



Robot Collaborative Interactive Artistic Design for Digital Art Using Embedded Systems

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Abstract. At present, the computer is in the stage of rapid growth, and designers can make full use of high technology to visualize their inspiration. Due to the high growth of embedded system and the emergence of intelligent theory and microprocessor, robot technology has gained greater development opportunities. This text mainly studies the application of embedded system in robot vision, constructs a robot fuzzy control system combined with deep learning (DL), and applies it to robot-based collaborative interactive artistic design to realize intelligent innovation of collaborative interactive artistic design based on intelligent robot aided decision. The results of robot simulation show that the proposed collaborative interactive artistic design method for robots is flexible in design, fast and accurate in modeling and strong in real-time simulation, which provides reliable guidance for the innovation of artistic design mode based on artificial intelligence (AI). On this basis, the extended application of AI in artistic design is discussed. Compared with the traditional artistic creation, it has high working speed, completes the creation quickly, and can also carry out batch production with the help of molds.

Keywords: Embedded system; Robots; Collaborative interaction; Artistic design for Digital; Artificial intelligence energy

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1 INTRODUCTION

Human beings are inseparable from the influence of art in social life, and art is an important part of human spiritual life. Artistic design can add color to people's lives, create a beautiful living environment and bring warmth and comfort to the tense modern life [2]. On the basis of people's increasing demand for artistic design personality, designers can no longer design various products solely by their own opinions, they need to combine AI, art and people's needs [9]. The involvement of AI in the field of artistic design is increasing, especially with the rapid growth of AI, artistic design

can be presented to people in various forms [6]. Artistic design is the focus of AI's attention, and analyzing the application of AI in the field of artistic design can help people grasp the development direction of AI more accurately [7]. With the continuous improvement of people's requirements for their own working conditions, robot technology came into being [13]. As the product of the growth of science and technology in modern life, intelligent robots based on AI help people in many aspects of life. In artistic design, the auxiliary analysis of intelligent robots can help designers to better integrate their design inspiration and ideas into works of art [10].

In the history of mankind's continuous exploration, understanding and transformation of nature, machinery and automation have always been one of the technologies that people are constantly exploring [15]. The artistic design completed by AI can effectively convey the design intention that designers want to express and truly show the connotation of artistic works [26]. On the other hand, AI is also entering the perceptual art field of human beings, striving to make art intelligent [20]. Control system is the soul of robot and the core field of robot technology research, which includes not only the control technology of robot motion joints, but also complex technologies such as trajectory planning, machine vision and multi-information fusion [3]. Application-centered embedded system has penetrated into all aspects of life. Compared with other fields, intelligent robot system can be said to be one of the most typical and widely used fields of embedded system [1]. Robot technology is closely related to the growth of embedded system. Early robots used numerical control technology, and its development has been very slow [19]. In recent years, due to the high growth of embedded system and the emergence of intelligent theory and microprocessor, robot technology has gained greater development opportunities. Robot Collaborative Interactive Artistic Design system for the realm of Digital Art, leveraging the capabilities of Embedded Systems. The proposed system aims to bring together the realms of robotics, interactivity, and artistic expression to create innovative and dynamic digital art installations. By integrating embedded systems into the design, the collaborative robots will possess enhanced computational power and intelligence, enabling them to interact with artists and audiences in real-time, fostering a symbiotic relationship between humans and machines

Because the sensor system of intelligent robot is becoming more and more complex, so at this stage, the control system design of intelligent robot has to consider a variety of sensor data information for fusion [11]. Lins et al. [12] pointed out that in the control system of intelligent robot, the sensor system is used to sense and measure external environmental information, which is equivalent to human eyes. Xu et al. [24] believe that whether an intelligent robot control system can make correct decision-making behavior according to the actual situation mainly depends on whether the data obtained by the sensor system is true and effective, and the speed at which the sensor obtains external information is also closely related to the performance of the intelligent robot control system. The growth of AI, parallel processing and neural network has promoted the practicality of robot vision system [18]. In this environment, the research of robot vision has gone through the development stage from laboratory to practical application. This text mainly studies the application of embedded system in robot vision, constructs a robot fuzzy control system combined with DL, and applies it to collaborative interactive artistic design based on robot. The control system inputs the data information collected by sensors into the fuzzy controller for data processing, and generates the optimization strategy of artistic design through the color and modeling database in the computer network, which makes the works more novel, and then realizes the intelligent innovation of collaborative interactive artistic design based on intelligent robot-aided decision-making, and promotes the growth of artistic thinking.

