Design of Cerebral Palsy Rehabilitation Training System Based on Human-Computer Interaction

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Abstract: With the development of computer science and technology, human-computer interaction technology, as an important branch of computer science and technology, is also widely used in rehabilitation medicine. Therefore, in order to improve the effect of cerebral palsy rehabilitation and promote the application of human-computer interaction technology in the field of cerebral palsy rehabilitation, it is of great significance to study the key technology of human-computer interaction for robot assisted cerebral palsy rehabilitation training system. In this paper, according to the symptoms of spastic cerebral palsy children's language disorders and poor limb motor ability, based on human-computer interaction technology of speech recognition and action recognition, respectively, designed a robot assisted cerebral palsy rehabilitation training system, the system action recognition rate can reach more than 96% success rate, to meet the daily needs.

Key words: Cerebral Palsy Rehabilitation, Human-computer Interaction, Action Recognition, speech recognition

1. Introduction

Human computer interaction technology, that is, the interaction mode between human and robot, is an important part of modern computer science. It involves a wide range of subject knowledge, and the technical system is very complex. It plays an important role in the interaction between users and robots. Human computer interaction technology is also widely used in various fields, such as human-computer interaction technology. In the rehabilitation training of cerebral palsy, language training and action training are two important parts. After the emergence of human-computer interaction technology, its powerful language recognition function and action recognition function provide a new idea for the rehabilitation training of cerebral palsy. To improve the technical level of cerebral palsy rehabilitation training system through human-computer interaction technology related to voice and action, combined with the assistance of rehabilitation robot, provides a new idea for cerebral palsy rehabilitation training [2]. Based on the speech recognition and action recognition technology of human-computer interaction, a robot assisted rehabilitation training system for cerebral palsy is designed. Through the intelligent assistance of the training process, the burden of the rehabilitation teacher is reduced, the whole rehabilitation process is simplified, and the patients are motivated to participate in the training actively in an interactive way, so as to enhance the ability of communication and object recognition, and improve the limb function, hand and eye function Coordination and cognitive level, improve their quality of life [3].

In the 1950s, speech recognition technology developed rapidly, and the bell research center of Germany developed Audry system based on this technology. The system can recognize 10 English numbers at a time, which plays an important reference role for the research of recognition technology in the world. Speech recognition technology is mainly supported by the central processing unit and language recognition system of the computer. By transforming human language into text information or

control instructions that can be recognized by the computer, the computer system can interact and communicate with people [4]. Although there are many difficulties in the development of speech recognition technology, its ultimate goal is to develop a machine that can interact with any language intelligently. China's speech recognition technology began to study in 1958, but the development is very slow. Until 1973, the Institute of acoustics of Chinese Academy of Sciences officially began to study computer speech recognition. After entering the 1980s, computer technology has developed rapidly in China, and digital signal technology is also developing. With the support of computer and digital signal technology, speech recognition technology has developed rapidly in China, and has rapidly become a hot topic in the field of computer research, creating conditions for the development of speech recognition. In recent years, with the rapid development of speech recognition technology, it has become the main human-computer interaction technology. The speech recognition function of smart phones, the artificial intelligence of robots, even the Internet to find information can also use voice input. Microsoft researchers Frank seide, Li Gang and Yu Dong use the deep neural network model to build the model. After using this technology, the relative error rate of speech recognition is reduced by 30%. Kinect, a new generation of somatosensory data acquisition device, is a depth camera based on depth image [5]. The depth image can be understood as the spatial distance coordinate set between the acquisition device and each point of the object to be recognized. Therefore, the depth image recognition function has the 3D dynamic scanning function. Compared with the color image, the image recognition depth of the device is very high, and the robustness is strong. The change of environment brightness and background color has no influence on the recognition quality. In addition, in the aspect of recognizing depth image, it can automatically recognize the distance difference between different objects, and synthesize a fuller gray image after hierarchical processing of the gray value of the image, so that it has the anti occlusion recognition function to a certain extent [6].

In this paper, speech recognition technology and speech recognition technology are applied to the rehabilitation of children with cerebral palsy.

