Applying an Artificial Neuromolecular System with Autonomous Learning Capability to Learn to Control the Movement of a Six-Axis Robotic Arm

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Abstract—**With the widespread use of intelligent robots, robotic arms play an increasingly vital role across various fields. This study explores using a system endowed with autonomous learning capabilities to learn and control the movements of a six-axis robotic arm. The research method enables this robotic arm to autonomously determine its movement trajectory, transitioning from a specific point to a fixed position while grasping an object at a designated angle. This process involves managing the broader movement trajectories associated with the arm's operations and ensuring precise coordination for practical suction actions. The WLKATA Mirobot serves as the experimental testbed for this study; it is a compact six-axis machine designed for tabletop use. The primary control mechanism is linked to an artificial neuromolecular system developed earlier in this team, characterized by a closely aligned relationship between structure and function that evolves. This design facilitates continuous learning, allowing the robotic arm to accomplish assigned tasks without rigid time constraints. Various trajectories were established in the experiments, enabling the arm to navigate toward desired target points based on specific requirements. The results indicate that the system can successfully reach target points and effectively grasp objects. Additionally, thorough testing was conducted to evaluate whether the molecular-like nervous system allows the robotic arm to execute corresponding movements proficiently. The study shows that this molecular-like jumpy system can effectively utilize previously learned actions after a learning period. This adaptability enables the robotic arm to adjust its operations for similar tasks, thereby achieving what is known as the transfer learning effect.**

Keywords- sensors; artificial neural networks; computational intelligence; robot; autonomous learning.

I. INTRODUCTION

In today's highly developed world of information technology, the application of robots has become indispensable and essential. Their application ranges from simple robot-arm operation to complex robot-arm collaboration and even to the operation of humanoid arms. Traditional robot arms are mainly used in large-scale manufacturing industries, but collaborative robot arms have emerged rapidly in recent years. They are relatively minor, lighter, and more flexible. In addition, collaborative robotic arms are relatively simple to program, making them easier to reconfigure and deploy to production environments where products are small and diverse. The unique design of collaborative robotic arms allows them to work alongside human operators to perform highly repetitive tasks and integrate complex tasks. This collaborative approach improves production efficiency and reduces the physical burden on human operators, allowing them to focus more on more creative and intelligent tasks. With the continuous development of industrial automation, path planning has become one of the key issues in robot arm applications. Ensuring the robot arm can accurately move from the current to the target position has always been crucial. Robots have surpassed humans in well-structured and highly repetitive tasks through advanced control technology and machine learning methods, achieving faster and more precise motion control. The robot arm can calculate and realize its optimal motion path between two specified positions, further improving its application scope and benefits [1].

This study uses the WLKATA Mirobot as an experimental tool to collect the trajectories required for specific task requirements. WLKATA Mirobot is a desktop six-axis robotic arm with 6 degrees of freedom (Figure 1). This design combines flexibility and complex free rotation to provide a desktop robotic arm designed to simulate an innovative factory robotic arm. Its simulated factory application areas include fruit picking production lines, smart garbage sorting production lines, artificial intelligence sorting production lines, deep learning dynamic sorting production lines, etc. The primary control mechanism is the artificial neuromolecular system developed earlier in this team [2], characterized by a closely aligned relationship between structure and function that evolves. This design facilitates continuous learning, allowing the robotic arm to accomplish assigned tasks without rigid time constraints. Various trajectories were established in the experiments, enabling the arm to navigate toward desired target points based on specific requirements. The rest of the paper is structured as follows. In Section II, we present. the design of this six-axis robot. The experiments and results are presented in Section III. Finally, we draw our conclusions in Section IV.

II. METHOD

This study uses the trajectory data collected by WLKATA Mirobot and then uses the artificial neuromolecular system to learn the trajectory data. This

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research experiment consists of two parts. The first part is a large-scale movement experiment in which the system has to learn how to control the relatively large movement trajectory of the six-axis robot arm. The second part is a small-scale movement experiment in which the system has to learn how to coordinate the six-axis robot arms to produce detailed suction movements. Unlike the first part of the experiment, the control of the robotic movement requires high precision positioning accuracy, ensuring that the robot arm can accurately reach the target point.

The core processing component of the ANM system includes all control and information processing neurons, forming the Central Processing Subsystem (CPS). This system functions similarly to the brain's processing mechanism and is seen as a converter between input and output. The CPS is mainly composed of a set of reference neurons and information processing neurons (cytoskeletal neurons or enzyme neurons). When the system starts receiving external information, each information-processing neuron learns from different sensory neurons, adjusting the connection states appropriately to meet the system's requirements. The detailed mechanism can be found in [3].

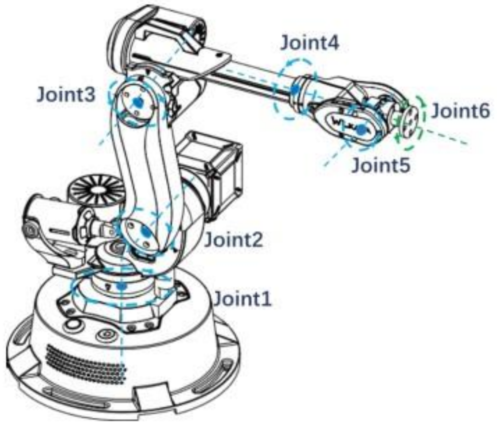

Figure 1. WLKATA Mirobot's.

III. EXPERIMENTS AND RESULTS

Various trajectories were established in the experiments, enabling the arm to navigate toward desired target points based on specific requirements. The results indicate that the system can successfully reach target points and effectively grasp objects. Additionally, thorough testing was conducted to evaluate whether the molecular-like nervous system allows the robotic arm to execute corresponding movements proficiently. The study shows that this molecular-like jumpy system can effectively utilize previously learned actions after a learning period. This adaptability enables the robotic arm to adjust its operations for similar tasks, thereby achieving what is known as the transfer learning effect.

The limitations of this study mainly arise from the constraints of the research equipment and methodology. Regarding the limitations of the research equipment, due to the design and assembly limitations of the machines, certain movements cannot simulate angles beyond the limits of human joint motion. Additionally, to some extent, the movements that the machine can present may be relatively difficult for humans.

In the future, these research results are expected to be applied to different robotic fields to improve the learning effectiveness of the system further. We also want to fine-tune detailed movements with appropriate models based on specific needs. In particular, the robot can learn to complete assigned tasks autonomously when facing an environment with high uncertainty.

IV. CONCLUSION

This research aims to explore how to use artificial intelligence to achieve automatic control of a robotic arm through self-learning. The method used in this research is to use a system motivated by biological information processing methods. There are two future research directions. The first is to continuously enrich the data on the movement of the robot hand and establish the norms of healthy human hand movements. The second is that in addition to some daily life activities used in this study, it may be possible to increase the study of patients' hand movements. This is a more objective analysis, which is its real practical application. Finally, in the future, we hope to collect enough data on the use of this technology to integrate Artificial Intelligence (AI) systems into this field of research and to further capture the specific biological characteristics of individuals.

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