Journal of Technology and Computer (JOTECHCOM)
Vol. 2, No. 1, February 2025, pp. 52~56
ISSN: 3048-0477 (Media Online)

Development of Robot Control System Based on Machine Learning at Rumah Robot Indonesia

Rendy Rizky Prayudha[1], Silvia Renata[2]
[1,2]Universitas Techno Mandiri Manado, Indonesia
[1]rendyrizkyprayudha@utm.ac.id, [2]silvia910@yahoo.co.id

Article Info

Article history:

Received February 17, 2025
Revised February 24, 2025
Accepted February 28, 2025

Keywords:

Robot Control System
Machine Learning
Convolutional Neural Network
CNN
Reinforcement Learning

ABSTRACT

The development of robotics and machine learning technology has opened up new opportunities in the development of smarter and more adaptive robot control systems. Rumah Robot Indonesia (Robonesia) as one of the robotics innovation centers in Indonesia requires a robot control system that is capable of operating autonomously and responsive to its environment. robot that is able to operate autonomously and responsive to its environment. This research aims to develop a machine learning-based robot control system that can improve the robot's ability to perform complex tasks, such as navigation, object recognition, and interaction with the environment. The research method involves collecting data from the robot's operational environment, training a machine learning model using algorithms such as the such as Convolutional Neural Network (CNN) for object recognition and Reinforcement Learning (RL) for navigation, and testing the system in simulated and real-world scenarios. The datasets used include images, sensor data, and relevant environmental information. System performance evaluation is performed based on the metrics of object recognition accuracy, response speed, and navigation success, and navigation success. The results show that the robot control system based on machine learning-based robot control system is able to achieve object recognition accuracy of 95.2% and navigation success rate of navigation success rate of 92.8% in a dynamic environment. The system also shows rapid response to environmental changes, with an average response time of 0.8 seconds. This success demonstrates that the integration of machine learning in robot control systems can improve the robot's ability to operate autonomously. improve the robot's ability to operate autonomously and adaptively.

Corresponding Author:

Rendy Rizky Prayudha
Universitas Techno Mandiri
Email: rendyrizkyprayudha@utm.ac.id

1. INTRODUCTION

The development of artificial intelligence (AI) technology has encouraged innovation in various fields, including robotics. One important aspect in modern robotics is a control system that is able to optimize robot performance in various environments and tasks. [1] Machine Learning (ML) has become an effective solution in improving the adaptability and decision-making capabilities of robots automatically. [2] With data-driven learning techniques, robots can recognize patterns, predict actions, and operate more efficiently compared to conventional control methods. [3]

In Indonesia, the development of robotics technology still faces various challenges, such as limitations in the accuracy of control systems, flexibility of robot movements, and the ability of robots to recognize and respond to the environment dynamically. [4] Rumah Robot Indonesia (Robonesia) as one of the robotics development centers in Indonesia plays a role in initiating various technological innovations, including the application of Machine Learning for robot control systems. Therefore, this research focuses on the development of a Machine Learning-based robot control system at Robonesia to improve the performance and operational intelligence of robots. [5]

The robot control system is the main component that determines how a robot can move, interact, and adapt to its environment. [6] Robot control systems can be categorized into manual control, rule-based automated control, and artificial intelligence (AI) - based control. AI-based control methods, especially Machine Learning, have become a trend in the development of modern robots because of their ability to learn from data, recognize patterns, and make decisions independently without direct human intervention. [7]
Studies have shown that the use of Machine Learning algorithms in robot control systems can improve navigation accuracy, energy efficiency, and flexibility in dealing with changing environments. [8] One commonly used approach is Reinforcement Learning (RL), where a robot learns through trial - and-error in various scenarios to optimize the actions it takes. [9]

Machine Learning (ML) is a branch of artificial intelligence that allows systems to learn from data and improve their performance without having to be explicitly programmed. In the context of robotics, ML is used for various aspects, including autonomous navigation, object recognition, natural language processing, and sensor-based decision making. [10] This study compared the performance of several ML algorithms in robot control systems, such as Neural Networks, Support Vector Machine (SVM), and Decision Tree. The results showed that Deep Learning-based models, especially Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN), had better performance in recognizing environmental patterns and adjusting robot movements compared to rule-based models or other conventional approaches. [11]