2. Related Concepts

2.1 Basic Model of Human Computer Interaction System

In fact, human-computer interaction system is a system to realize the interaction between human and robot by different means of interaction. On the whole, the human-computer interaction system is mainly composed of four parts, namely: identification object, interactive identification equipment, system main body and robot system. In the aspect of the interaction setting of the recognition object, the information of the interaction mode of the recognition object is mainly input through the interaction recognition device. The input information needs to be processed through data to be recognized by the system, and then the follow-up tasks are completed according to the specific program design of the system. The system will build a communication mechanism with the robot system, and output relevant information to the user after execution, so as to realize the interaction between human and robot [7].

In this paper, the human-computer interaction system is a system based on human-computer interaction technology to realize the interaction between human and robot. The key technologies are speech recognition technology and action recognition technology in human-computer interaction. This system takes the auxiliary robot system as the output feedback system, and conceives a human-computer interaction system model. The framework includes recognition object, recognition processing module, execution module and robot assistant system. Recognition processing module, the module is mainly used to process the recognition information of the object, according to the different

ways of interaction, the object's voice information or action information is converted into digital information that can be directly processed; execution module, the module is mainly used to provide the hardware and software platform needed for the recognition processing module; robot auxiliary system, the module is the recognition information given by the execution module The results are fed back to the object through robot assisted expression, and the user can judge whether it meets the requirements according to the results feedback. The development goal of human-computer interaction system is to enable human and robot to communicate and interact with each other. In the system model, recognition processing module is the key, including speech recognition processing module and action recognition processing module. Aiming at the speech recognition technology and action recognition technology in human-computer interaction technology, according to the human-computer interaction system model, two kinds of interaction systems are designed respectively: robot assisted cerebral palsy rehabilitation training system based on speech interaction and robot assisted cerebral palsy rehabilitation training system based on action interaction. They have different recognition processing module and execution module, but through the same way Robot assisted system to express and feedback results [8].

2.2 Robot Assistant System

In the human-computer interaction system, the robot auxiliary system is needed as the output feedback system to feedback the recognition results and realize the interaction between human and robot. Bionic robot hand is a kind of robot system which can make a variety of gestures with the same motion characteristics as human hand. It mainly realizes the control purpose through the internal control chip. In the aspect of controlling the bionic robot hand to complete the corresponding gesture action, it mainly depends on the control chip and the steering gear connected with five fingers. The five steering gears in the bionic robot hand are actually a driving device based on angle control, which can realize the position transformation according to different control requirements, or always maintain the same motion law, and the maximum rotation angle is 180 degrees. The steering gear is controlled by power interface, ground interface and PWM (pulse width modulation) interface. The PWM interface is the main transmission line of the angle control signal. The frequency and time of the transmitted signal pulse depend on the control angle. The control mechanism is pulse code modulation, and the width of the pulse will determine the steering angle [9].

2.3 Geometric Matching Recognition

Geometric matching method mainly obtains the three-dimensional coordinate position information of one or more joint points in space through Kinect's bone tracking, calculates the distance or angle information between the feature joint points according to the action features to be recognized, and quickly identifies and matches by comparing with the threshold value. People face Kinect, right is X-axis positive direction, upward is Y-axis positive direction, backward is z-axis positive direction [10].

$$\mathrm{d}_{AB} = \sqrt{\left(x_1 - x_2\right)^2 + \left(y_1 - y_2\right)^2 + \left(z_1 - z_2\right)^2} \qquad (1)$$

When calculating the angle characteristics of multiple joint points, the space vector method can be used to calculate the running angle of the joint. In terms of the use of vectors, the coordinates corresponding to Kinect need to be mapped on the mathematical coordinate system. The conversion formula is as follows:

$$\overrightarrow{AB} = \left(x_2 - x_1, y_2 - y_1, z_1 - z_2\right) \qquad (2)$$

With the transformation formula, to calculate the angle of the joint point, take the elbow joint point as an example, you can directly calculate the angle of the space vector, such as the formula

$$\overrightarrow{ES} = (Sx - Ex, Sy - Ey, Ez - Sz) \quad (3)$$

$$\overrightarrow{EH} = (Hx - Ex, Hy - Ey, Ez - Hz) \quad (4)$$

$$\theta = \arccos \frac{\overrightarrow{ES} \bullet \overrightarrow{EH}}{\left|\overrightarrow{ES}\right|\left|\overrightarrow{EH}\right|} \quad (5)$$

According to the above joint point distance formula and angle formula, the three-dimensional position coordinate information of shoulder joint point shoulder, elbow joint point elbow, hand joint point hand, knee joint point knee and foot joint point is obtained through Kinect bone tracking.

