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Investigation on Artificial Intelligence Algorithms in Robot Object Recognition Systems under the Background of Big Data

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Abstract: *With the development of artificial intelligence algorithms, the application of big data in various fields is becoming increasingly widespread, including computer vision, speech recognition, intelligent robots, etc. However, there are few applications for robot object recognition systems. This article would combine existing artificial intelligence technologies to study object recognition systems, and upgraded the robot object recognition system using convolutional neural network models and error back propagation models, respectively. Through experiments, it was found that convolutional neural networks could shorten the time to 0.8 seconds, while the error back propagation model could improve the recognition accuracy to 95%, with an average accuracy of 91.7%. The results indicated that the convolutional neural network model had a significant effect in shortening recognition time; while the error back propagation model was effective in improving recognition accuracy.*

Keywords: *Object Recognition System, Artificial Intelligence Algorithm, Big Data, Convolutional Neural Network, Error Back Propagation*

1. Introduction

With the development of computer technology, artificial intelligence has become a research hotspot and has made significant breakthroughs in various fields. In fields such as image recognition, speech recognition, and intelligent robots, artificial intelligence algorithms have demonstrated strong learning and perception abilities. Especially in image recognition, artificial intelligence algorithms can directly extract features from a large amount of data and classify images based on these features. In speech recognition, artificial intelligence algorithms have demonstrated strong feature extraction and learning abilities, which can extract more effective features from a large amount of data. Therefore, an object recognition system designed based on artificial intelligence algorithms can solve the problem of robot object recognition.

Scientists in many fields around the world have conducted some research on object recognition systems. Solvi and Cwyn conducted research on object recognition in the visual and tactile senses of bumblebees. Experiments showed that bumblebees had the ability to integrate sensory information, which required independent internal representations of channels [1]. Shi, Binbin proposed a vehicle multi target recognition and classification method based on object detection algorithm. The results showed that this method had good accuracy, low false detection rate, and good robustness [2]. Seijdel, Noor displayed objects on increasingly complex backgrounds to investigate whether recursive computation was becoming increasingly important for segmenting objects from more complex backgrounds. Three pieces of evidence indicated that cyclic processing was crucial for identifying embedded objects in complex scenes [3]. Nayebi, Aran developed a task optimized convolutional recurrent network model, which more accurately simulated the timing and gross neuroanatomy of the ventral pathway. The results indicated that the repetitive function in the ventral pathway was aimed at adapting to high-performance networks in the cortex, thus obtaining computational power through temporal rather than spatial complexity [4]. Hajra, Sugato recorded gait analysis of different volunteers by using friction nanogenerator equipment and digital signal processing routes to effectively distinguish gait patterns, so as to prevent falls and injuries. The friction nanogenerator device was used to charge commercial capacitors and supply power for watches. In addition, it was also connected to the robot gripper for object recognition [5]. Although their research on object recognition was thorough, they could still detect some shortcomings.

The article used artificial intelligence algorithms to upgrade the robot object recognition system of a robot research company. The system utilized artificial intelligence algorithms to improve the accuracy of object recognition while also shortening the recognition time. This breakthrough would play a crucial role in the field of robotics research.

2. Artificial Intelligence Algorithms

Artificial intelligence is a theory and method that studies how human intelligence is implemented in computers. Artificial intelligence algorithms refer to one or more algorithms in artificial intelligence technology, mainly divided into two types: rule algorithms and heuristic algorithms. Rule algorithm refers to a method of finding patterns through repeated experiments on known results; Heuristic algorithms are methods of finding patterns through learning, exploring, and summarizing experiences [6].

Nowadays, artificial intelligence technology has been widely used in fields such as image recognition, speech recognition, intelligent robots, and has achieved significant breakthroughs in these fields [7]. In the big data environment, rapid recognition of feature objects can be achieved through feature extraction and learning [8]. Artificial intelligence has strong learning and cognitive abilities when classifying features such as images and sounds. Among them, neural network algorithm, error backpropagation algorithm, wavelet analysis algorithm, genetic algorithm, particle swarm optimization algorithm, etc. are the research focuses of this article.