2 APPLICATION OF AI TECHNOLOGY AND INTELLIGENT ROBOT IN ARTISTIC DESIGN

With the continuous improvement of people's aesthetic concept, the personalized requirements for artistic design are constantly changing, so as a designer, we can't meet people's aesthetic

requirements through our own efforts, so we should constantly promote the growth of technology to better and meet the diversified requirements [22]. Artistic designers' feelings and views on the world and human social life need some technical means if they want to fully show them in their works. AI plays an important role in artistic design for designers. According to the characteristics and functions of AI, designers find specific ways to use AI to express their works in artistic design, so as to better present artistic design works [4]. Figure 1 shows the concept of artistic design mode based on virtual reality.



Figure 1: Artistic Design Mode Based on Virtual Reality.

AI plays an important role in many fields, and also has a far-reaching impact on artistic design, prompting more forms of artistic design products to be re-created. For art, creativity makes the tree of artistic life evergreen, and people's creativity is the support of artistic brilliance, which injects vitality and vitality into artistic development. The effective application of AI technology in artistic design can not only greatly reduce the work pressure of designers, but also greatly shorten their working hours and promote the development and progress of art education [21]. The technical application of AI has been universally recognized, and at the same time, the application scenarios of AI are no longer limited. The forms of artistic expression are diverse and closely related to the growth of the times. Although its forms are constantly changing, its essence will not change [23]. As far as works of art are concerned, they are closely related to human subjective thoughts, both in terms of creation and appreciation in the later period.

AI can analyze a large amount of data in a short time, but it can't analyze human thoughts. In this way, it can be explained that AI can't judge and grasp emotions, which makes AI unable to present what people are concerned about in the art field, and it is difficult to create works with strong shock [5]. Through the experience and communication in the virtual environment, the design concept expressed in the design works can be effectively conveyed, and artists can use this technology to show their works more truly, so that people can be personally present and appreciate the details of art more intuitively. AI gradually moves from rational thinking to perceptual thinking, and then forms a sound system, establishes green and innovative ideas, and constantly promotes the development and progress of art and design industry.

3 ROBOT FUZZY CONTROL SYSTEM BASED ON DL

The design of fuzzy control rules is based on the relationship between the input and output of the controller, that is, the relationship between the distance between intelligent robot and obstacles, the angle information of intelligent robot and the left and right wheels output by intelligent robot [14]. The design of fuzzy rule base is mainly based on expert experience and practical experience to design fuzzy control rules, including the design of control variables and the design of rule number. As shown in Figure 2, the robot is an open control system [17]. The design of fuzzy controller parameter library mainly includes transforming the input into the universe corresponding to the input after fuzzification. After fuzzy synthesis operation, these multi-inputs can get a numerical value to express the comprehensive satisfaction degree of multi-input rules, which is then used in the output function. The input object of fuzzy synthesis operation is the membership value of two or more fuzzy input variables, and the input is a unique numerical value.

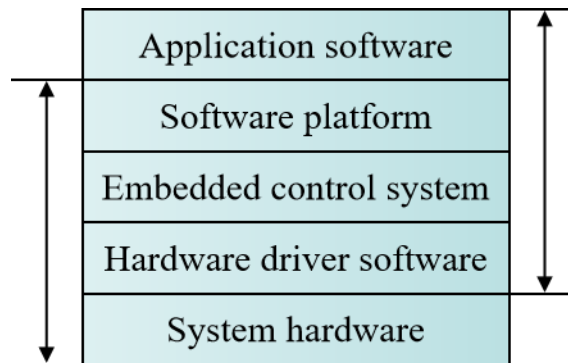


Figure 2: Open Control System Architecture of Robot.

In the growth of intelligent robot control system, due to the continuous growth of scientific power, the sensor system of intelligent robot has become increasingly complex. The sensor system of intelligent robot has changed from a single sensor in the past to an intelligent robot carrying a variety of sensor information.