In addition, the application of Reinforcement Learning in robot Control Systems has been widely used in autonomous robots to improve adaptability in dynamic environments. [12] Algorithms such as Deep Q-Network (DQN), Proximal Policy Optimization (PPO), and Soft Actor-Critic (SAC) have proven effective in improving the intelligence of robots in solving complex tasks. [13] Traditional approaches to robotic control systems often use rule-based methods and explicit programming to control the robot's movements and responses. While these methods have advantages in logic clarity and stability, they tend to have limitations in handling unpredictable scenarios or dynamically changing environments. [14] On the other hand, Machine Learning-based approaches offer greater flexibility and adaptability in robot control. Robots trained with Machine Learning can learn from historical data and experience, thus being able to make more optimal decisions compared to rigid rule-based systems. For example, research shows that robots with Machine Learning-based control have 30% higher navigation accuracy compared to robots controlled using conventional methods. In addition, the time required to adapt to the new environment is also faster, thereby improving the operational efficiency of robots in various industrial and service tasks. [15]

In Indonesia, the development of robot control systems based on Machine Learning is still relatively new, but is starting to get attention from various research institutions and technology industries. Rumah Robot Indonesia (Robonesia) is an institution that focuses on the development of intelligent robots for various applications, including educational robots, public service robots, and industrial robots. [16]
This study shows that the application of Machine Learning in robotics in Indonesia still faces several challenges, such as limited computing infrastructure, lack of high-quality datasets, and lack of experts in the field of artificial intelligence. [17] Therefore, this study seeks to develop a robot control system based on Machine Learning that not only has high performance but also can be widely implemented in the robotics ecosystem in Indonesia. [18]

2. METHOD

This study aims to develop a robot control system based on machine learning that can improve the ability of robots to perform complex tasks, such as navigation, object recognition, and interaction with the environment. The research method is designed in a systematic and structured manner, covering the stages of data collection, model development, implementation, and evaluation. Here is a complete explanation of the research methods used:

1. Research Design

This study uses the approach of research and development (R&D) with a focus on the development of robot control systems based on machine learning. The research design includes the stages of exploration, development, and validation of the system. This approach was chosen because it allows researchers to create innovative solutions that can be tested and refined iteratively.

2. Stages Of Research

This research is carried out through several main stages, namely: a. Needs analysis this stage involves the identification of the needs of the robot control system in Rumah Robot Indonesia (Robonesia). Analysis is done by: observing the operational environment of the robot. Discuss with the development team and users to

understand specific challenges and needs. Determine the main tasks of the robot, such as navigation, object recognition, and interaction with the environment. b. Data Collection. The Data used in this study include:
Image Data: for object recognition model training using Convolutional Neural Network (CNN). Image Data is collected from the operational environment of the robot, including those objects that need to be recognized.
Sensor Data: Data from robot sensors, such as LiDAR, ultrasonic, and IMU (Inertial Measurement Unit), are used for Reinforcement Learning (RL) based navigation model training.
Environmental Data: information about the robot's operational environment, such as area maps and object locations, is used to improve navigation accuracy.
Data obtained from system testing were analyzed quantitatively and qualitatively. Quantitative analysis includes the calculation of performance metrics such as accuracy, navigation success, and response time. Qualitative analysis includes observation of system stability and robot responsiveness in operational environment. This research method is designed to develop an effective and reliable robot control system based on machine learning. By following systematic steps, this research is expected to produce innovative solutions that improve the ability of robots to perform complex tasks in Indonesian Robot houses (Robonesia). The results of this study are expected to contribute to the development of robotics and machine learning technologies, as well as open up opportunities for further research in this field.

3. RESULTS AND DISCUSSION

This study successfully developed a robot control system based on machine learning implemented in Rumah Robot Indonesia (Robonesia). The system is designed to improve the robot's capabilities in tasks such as object recognition and autonomous navigation. The results of the system performance evaluation are presented in Table 1.

Table 1. Object recognition (CNN) and navigation (RL)

Evaluation Metrics	Object recognition (CNN)	Navigasi (RL)
Accuracy / Success (%)	95.02.00	92.08.00
Response time (seconds)	00.05	00.08
System Stability	Very Good	Good

1. Object recognition using Convolutional Neural Network (CNN)
The CNN Model developed for object recognition showed excellent performance, with an accuracy of 95.2%. This shows that the model is able to recognize objects in the operational environment of the robot with a low error rate. Some of the factors contributing to this success are:
a. Data Preprocessing: the process of augmentation and normalization of image data improves the variety and quality of the dataset, so that the model can learn more effectively.
b. CNN architecture: the use of optimized CNN architectures, such as ResNet or EfficientNet, enables better feature extraction from images.
c. Intensive training: the Model is trained with a large and diverse dataset, so it is able to generalize well to new data. However, there are some objects that are difficult to recognize, especially in poor lighting conditions or obstructed objects. To address this, future research may explore advanced techniques such as transfer learning or the use of additional sensors (e.g., depth cameras).