3. The Design of Intelligent Analysis in Human-computer Interaction

3.1 System Programming

System programming is divided into interactive interface and system program flow. The interactive interface is a graphical user interface designed with C #. The form library inherits ccskinmain in cskin and is mainly divided into three areas. The top left shows the bone image captured in real time, the top right shows the training image of five actions, and the bottom is the button control and recognition result display area. The bottom status bar shows the startup time and Kinect connection information. In the program flow, use the serial class in C # System.IO.Ports . serialport to control the serial port of the computer task manager, and communicate with the robot assistant system through the serial port, so as to realize the purpose of the robot's thumbs up action feedback when the action is recognized.

3.2 Action Recognition Method

Based on Kinect, the main methods of action recognition are as follows: statistical recognition, vector machine recognition, template recognition, neural network and so on.

3.3 Vector Machine Recognition Method

Corinna Cortes and Vapnik are the proponents of support vector machine (SVM). They pointed out in 1995 that SVM has a good effect on the classification and recognition of a small number of samples and nonlinear actions. They introduce SVM into function fitting and machine learning in the following research. Support vector machine classification mainly takes VC theory as the core, and risk minimization criterion has the ability to restrict it. In essence, SVM is a machine learning method with the function of supervision. In order to construct two kinds of linear classification model, we need to use the SVM algorithm to classify two different types of samples. After the linear classification model is built, new instances need to be introduced into the model. The classifier defines the two classes of related samples as linear classifiers.

3.4 Neural Network Method

Human neural system is very complex, which contains a large number of neurons, and there are many similarities between neural network and human system. Different neurons mainly refer to weight value in connection. Neural network has strong learning ability and self-organization ability, which is very suitable for large-scale data. It has high robustness and noise resistance in mathematical operation.

BP (back propagation) neural network and convolution neural network are mainly used in action recognition. The former is based on feedforward neural network, including input layer, hidden layer and output layer. In the aspect of action recognition, a large number of feature data must be collected first, and the weights of different layers can reach the connected state through input layer training. The input samples can map different neuron states through the operation of different weights, and the classification can be obtained from the output layer training. If there is a big difference between the classification results and the expected results, the final goal can be achieved through network training. Convolutional neural network has many layers of neurons and many sets

It has become the convolution layer, pooling layer and connecting layer. In the process of action recognition, all network layers need the support of action features in order to obtain action data. Through the network training of action features, the recognition results can be obtained.

Through the understanding of the above action recognition methods, we need to classify and recognize five limb actions, extract the feature information from the bone point information obtained by Kinect, and use BP neural network to realize action recognition.

4. Test and Analysis

4.1 System Test

Table 1. Action Test Results

Action name	Discrimination
Flat arms	84%
Lift the arm	86%
Arms crossed	76%
Left leg lift	82%
Right leg lift	82%

It can be seen from the above table that the recognition rate of the five actions is not high, and the recognition effect is not ideal. Using geometric matching action recognition method requires that the tester is facing Kinect, the direction can't be changed, the constraint conditions can't be adjusted automatically, and the corresponding constraint conditions need to be designed for specific objects, which has limitations and the experimental effect is not good.

4.2 Feature Extraction

Table 2. Partial Distance Features Extracted From 5 Sets of Actions

Feature sequence	Flat arms	Lift the arm	Arms crossed	Left leg lift	Right leg lift
1	686.413	547.689	402.759	450.011	813.244
2	705.615	437.380	389.254	527.987	731.904
3	836.977	665.976	1363.499	426.261	566.978
4	826.098	753.416	1360.237	428.225	1081.695
5	1176.221	1085.643	1828.704	272.234	535.031
6	1275.940	1151.199	1775.458	295.509	528.305
7	68.720	276.456	248.454	795.486	989.989

Part of the distance feature information extracted from the five actions is shown in Table 2.

