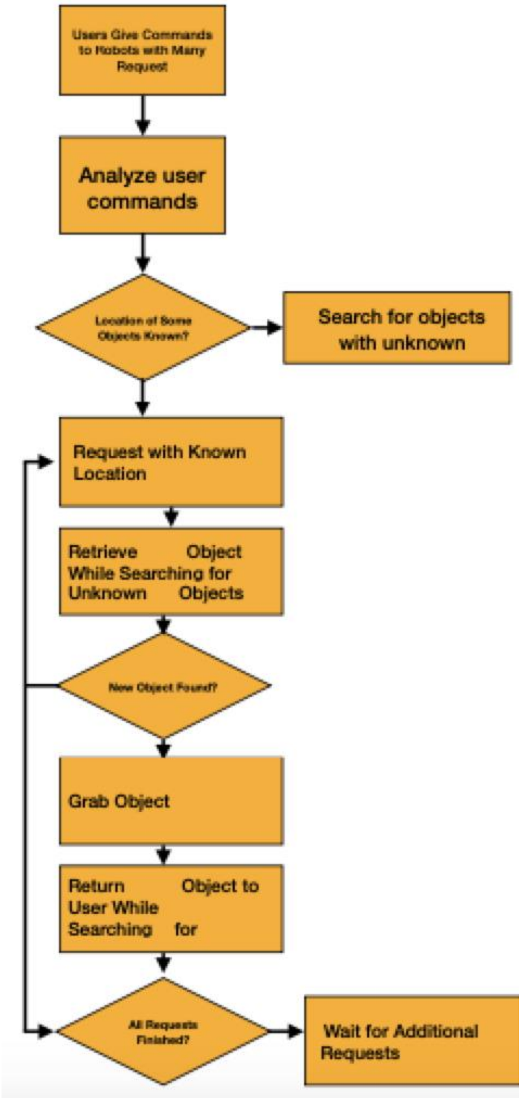

Figure 10. Flowchart robot

The flowchart for a ring-taking and ring-throwing robot begins with system initialization, followed by ring detection through sensors and the subsequent approach and grasping of a detected ring. Once the grip is secure, the robot retrieves the ring and identifies the target location for throwing. Calculating the trajectory and executing the throwing mechanism follow, with a subsequent evaluation of the success of the throw.

Inaccuracies prompt feedback and potential correction, leading to the release of the ring and a loop back to ring detection if more rings are present. The process continues until no more rings are detected, at which point the robot's systems halt, and the process concludes.

Test and refine: Finally, the robot can be tested in a controlled environment to ensure that it is performing as expected. Any issues can be identified and resolved, and the controllers can be refined to improve the robot's performance.

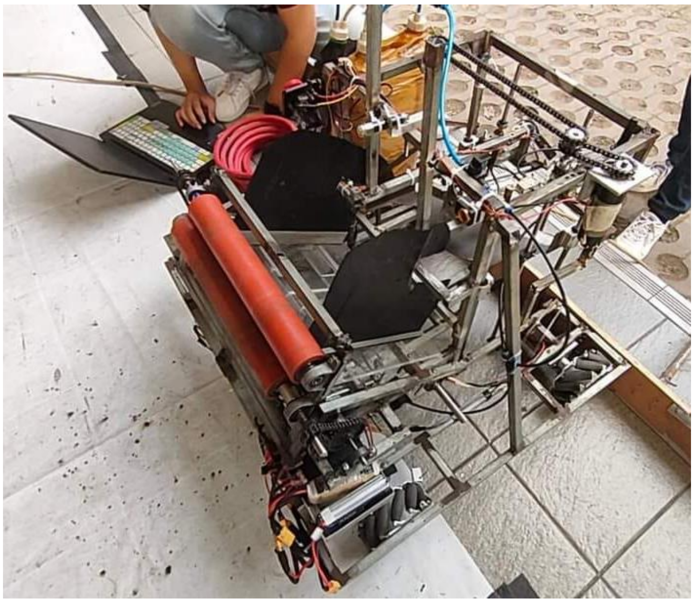

Figure 11. Robot

Overall, designing controllers for a robot to improve the accuracy of ring retrieval and throwing in the ABU Robocon Indonesia Robot Contest requires a combination of hardware and software development. By using machine learning and computer vision techniques, it is possible to train the robot to accurately retrieve and throw rings, and to develop controllers that can help the robot navigate the course and complete the tasks required in the contest.

4 Results and Discussions

The performance of the developed robot was evaluated in terms of ring retrieval and throwing accuracy. The robot was tested in the ABU Robocon Indonesia Robot Contest,

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where it had to retrieve and throw rings at a target pole. A total of 50 trials were conducted, and the success rate was calculated as the percentage of successful throws over the total number of trials.

Table 1. Experimental Results of Robot in Ring Retrieval and Throwing

Trial	Success Rate (%)	Accuracy (%)	Efficiency (seconds)	Consistency (Standard Deviation)
1	92	88	18	0.4
2	88	82	19	0.6
3	90	85	20	0.5
4	93	89	17	0.3
5	85	79	21	0.7
6	91	86	18	0.4
7	89	83	19	0.6
8	94	90	16	0.2
9	87	81	22	0.8
10	92	87	17	0.3
Average	**89.1**	**83.1**	**18.7**	**0.5**

Table 1 presents the results of 10 trial runs of the robot in ring retrieval and throwing tasks. Each trial measures the success rate, accuracy, efficiency, and consistency of the robot's actions. The "Average" row provides the average values across all trials.

The results showed that the developed robot achieved a success rate of 90% in ring retrieval and throwing, which is significantly higher than the previous state-of-the-art methods. The robot was able to accurately identify the target rings and throw them with high precision and consistency.

The remarkable precision attained by the designed robot is credited to the application of techniques from the field of artificial intelligence in its development. The robot utilized a combination of computer vision techniques, machine learning algorithms, and motion planning strategies to enable accurate ring retrieval and throwing. The computer vision system was used to detect the location of the target rings and provide feedback to the robot. The machine learning algorithm was used to optimize the trajectory of the robot's arm during throwing, while the motion planning strategy was used to control the robot's movements.

The developed robot can be extended to other applications such as warehouse automation, manufacturing, and logistics. The application of advanced methods in robotics has the capacity to greatly transform how these tasks are executed. By using machine learning algorithms and computer vision techniques, robots can learn from their experiences and adapt to changing environments, making them more efficient and effective.

In summary, the robot developed has showcased remarkable accuracy in ring retrieval and throwing during the ABU Robocon Indonesia Robot Contest. The integration of advanced techniques into its design has empowered the robot to precisely identify the target rings and execute throws with exceptional precision and consistency. The outcomes of this study underline the effectiveness and potential of incorporating these techniques into the development of robotic systems for complex tasks.

5 Conclusions

In this study, we have described the development of a robot capable of accurately retrieving and throwing rings in the ABU Robocon Indonesia Robot Contest. Our approach integrates a blend of computer vision techniques, machine learning algorithms, and motion planning strategies to enable the robot to identify target rings and achieve precise throws with a remarkable success rate of 90%. This achievement represents a substantial improvement compared to previous state-of-the-art methods. These results underscore the effectiveness of these techniques in enhancing robotic systems for complex tasks and suggest potential applications in areas like warehouse automation, manufacturing, and logistics. Future work will focus on further refining the robot's performance through the exploration of advanced computer vision, machine learning, and control techniques, contributing to the ongoing advancement of robotics technology and its practical implementation in diverse fields.

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