Multi-sensor information fusion of robot is to comprehensively process information from multiple sensors or multiple sources, thus forming accurate and reliable conclusions. It can be said that multi-sensor information fusion is a common basic function in human beings and other biological systems [8]. Generally speaking, fuzzifying the input of practical problems is the first step to establish a fuzzy reasoning system, that is, selecting the input variables of the system and determining that these inputs belong to appropriate fuzzy sets according to their corresponding membership functions [16]. Fuzzy controller parameter base and fuzzy control rule base are important parts of knowledge base design. The main function of fuzzy controller parameter library is to provide suitable membership function, quantization factor and fuzzy set division for control system. Generally speaking, using a single sensor can't guarantee the accuracy and reliability of the input signal, and it may even cause the intelligent robot system to obtain the wrong environmental information, and then make the system decision-making mistakes.

Assuming that the input and output functions of artistic image feature information are expressed as R and R' respectively, the bilateral filtering discrete form expression of artistic image feature information is as follows:

$$R' = [k, j] = \sum_{m=-p}^p \sum_{n=-p}^p B[m, n, k, j] R[k - m, j - n] \quad (1)$$

Where p represents a pixel of artistic image feature information; m represents the variance of artistic image feature information; n represents the standard deviation of artistic image feature information; $B[m, n, k, j]$ represents Gaussian kernel function of artistic image feature information, and its calculation expression is as follows:

$$B[m, n, k, j] = \frac{\exp\left(-\frac{m^2+n^2}{2\sigma_\delta^2} - \frac{R[k-m, j-n]}{2\sigma_\xi^2}\right)}{R(k, j)} \quad (2)$$

Where σ represents the scale parameter of artistic image feature information.

Multi-sensors can give full play to the advantages of each sensor and provide complete information for system decision-making. Multi-sensor information has the characteristics of information redundancy, information complementarity, real-time and low cost, but the diversification of information brings difficulties to the reliability and real-time of information transmission and processing [25]. Therefore, it is necessary to design an appropriate information fusion method to synthesize a valuable understanding of the environment from the various measurement characteristics of multi-sensor information. The deep learning model of robot fuzzy control system is shown in Figure 3. In the actual operation of intelligent robots, there are few obstacles in front of them. Generally speaking, the side of intelligent robots meets obstacles. Therefore, in the actual robot movement, it is often necessary to measure the distance between the intelligent robot and the side obstacles.

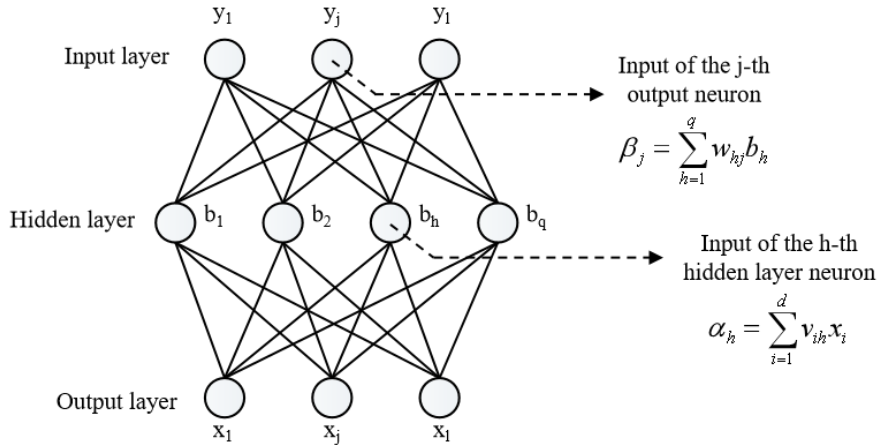


Figure 3: DL Model of Robot Fuzzy Control System.

Let X_i^k represent the sum of inputs of neurons i in k layer, and Y_i^k is the output. The weights of neurons j in the Y_i^k layer to i in the k layer are W_{ij} , so there is the following functional relationship:

$$Y_i^k = f(X_i^k) \quad (3)$$

$$X_i^k = \sum_{j=1}^{n+1} W_{ij} Y_j^{k-1} \quad (4)$$

Generally, f is an asymmetric Sigmoid function:

$$f(x_i^k) = \frac{1}{1 + \exp(-x_i^k)} \quad (5)$$

If the output layer is the m layer, the actual output of the i neuron in the output layer is Y_i^m . Let the corresponding visual signal be Y_i , and define the error function e as:

$$e = \frac{1}{2} \sum_i (Y_i^m - Y_i)^2 \quad (6)$$

When the inputs have been fuzzified, we can know the degree to which these inputs meet the corresponding fuzzy reasoning rules. However, if the condition of a given fuzzy rule is not a single input, but multiple inputs, it is necessary to comprehensively consider and analyze these multiple inputs by using fuzzy synthesis operation.