1) Neural network algorithms: After the 1940s, people began to use neural networks. It is formed by a large number of neurons connected with adjustable connection weights, and has advantages such as large-scale parallel processing, distributed information storage, and good self-organizing and self-learning ability [9].

2) Error backpropagation method: It is a learning method based on supervised artificial neural networks. In theory, this model can approximate any function, and its basic structure is composed of elements of a nonlinear variable, with powerful nonlinear mapping function [10].

3) Wavelet analysis algorithm: This is a method that inherits and develops the concept of short time Fourier transform, overcomes the defect that its window size does not depend on frequency, and provides a “time-frequency” window that changes with frequency. It is a good means of signal “time-frequency” analysis and processing [11].

4) Genetic algorithm: This is a computing mode that imitates natural selection and genetic mechanism in Darwin’s biological evolution theory, and uses the natural evolution process to find the best solution [12].

5) Particle swarm optimization algorithm: This is a new type of evolutionary algorithm that has developed in recent years. The best solution is obtained through an iteration starting from a random solution [13].

3. System Structure Design

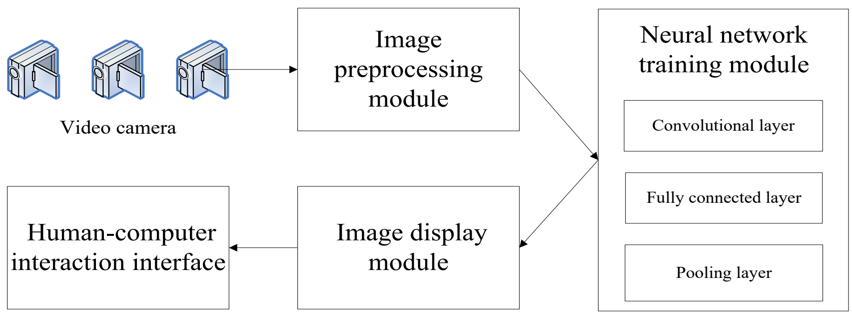

Figure 1: Overall structure of object recognition system.

The overall structure of the system is shown in Figure 1, which consists of four parts: image preprocessing module, neural network training module, image display module, and human-computer interaction interface. The main research content of the article is artificial intelligence object recognition, and the system analyzes and recognizes images through training neural network models. In order to improve the stability of the system, the article adopts a three-layer neural network model as the training algorithm, which is a convolutional layer, a pooling layer, and a fully connected layer. By combining these three layers network models, image classification and recognition are achieved. The system uses three video cameras to capture images, and then processes and analyzes them [14].

Object recognition refers to the quantitative recognition of the physical, chemical, and biological properties of an object. The measurement of this type of cognition is often achieved through the perception of material features such as brightness, color, size, shape, distance, pressure, vitality, and movement status. For vision, light, dark, and color are the quantitative cognition of object morphological features, while size and shape are the quantitative cognition of object surface features. Distance is a quantitative understanding of the positional features of an object. Stress is a quantitative understanding of the characteristics of an object's motion state, while vitality is a quantitative understanding of the speed characteristics of an object's motion. Sound can also be seen as a type of immaterial information, which includes size information (size difference), medium information (medium difference), frequency information (frequency speed), direction information (up, down, left, right, front, and back), and waveform information (waveform length). The tactile sensation mainly includes temperature, hardness, humidity, and state; odor and taste are composed of substances and chemistry. Nowadays, the combination of technology (sensors) and computers has enabled object recognition to have a larger resolution range and accuracy than humans themselves, and can be processed through programming [15].