4.3 GA Optimized Neural Network

The number of test sample groups is 250, and the number of samples for each action is 50. The action data is collected from five different test objects. The test samples are selected to test the GA

optimized neural network, and the recognition rate of the optimized neural network is compared with that of the non optimized neural network, as shown in Figure 1

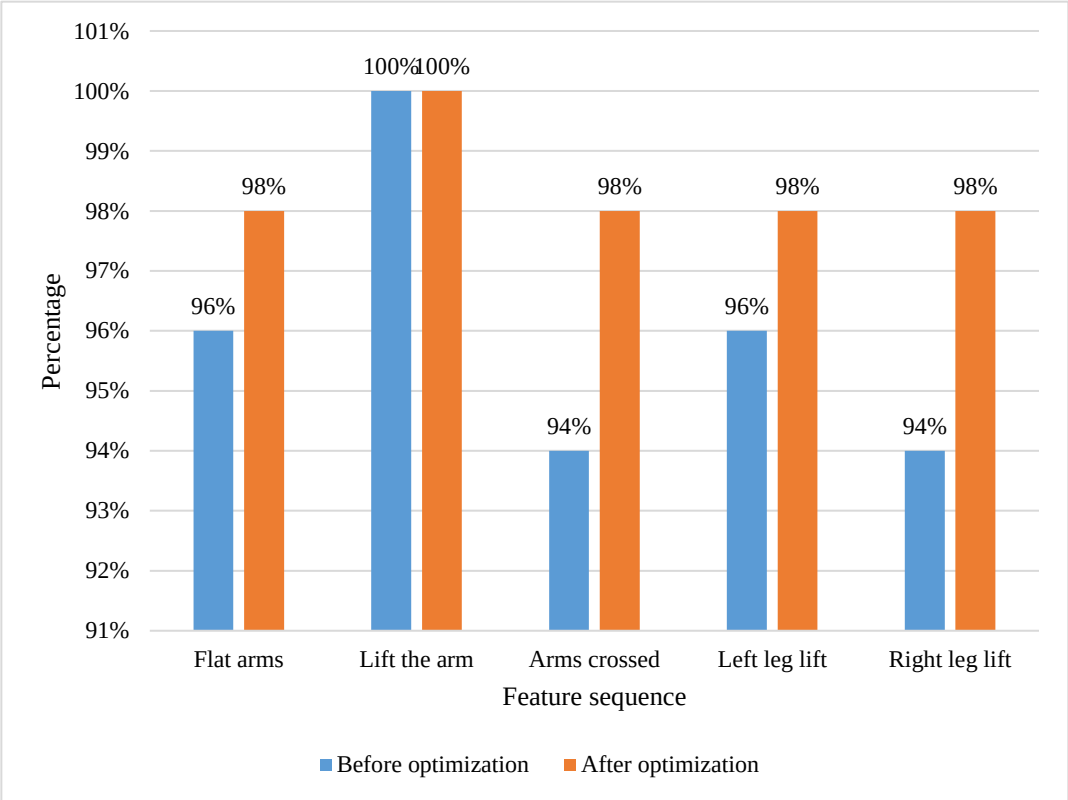

Figure 1. Comparison of Recognition Rates Before and After Optimization

4.4 Test Under Different Light Conditions

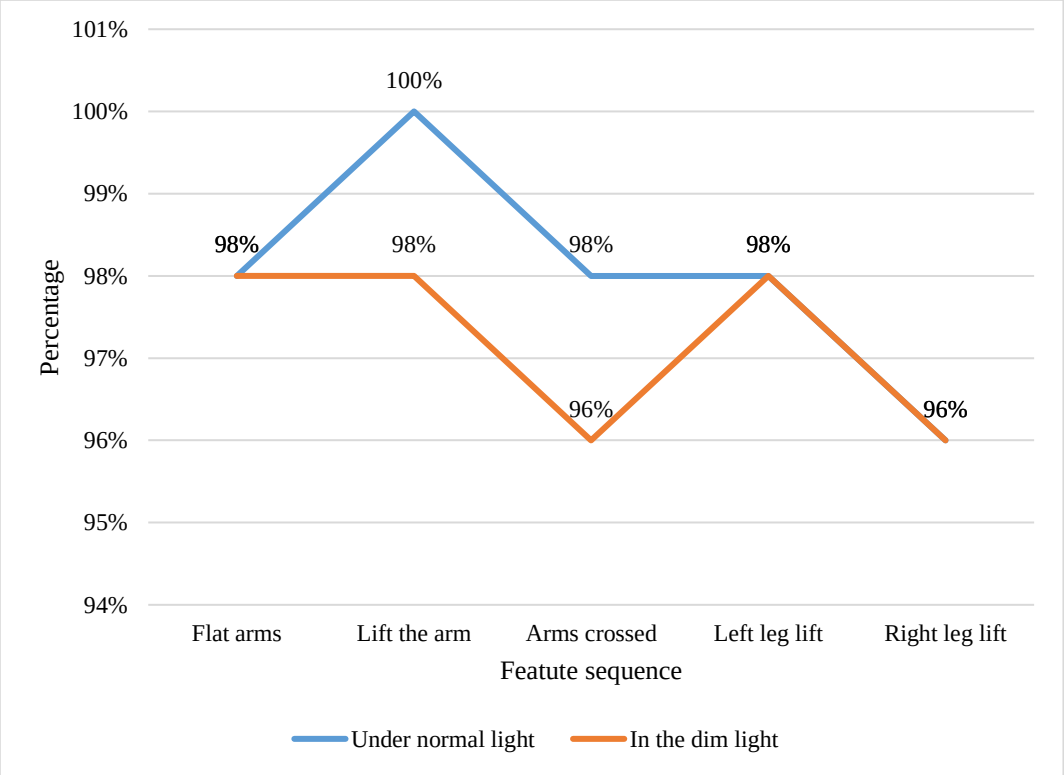

Figure 2. Recognition Rate Under Different Indoor Illumination

Because Kinect depth sensor uses infrared sensor, it can collect infrared spectrum to generate depth image and get bone information. When people appear in the sun, the sun is an infrared source, and the depth image collected by Kinect is inaccurate, so the system will lose its function in the direct sunlight environment. For the indoor rehabilitation movement training of cerebral palsy, the training is not affected by the sun, so it is not easy to be affected by the light conditions and complex background. As shown in Figure 2, the recognition rate of the indoor training system under different light conditions is compared. Five testers are tested with 10 groups of actions under normal light and partial dark light respectively.

In the figure, the change of recognition rate under partial dark light is not big compared with that under normal light, which also proves that different lighting environment will not affect the recognition rate of the system.

5. Conclusion

In this paper, aiming at the symptoms of spastic cerebral palsy children's language disorder and poor motor ability, we study the speech recognition and action recognition in human-computer interaction technology, and apply them to the rehabilitation training of cerebral palsy. We design the robot assisted cerebral palsy rehabilitation training system based on speech interaction and the robot assisted cerebral palsy rehabilitation training system based on action interaction, and compare their systems Performance analysis. In the robot assisted cerebral palsy rehabilitation training system based on action interaction, five kinds of limb actions are designed as action training schemes by applying action recognition, and the recognition results are fed back by the bionic robot hand system. Kinect is used to obtain bone information, and geometric matching is used to identify the action first. The result is poor and has limitations. Then the neural network is selected to optimize the action interaction system, and the Euclidean distance of 14 groups of bone points is selected as the action feature. Then the BP neural network and GA optimized neural network are selected to learn and train the action feature respectively. The recognition rate of the two neural networks is compared and analyzed, and the recognition effect of GA optimized neural network is better. Finally, the interaction interface of the system is designed, the influence of different lighting environment on the system is compared, and the training effect of the system is analyzed through specific cases.

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