4 COLLABORATIVE INTERACTIVE ARTISTIC DESIGN BASED ON EMBEDDED ROBOT

The output of fuzzy controller is a fuzzy set, which contains all kinds of information of control quantity, but the controlled object can only accept an accurate control quantity. The data obtained by the sensor system of intelligent robot needs effective information fusion, and extracting the most effective data from the environment can reduce the complexity of the control system of intelligent robot and improve the real-time obstacle avoidance ability of the control system of intelligent robot. If the confidence of correlation matching is high, the template can be updated according to the image at the matching point of this frame image; If the confidence is low, it means that the matching is unstable, and the previous matching template should be used to match the the next frame. The vision optimization logic of intelligent robot is shown in Figure 4.

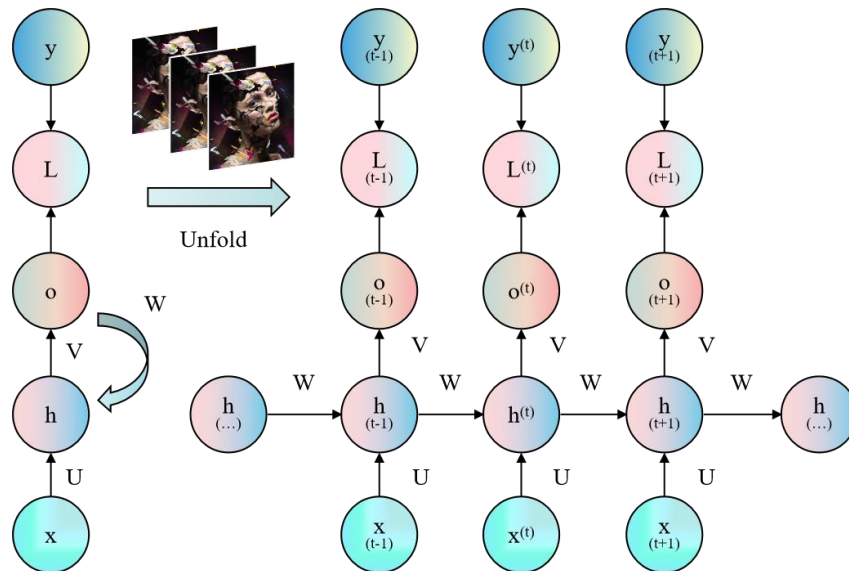


Figure 4: Visual Optimization Logic of Intelligent Robot.

In order to make effective use of sensor information, it is necessary to synthesize and fuse sensor information in some form, and adopt various processing methods for different types of information. Fuzzy control technology describes the relationship between system variables through fuzzy control rules. In the design process of fuzzy controller, if the original data collected by all sensors are directly used as the input of fuzzy controller, the input variables of fuzzy controller will increase greatly, so the fuzzy control rules will increase relatively, and the complexity of fuzzy controller will also

increase, thus affecting the real-time performance of robot control system. Template updating is one of the important problems to be solved in target tracking. If the template is updated too fast or too slowly, the tracked target may be lost.

Let the eigenvector of sample x_i be expressed as $(a_{i1}, a_{i2}, a_{i3}, \dots, a_{im})$. Then, the expectation and variance of each attribute in all sample points X are calculated respectively:

$$avg(X(a_i)) = \frac{1}{g_i} \sum_{j=1}^{g_i} a_{ji} \quad i = 1, 2, \dots, m \quad (7)$$

$$std(X(a_i)) = \sqrt{\frac{1}{g_i-1} \sum_{j=1}^{g_i} (x_i(a_i) - avg(X(a_i)))^2} \quad i = 1, 2, \dots, m \quad (8)$$

Where $x_i(a_i)$ is the value of sample j on the a_i attribute. The formula will be dimensionless:

$$x_j(a_i) = \frac{x_i(a_i) - avg(X(a_i))}{std(X(a_i))} \quad (9)$$

The data obeys the normal distribution of $N(0,1)$, and the dimensions between attributes are removed.

The input of fuzzy implication calculation process is a single numerical value, that is, fuzzy set, which is obtained by the synthesis operation of the previous input fuzzy sets, and the output is a conclusion fuzzy set deduced according to fuzzy rules. When the deviation is large, select the control quantity to quickly eliminate the deviation; When the deviation is small, the stability of the system should be the main consideration. Output synthesis is the process of synthesizing the fuzzy sets of all fuzzy rule outputs. For each output variable, the synthesis is only performed once. Finally, only one fuzzy output set is obtained for each output variable.