Everything has its own unique physical and energy characteristics. Material characteristics include external characteristics such as shape, size, structure, and internal characteristics such as composition and structure. Among them, gravity (weight), magnetic force, sound wave and electromagnetic spectrum characteristics (y ray, X ray, visible light, infrared, radio wave, etc.) are all one of them. The similarity and difference of colors are the basis for identifying objects. All substances belonging to the same attribute have the same physical and energy properties, which can be distinguished based on the differences in physical and energy properties [16].

In the practical application scenario of robot object recognition, robots used for sorting items may be the most typical. When designing a sorting and recognition robot, it is necessary to consider the actual production application of the robot as a whole. Based on the analysis of the overall composition of the robot structure layout, the robot is mainly composed of two parts: One is the hardware system, and the other is the software system. Among them, the composition of the hardware system includes a series of structural components such as the main operating system, control cabinet, and computer terminal. Among these construction areas, the most important and core is the control cabinet. The control cabinet is the brain of the robot, which is connected by cables to the physical system of the robot. The computer end of the robot and the control cabinet need to use network communication protocols for information processing and coordination [17].

In order for the sorting robot to work in the production process, it is also necessary to have collaborative cooperation between various components and systems. Only with mutual cooperation can it run smoothly in production. In terms of the degree of coordination between hardware and software, in order for robots to recognize and distinguish objects, it is necessary to use the camera on the robot and the input of the object program to achieve object recognition. After identifying the object, the central system can issue commands to the external system to implement the final command operation [18].

When identifying and conceptualizing sorting robots, the most important aspect of the entire robot's conceptual design work is the installation design of the control cabinet. When designing the control cabinet system, it is necessary to combine the central control system with the design of external accessory systems. On this basis, corresponding control strategies were proposed based on the actual operational needs of the enterprise. The classification robot is recognized. When the robot is performing classification, it uses the grasping disc of the robotic arm to make contact with the object, realizing that both hands are connected to the vacuum generator, thereby completing the recognition and classification of the object [19].

When planning the software of the sorting robot, the following aspects should be considered: 1) determining the material of the goods and the robotic arm; 2) image-based robotic arm operation system; 3) identification of physical objects; 4) classification of robotic arms. In its implementation process, the software system implements instructions for each operating component through the control

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cabinet. After receiving the undetected signal of the object detection instruction, the computer starts the camera to judge the status of the object. After this series of operations, the actual object is analyzed by the wireless transmission protocol of the software system. Finally, the operation is completed in cooperation with each component.

When robots perform operations, in order to ensure the accuracy of this series of operations, the robot's object recognition system is particularly important. Its object recognition system mainly consists of two operating systems: a camera and an optoelectronic sensor. Photoelectric sensors are important systems for judging the quality of objects. After the robot accurately judges the object, the camera system recognizes the object. These two systems work together to form the robot's object recognition operation [20].

4. Experimental Evaluation

The object recognition system in the article adopts two artificial intelligence algorithms, namely convolutional neural network model and error backpropagation algorithm. The convolutional neural network model uses a bidirectional encoding representation algorithm, which can process large-scale data and has strong feature extraction ability. The calculation formula is shown in Formula (1). The error backpropagation model uses an adaptive motion estimation algorithm, which can effectively process small-scale data. Both models can accurately identify, and the calculation formulas are shown in Formulas (2) and (3).

$$K_i = \left(\frac{1}{S_i} \sum_{j=1}^{S_i} \left| R_j - C_i \right|^n \right)^{1/n} \tag{1}$$

In Formula (1), Rj represents the jth vector in cluster i, Ci is the centroid vector of cluster i, and Si is the number of vectors in cluster i.

$$Q = \frac{\sum_{\alpha=1}^{x} 3b_\alpha - \hat{b}_\alpha 4^2}{2x} \tag{2}$$

$$z = \sum_{\alpha=1}^{x} \frac{\left| b_\alpha - \hat{b}_\alpha \right|}{x b_\alpha} \tag{3}$$

In Formulas (2) and (3), x is the number of samples; $\hat{b}_\alpha$ is the network output value of the αth sample; b_α is the actual value of the αth sample [21].