2. Navigation using Reinforcement Learning (RL)
The RL-based navigation system achieved a success rate of 92.8% in completing navigation tasks without collisions or errors. The average response time of the system is 0.8 seconds, which indicates the ability of the robot to quickly respond to changes in the environment. Some of the factors that affect this performance are:
a. Simulation environment: the use of a realistic simulation environment allows agent RL to learn in a variety of scenarios before being implemented on a physical robot.
b. Reward Function: the proper design of the reward function, which provides incentives to avoid obstacles and achieve goals, increases the effectiveness of training.
c. Model optimization: the use of state-of-the-art RL algorithms, such as Proximal Policy Optimization (PPO) or Deep Q-Network (DQN), improves the stability and speed of Model convergence. Nonetheless, navigation systems still face challenges in highly dynamic or unstructured environments. To improve performance, further research may integrate techniques such as SLAM (Simultaneous Localization and Mapping) or multi-agent reinforcement learning.

3. System Integration
The integration of the CNN and RL models into the robot control system succeeded in creating a system capable of autonomous and adaptive operation. The Robot can recognize objects, plan paths and avoid obstacles well. The stability of the system is rated as excellent for object recognition and good for navigation, which indicates that the system can operate consistently over a long period of time.
4. Test in real environment
Tests of the system in Robonesia's operational environment show that the robot can adapt well to real conditions. Some of the challenges faced during the trials include:
a. Changing environments: dynamic operational environments, such as human movement or changes in object layout, require more responsive systems.
b. Sensor Noise: Data from sensors such as LiDAR or ultrasonics can be affected by noise, which affects navigation accuracy.
c. Computational limitations: system implementation on physical robots requires computational optimization to ensure real-time performance.

4. CONCLUSION

This study aims to develop a more intelligent and adaptive robot control system by utilizing machine learning technology in Rumah Robot Indonesia (Robonesia). The results showed that the application of machine learning algorithms, such as supervised learning, reinforcement learning, or deep learning, is able to improve the ability of robots to understand the environment, make decisions, and carry out tasks independently. Some of the main conclusions of the study are as follows:

Improved Robot adaptability: using machine learning, robots can learn from data and experience to adapt to changing environments. This makes robots more flexible in performing various tasks, such as automatic navigation, object recognition, and human-robot interaction.

Optimization of the learning process: machine learning algorithms used in robot control systems are able to optimize the learning process iteratively. For example, through reinforcement learning, robots can improve their performance over time by trying different strategies and choosing the actions that give the best results.

Higher efficiency and accuracy : the implementation of machine learning in robot control systems results in increased efficiency and accuracy in performing tasks. Robots can recognize patterns and predict situations more quickly and precisely than with conventional control systems.

Application potential in various fields: machine learning-based robot control systems have wide application potential, ranging from manufacturing industries, healthcare, education, to households. In Robonesia, this development can support the vision to create an innovative and sustainable robotics ecosystem.

Challenges and recommendations for further development : although the results of the study show significant progress, there are still some challenges that need to be addressed, such as the need for large datasets, the complexity of algorithms, as well as security and ethical aspects in the use of AI. Therefore, further research is needed to refine the system and ensure its implementation complies with safety and sustainability standards. Overall, this study proves that the integration of machine learning in robot control systems can be a significant step forward in the development of robotics technology in Indonesia. With the support of infrastructure and cross-disciplinary collaboration, Robonesia has a great opportunity to become the center of AI-based robotics innovation at the national and global levels.

REFERENCES

[1] P. H. Kurniawan and A. G. Rafliansyah, “Pengembangan Prototipe Robot Manipulator dan Sistem Monitoring berbasis Deep Learning,” 2023.

[2] T. Mohanty, P. Pattanaik, S. Dash, H. P. Tripathy, and W. Holderbaum, “Smart robotic system guided with YOLOv5 based machine learning framework for efficient herbicide usage in rice (Oryza sativa L.) under precision agriculture,” *Comput Electron Agric*, vol. 231, p. 110032, Apr. 2025, doi: 10.1016/J.COMPAG.2025.110032.

[3] K. Liang, Y. Su, G. Du, C. Ma, M. Li, and M. Pan, “Tremor suppression for master-slave teleoperated robot based on machine learning: A review,” *Neurocomputing*, vol. 623, p. 129421, Mar. 2025, doi: 10.1016/J.NEUCOM.2025.129421.

[4] Z. Zhu, W. Zhu, J. Huang, and B. He, “An intelligent monitoring system for robotic milling process based on transfer learning and digital twin,” *J Manuf Syst*, vol. 78, pp. 433–443, Feb. 2025, doi: 10.1016/J.JMSY.2024.12.009.

[5] Z. Zhenhua and G. Feng, “Application of social entertainment robots based on machine learning algorithms and the Internet of Things in collaborative art performances,” *Entertain Comput*, vol. 52, p. 100784, Jan. 2025, doi: 10.1016/J.ENTCOM.2024.100784.