5 SYSTEM EXPERIMENT AND TEST

If you want to create, suspend, resume, change priority and delete tasks, you need to use task control blocks to achieve it. The task scheduling program will be executed at regular intervals, but the specific time depends on the user's setting of clock interrupt. The control system inputs the data information collected by sensors into the fuzzy controller for data processing, and generates the optimization strategy of artistic design through the color and modeling database in the computer network, which makes the works more novel, and then realizes the intelligent innovation of collaborative interactive artistic design based on intelligent robot-aided decision-making, and promotes the growth of artistic thinking. In order to verify the effectiveness of the proposed artistic image detection model based on fuzzy control algorithm, the traditional artistic image detection methods are compared by comparative simulation experiments. The detection effect of the operator is evaluated by the number and accuracy of edge pixels, as shown in Table 1. Misjudging points in the table means judging non-edge points as edge points.

	Original image	Robert	Sobel	Prewitt	LOG
<i>Edge points</i>	850	788	659	627	599
<i>Detection ratio</i>	-	86.8%	84.7%	79.7%	85.5%
<i>Misjudgment point</i>	-	None	Basically none	None	Basically none

Table 1: Comparison of Detection Effects Without Noise.

Most of the artistic images processed by robots are images polluted by noise, even if they are smoothed and denoised before processing. Table 2 shows the comparison results of detection effects when Gaussian noise is added.

	Original image	Robert	Sobel	Prewitt	LOG
<i>Edge points</i>	850	776	669	651	575
<i>Detection ratio</i>	-	79.4%	84.6%	75.5%	82.6%
<i>Misjudgment point</i>	-	Basically none	Have	Have	Basically none

Table 2: Comparison of Detection Effects When Gaussian Noise is Added.

In the simulation environment, the collected artistic image data are simulated by changing parameters continuously, and the simulation effect diagram is shown in Figure 5.

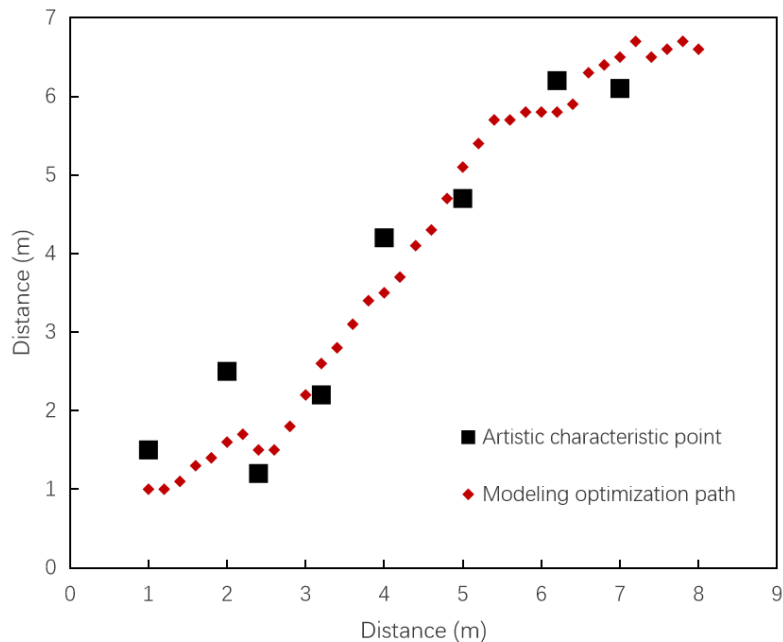


Figure 5: Simulation Results of Fuzzy Control of Intelligent Robot.

As can be seen from the above figure, the intelligent robot can realize the artistic design optimization function by using fuzzy control algorithm in the environment shown in the above figure, and achieve the expected effect. Because the environmental information of the robot is uncertain and nonlinear, and a single sensor has a certain degree of measurement error, the multi-sensor information fusion technology based on fuzzy control is adopted in the research of robot artistic image information processing in this subject. The comparison of search efficiency of robot vision optimization algorithm is shown in Figure 6.

Taking the recognition accuracy of artistic images as the test index, the particle swarm optimization (PSO) algorithm is selected as the comparison object, and the experimental results are shown in Table 3 and Table 4.