Next, the experiment enters the next stage, which is the data collection stage. The data is sourced from a robotics research company, and the best and average data of robot recognition in the past five years have been extracted, as shown in Table 1.

Table 1: Data table for the last five years.

	2018	2019	2020	2021	2022
Highest accuracy	81%	82%	85%	87%	89%
Shortest time(s)	3.2	3.0	2.7	2.6	2.4
Average accuracy	78%	80%	81%	83%	86%
Average time(s)	3.5	3.3	3.0	2.9	2.8

From Table 1, it could be seen that over the past five years, the accuracy of recognition was increasing year by year, and the time required for recognition was also decreasing year by year, all of which were improving year by year. However, not only has the average accuracy not yet reached 90%, but the highest accuracy has also not been achieved. The required time has not yet reached within 2 seconds, which was still not ideal.

The experimental team introduced two types of artificial intelligence algorithm models, namely convolutional neural network model and error backpropagation model, into the robot recognition system. A total of ten experiments were conducted, and then the recognition data of the two were compared. The results are shown in Figure 2- Figure 3.

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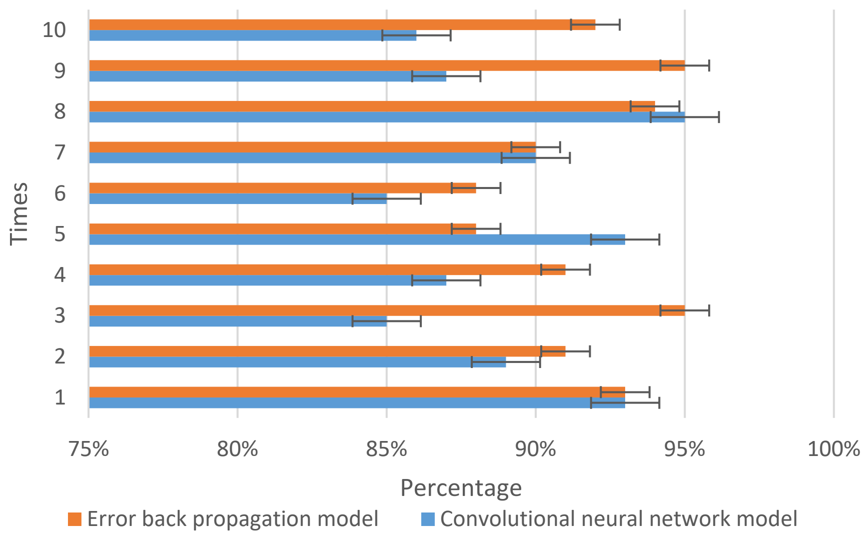

Figure 2: Comparison results of recognition accuracy.

From Figure 2, it could be seen that the recognition accuracy of the convolutional neural network model reached the highest level for the eighth time, with an accuracy of 95%. The third and sixth times were the lowest, with an accuracy of 85%. The average accuracy of ten times was 89%; in the recognition accuracy of the error backpropagation model, the third and ninth times achieved the highest accuracy of 95%. The fifth and sixth times were the lowest, with an accuracy of 88%. The average accuracy of ten attempts was 91.7%. Both models had the highest accuracy of 95%. However, the average accuracy of the convolutional neural network model was only 1% below 90%, which was still not ideal. The average accuracy of the error backpropagation model reached 91.7%, exceeding 90%. Therefore, it could be concluded that the error backpropagation model was more significant than the convolutional neural network model in improving the accuracy of robot object recognition [22].