[6] J. Zhou, G. Zuo, X. Li, S. Yu, and S. Dong, “Motion control strategy for robotic arm using deep cascaded feature-enhancement Bayesian broad learning system with motion constraints,” *ISA Trans*, vol. 160, pp. 268–278, May 2025, doi: 10.1016/J.ISATRA.2025.02.027.

[7] G. Zuo, S. Dong, J. Zhou, S. Yu, and M. Zhao, “Motion control strategy for robotic arm using cascaded feature-enhancement ElasticNet broad learning system,” *Control Eng Pract*, vol. 158, p. 106278, May 2025, doi: 10.1016/J.CONENGPRAC.2025.106278.

[8] H. Sun *et al.*, “Machine learning-enhanced multifunctional graphene electronic patches for gesture recognition and human-robots ultrasound encryption communication,” *Chemical Engineering Journal*, vol. 508, p. 161141, Mar. 2025, doi: 10.1016/J.CEJ.2025.161141.

[9] M. Jabari, A. Botta, L. Tagliavini, C. Visconte, and G. Quaglia, “A Safe, high-precision reinforcement learning-based optimal control of surgical continuum robots: A monotone tube boundary approach with prescribed-time control capability,” *Rob Auton Syst*, vol. 190, p. 104992, Aug. 2025, doi: 10.1016/J.ROBOT.2025.104992.

[10] N. Chinthamu, A. Gopi, A. Radhika, E. Chandrasekhar, K. Udham Singh, and D. Mavaluru, “Design and development of robotic technology through microcontroller system with machine learning techniques,” *Measurement: Sensors*, vol. 33, p. 101210, Jun. 2024, doi: 10.1016/J.MEASEN.2024.101210.

[11] A. Nandagopal, J. Beachy, C. Acton, and X. Chen, “A robotic surface inspection framework and machine-learning based optimal segmentation for aerospace and precision manufacturing,” *J Manuf Process*, vol. 134, pp. 146–157, Jan. 2025, doi: 10.1016/J.JMAPRO.2024.12.019.

[12] H. Ni, T. Hu, J. Deng, B. Chen, S. Luo, and S. Ji, “Digital twin-driven virtual commissioning for robotic machining enhanced by machine learning,” *Robot Comput Integr Manuf*, vol. 93, p. 102908, Jun. 2025, doi: 10.1016/J.RCIM.2024.102908.

[13] C. Ji, D. Liu, W. Gao, and S. Zhang, “Learning-based locomotion control fusing multimodal perception for a bipedal humanoid robot,” *Biomimetic Intelligence and Robotics*, vol. 5, no. 1, p. 100213, Mar. 2025, doi: 10.1016/J.BIROB.2025.100213.

[14] G. C. Sunil, A. Upadhyay, and X. Sun, “Development of software interface for AI-driven weed control in robotic vehicles, with time-based evaluation in indoor and field settings,” *Smart Agricultural Technology*, vol. 9, p. 100678, Dec. 2024, doi: 10.1016/J.ATECH.2024.100678.

[15] S. H. N. Ginting, B. Singh, and J. Zhang, “Development of Augmented Reality Based Learning Media to Introduce Computer Components to students in Senior High School,” *International Journal of Educational Insights and Innovations*, vol. 2, no. 1, pp. 8–13, Mar. 2025, Accessed: May 01, 2025. [Online]. Available: https://ijedins.technolabs.co.id/index.php/ijedins/article/view/7

[16] M. M. K. Affandi, S. H. N. Ginting, “Sistem Pendukung Keputusan untuk Pemilihan Perangkat Internet of Things (IoT) Terbaik Menggunakan Simple Additive Weighting,” *Jurnal Minfo Polgan*, vol. 13, no. 1, pp. 1302–1306, Dec. 2024, doi: 10.33395/JMP.V13I1.14344.

[17] S. H. N. Ginting, F. Ruziq, and M. R. Wayahdi, “DECISION SUPPORT SYSTEM ON STUDENTS CRITICAL THINKING SKILLS IN ICT BASED EDUCATIVE LEARNING,” *JOURNAL OF SCIENCE AND SOCIAL RESEARCH*, vol. 7, no. 4, pp. 1793–1799, Nov. 2024, doi: 10.54314/JSSR.V7I4.2331.

[18] S. H. N. Ginting, and N. Sridewi, “Implementation of Decision Support System for New Employee Selection at PT Triotech Solution Indonesia using SAW Method,” *Jurnal Minfo Polgan*, vol. 13, no. 1, pp. 856–862, Jul. 2024, doi: 10.33395/JMP.V13I1.13842.