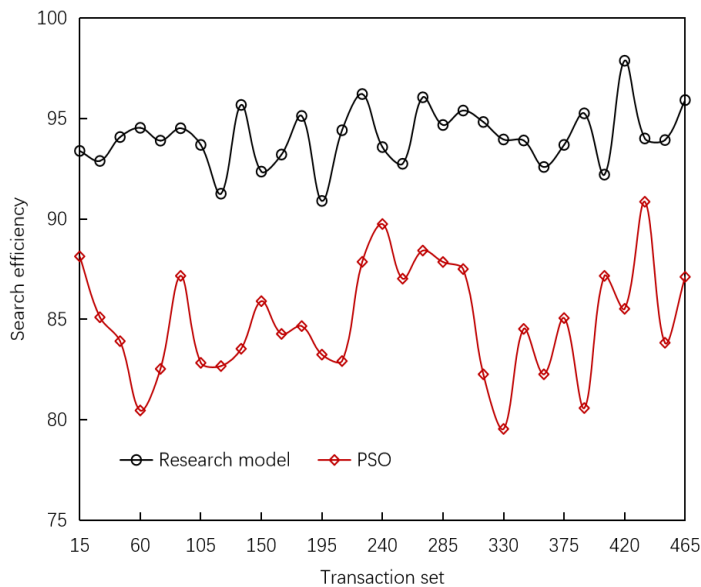


Figure 6: Comparison of Search Efficiency of the Algorithm.

Sample size	Image recognition accuracy (%)
15	99.15
30	98.84
45	98.17
60	97.46
75	97.45
90	97.38
105	97.32

Table 3: Image Recognition Accuracy of This Method.

Sample size	Image recognition accuracy (%)
15	97.89
30	96.54
45	95.48
60	94.32
75	93.17
90	92.98
105	92.75

Table 4: Image Recognition Accuracy of Pso Algorithm.

According to the test data, when the quantity of test samples began to increase, the accuracy of artistic image recognition of each method showed a downward trend. Extracting feature similarity between different artistic features further strengthens the feature resolution ability of multi-modal fusion of artistic images.

6 THE EXTENDED APPLICATION OF AI IN ARTISTIC DESIGN

AI can provide data support and technical support for artistic design. Nowadays, the artistic design of AI can't completely get rid of people's thoughts, and the artistic design broadens its coverage through AI, thus raising the artistic design to a brand-new level. Artistic design should be innovative, so artistic designers should constantly learn, consolidate the professional knowledge of artistic design, supplement the knowledge of other disciplines, combine AI with artistic design, and constantly innovate artistic design. The influence of AI in artistic design is expanding.

AI helps designers save design time, improve design efficiency and reduce work pressure, so that designers can devote more time and energy to the exploration of inspiration and the study of artistic design, which is of milestone significance to the growth of artistic design. As far as the creation of artistic products is concerned, people need to watch them later after they are created, and these are based on human subjective intentions. AI filters massive data through certain methods to provide data support for artistic design, which is a technical tool lacking human emotions and thoughts. No matter how AI develops, it can't design all the judgments and ideas of human beings, which is also the embodiment that the most perfect products can't be presented in product artistic design. Moreover, for the field of artistic design, how to effectively reflect human thoughts and emotions in design with AI is also the main trend of this technology research and development in the future.

7 CONCLUSION

In the history of mankind's continuous exploration, understanding and transformation of nature, machinery and automation have always been one of the technologies that people are constantly exploring. People's aesthetics is not born, but accumulated in the later period. Therefore, in the field of artistic design, it is necessary to effectively integrate AI with it, and then provide a more comprehensive impetus for the growth of various industries. The artistic design completed by AI can effectively convey the design intention that designers want to express and truly show the connotation of artistic works.

This text mainly studies the application of embedded system in robot vision, constructs a robot fuzzy control system combined with DL, realizes intelligent innovation of collaborative interactive artistic design based on intelligent robot aided decision-making, and promotes the growth of artistic thinking. The test results show that the robot embedded control system can realize the recognition and optimization of artistic images well, has high working speed, can assist designers to finish their creation quickly, and can also carry out batch production with the help of molds. In the future research, sensors with higher precision, faster response and more stable performance can be selected in the choice of hardware, and chips with faster processing ability and stronger processing ability can be selected in the choice of processor.

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