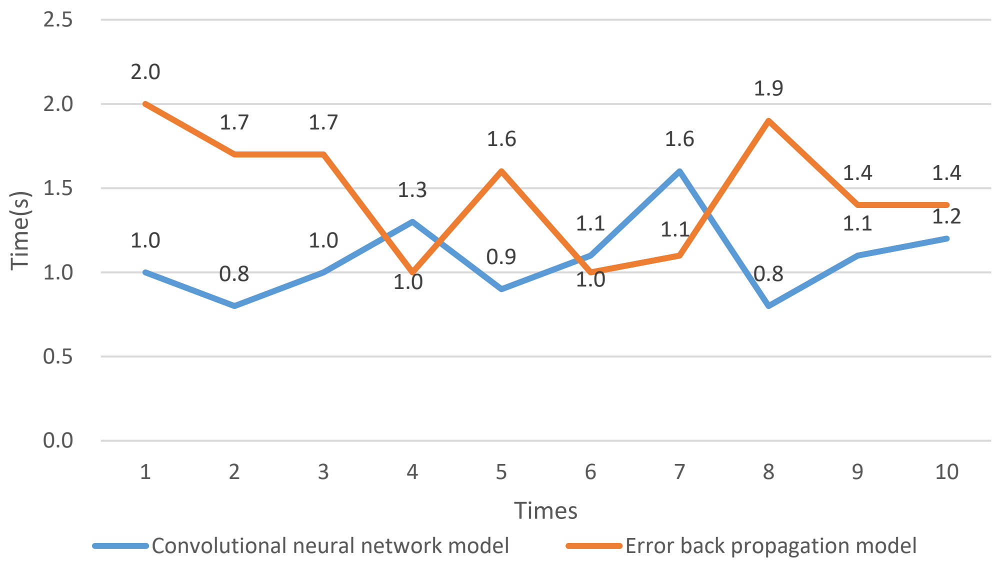

Figure 3: Recognition time comparison result chart.

From Figure 3, it could be seen that in the convolutional neural network model, the shortest recognition time was the second and eighth times, which were 0.8 seconds. The longest was the seventh time, with a recognition time of 1.6 seconds and an average recognition time of 1.08 seconds; in the error backpropagation model, the fourth and sixth recognition times were the shortest, taking 1.0 seconds. The longest recognition time for the first time was 2.0 seconds, with an average recognition time of 1.48 seconds. The overall recognition time of both models was less than 2 seconds. However, the average recognition time of the convolutional neural network model was only 0.08 seconds away from 1 second, and the slowest one was also 0.4 seconds faster than the slowest one in the error backpropagation model. Therefore, it could be concluded that the convolutional neural network model was superior to the error backpropagation model in terms of recognition time.

After comparing the data of recognition accuracy and recognition time, the final conclusion could be drawn that the error backpropagation model was more suitable for improving recognition accuracy, while the convolutional neural network model was more suitable for accelerating recognition time. A combination of the two might be better.

5. Conclusions

This article studied the application of artificial intelligence algorithms in robot object recognition systems under the background of big data, and designed an object recognition system based on artificial intelligence. This system could achieve functions such as object detection, image classification, and object recognition, thus effectively improving the accuracy of the robot object recognition system and shortening the time required for object recognition. In the future, artificial intelligence algorithms can be applied in more fields and make greater progress. However, there are still some shortcomings in this article, which would be gradually improved in future research.

References

[1] Solvi, Cwyn, Selene Gutierrez Al-Khudhairy, and Lars Chittka. "Bumble bees display cross-modal object recognition between visual and tactile senses." Science 367.6480 (2020): 910-912.

[2] Shi, Binbin, et al. "Multi-object recognition method based on improved yolov2 model." Information Technology and Control 50.1 (2021): 13-27.

[3] Seijdel, Noor, et al. "On the necessity of recurrent processing during object recognition: it depends on the need for scene segmentation." Journal of Neuroscience 41.29 (2021): 6281-6289.

[4] Nayebi, Aran, et al. "Recurrent connections in the primate ventral visual stream mediate a trade-off between task performance and network size during core object recognition." Neural Computation 34.8 (2022): 1652-1675.

[5] Hajra, Sugato, et al. "A new insight into the ZIF-67 based triboelectric nanogenerator for self-powered robot object recognition." Journal of Materials Chemistry C 9.48 (2021): 17319-17330.

[6] Nakamichi, Noritaka, et al. "Oral administration of the food-derived hydrophilic antioxidant ergothioneine enhances object recognition memory in mice." Current molecular pharmacology 14.2 (2021): 220-233.

[7] Bocchi, Alessia, et al. "Object recognition and location: Which component of object location memory for landmarks is affected by gender? Evidence from four to ten year-old children." Applied Neuropsychology: Child 9.1 (2020): 31-40.

[8] Serban, Alex, Erik Poll, and Joost Visser. "Adversarial examples on object recognition: A comprehensive survey." ACM Computing Surveys (CSUR) 53.3 (2020): 1-38.

[9] Balasubramaniam, Vivekanadam. "Artificial intelligence algorithm with SVM classification using dermascopic images for melanoma diagnosis." Journal of Artificial Intelligence and Capsule Networks 3.1 (2021): 34-42.

[10] Wehbe, Ramsey M., et al. "Deep COVID-XR: an artificial intelligence algorithm to detect COVID-19 on chest radiographs trained and tested on a large US clinical data set." Radiology 299.1 (2021): E167-E176.

[11] Cho, Jinwoo, et al. "Artificial intelligence algorithm for screening heart failure with reduced ejection fraction using electrocardiography." ASAIO Journal 67.3 (2021): 314-321.

[12] Shang, Yonghui, et al. "A novel artificial intelligence approach to predict blast-induced ground vibration in open-pit mines based on the firefly algorithm and artificial neural network." Natural Resources Research 29.2 (2020): 723-737.

[13] Reyna, Matthew A., Elaine O. Nsoesie, and Gari D. Clifford. "Rethinking algorithm performance metrics for artificial intelligence in diagnostic medicine." JAMA 328.4 (2022): 329-330.

[14] Huang, J., et al. "An artificial intelligence algorithm that differentiates anterior ethmoidal artery location on sinus computed tomography scans." The Journal of Laryngology & Otology 134.1 (2020): 52-55.

[15] Kumar, T. Senthil. "Data mining based marketing decision support system using hybrid machine learning algorithm." Journal of Artificial Intelligence 2.03 (2020): 185-193.

[16] Rao, Arni SR Srinivasa, and Jose A. Vazquez. "Identification of COVID-19 can be quicker through artificial intelligence framework using a mobile phone–based survey when cities and towns are under quarantine." Infection Control & Hospital Epidemiology 41.7 (2020): 826-830.

[17] Pantanowitz, Liron, et al. "An artificial intelligence algorithm for prostate cancer diagnosis in whole slide images of core needle biopsies: a blinded clinical validation and deployment study." The Lancet Digital Health 2.8 (2020): e407-e416.

[18] Mokmin, Nur Azlina Mohamed. "The effectiveness of a personalized virtual fitness trainer in teaching physical education by applying the artificial intelligent algorithm." International Journal of Human Movement and Sports Sciences 8.5 (2020): 258-264.

[19] Rao, Arni SR Srinivasa, and Jose A. Vazquez. "Identification of COVID-19 can be quicker through artificial intelligence framework using a mobile phone–based survey when cities and towns are under quarantine." Infection Control & Hospital Epidemiology 41.7 (2020): 826-830.

[20] Hashimoto, Rintaro, et al. "Artificial intelligence using convolutional neural networks for real-time detection of early esophageal neoplasia in Barrett's esophagus (with video)." Gastrointestinal endoscopy 91.6 (2020): 1264-1271.

[21] Lv Z, Qiao L. Deep belief network and linear perceptron based cognitive computing for collaborative robots. Applied Soft Computing. 2020 Apr 20:106300.

[22] Qiao, Liang, Yujie Li, Dongliang Chen, Seiichi Serikawa, Mohsen Guizani, and Zhihan Lv. "A survey on 5G/6G, AI, and Robotics." Computers & Electrical Engineering 95 (2021): 107372.