Pieces Identification in the chess system of dual-robot coordination based on vision

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***Abstract*: With the research and development of chess robot and machine vision, chess robot with visual function has recently received an increasing interest in the community. This paper introduces the chess system of dual-robot coordination based on vision and the process of visual system structure, gives the coordinates translation from computer and image coordinates to actual coordinates. And in the process of pieces identification, it firstly gives the character segmentation method and training process based on BP neural network, and then identifies the pieces. All the work contributes to the chess system of dual-robot coordination based on vision .**

Keywords: coordinates translation; character segmentation; BP neural network

I. INTRODUCTION

There are two forms to be used in the identification of chessboard. One is to base on board as a sensor to identify pieces， the other is to base on the machine vision technology which uses video camera and image processing technology to identify the chessboard and pieces. With the development of machine vision, it has gradually replaced the board sensor model as a major one.

Machine vision has two types: monocular vision and binocular vision. When compared with each other, monocular vision is simpler, more convenient, and relies less on the hardware and software equipments; binocular vision algorithm is more complex, can achieve spatial orientation， but equipment requirements are much higher. Since the aim of this project is to achieve the coordinates location and pieces identification on the board plane, the monocular vision which is more affective and effective is chosen. In character recognition, the common methods are: neural network method[1], support vector machine method(SVM)[2], method based on wavelet transform[3] , and SIFT algorithm[4]. SVM algorithm is difficult to implement large-scale training samples[5~8]; SIFT algorithm has high mismatch; only neural network has strong ability of nonlinear fitting that can be mapped arbitrarily complex nonlinear relationship[9] and so it is chosen.

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This paper briefly introduces the chess system of dual-robot coordination based on vision, designs the translation algorithm from computer and image coordinates to actual coordinates, establishes a robot vision system that can identify pieces, all of which lay the foundation for the dual-robot coordinate chess system.

II. THE INTRODUCTION OF THE CHESS SYSTEM OF DUAL-ROBOT COORDINATION BASED ON VISION

The chess system of dual-robot coordination based on vision is a new research, which includes machine vision, computer control, dual-robot coordination movement, remote control, and some other cutting-edge technologies. It also emphasizes the functions of the system implementation and application of verification. The system design is shown in Figure1.

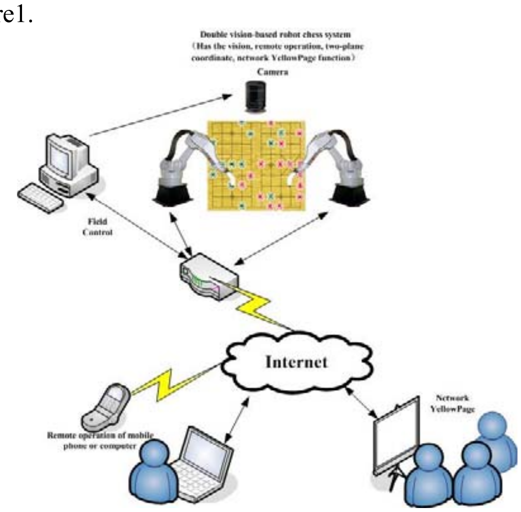

Figure1. the chess system of dual-robot coordination based on vision

In the system, pieces are identified by camera, and then the robot works according to the data transferred. Firstly DoubleRoboCol software is developed to ensure the coordination of the dual-robot in motion. Secondly, the service architecture of robot application is established to achieve the remote implementation of the system through network. Finally, a Web-based control system Web-Show is built to show the results of the project. Among these, pieces identification is one of the core functions of the system.

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III. Construction of Visual System

In the chess system of dual-robot coordination based on vision, the visual system is composed of a light source module, camera module and image processing platform module.

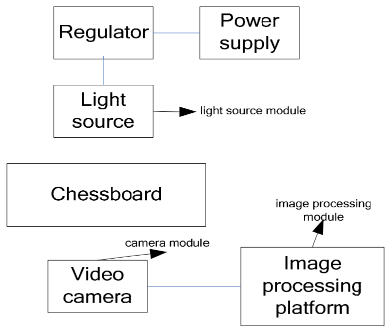

Figure2 The structure of visual system

In this system, the camera module is used to acquire the images; the light source is used to supply enough illumination for an ideal image; the image processing module is used to process the image in order to identify pieces.

The image is acquired by CMOS digital camera (DH-HV1303UM, with camera M0814-MP). The camera interface is USB and the length of the data transmission line is 4.5m. The camera should be put above the chessboard of which the distance from camera to the middle is 1m.

In the actual detection, the access to image capture is controlled by a program. After the robot completes one-step procedure of chess playing, it will send a control signal to the camera to capture an image. The image acquisition unit obtains the image through the camera USB, analyzes it using image processing algorithms, and identifies pieces according to the result and some relevant parameters.

IV. Coordinates Translation

A. Computer chessboard coordinates and actual chessboard coordinates

The computer controls the actual movement of the robot by the program, so firstly we should translate computer coordinates to actual coordinates.

Assume computer chessboard coordinates are (x', y'), and actual chessboard coordinates are (x, y), the relationship between (x', y') and (x, y) is as formula (1):

$$\begin{cases} x = \dfrac{x' - x_0'}{d'} * d \\ y = \dfrac{y' - y_0'}{d'} * d \end{cases} \tag{1}$$

In the chessboard, there are a total of 8×9 squares. In an actual board, the length of each square is d. In a computer chessboard, the length of each square is d'. The original coordinates in the computer chessboard are (x_0', y_0').

The original coordinates in the program are $(480,480)$, $d' = 80$, $d = 6cm$. The coordinates of any point are $(560,800)$, under the formula (1), the actual coordinates of the point are $(6,24)$.

B. Image coordinates and actual coordinates

There is a transformation between image coordinates and actual coordinates, so the coordinate mapping between them should be addressed.

According to the quadratic linear interpolation algorithm, the relationship between image coordinates (x', y') and actual coordinates (x, y) is as formula (2).

$$\begin{cases} x' = ax + by + cxy + d \\ y' = lx + my + nxy + r \end{cases} \tag{2}$$

In the image chessboard and the actual chessboard, the four vertices of the chessboard can be measured, so when put into formula (2), the variables can be determined.

V. Image Identification Processing

A. The overall identification processing

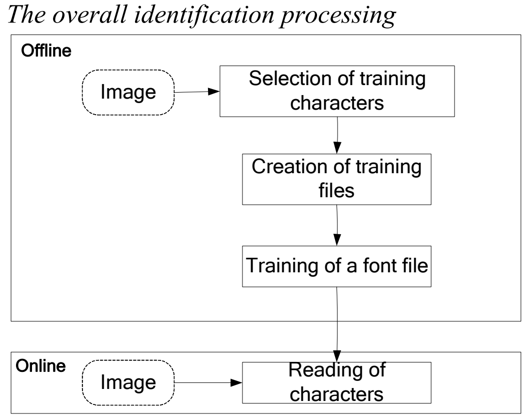

Figure3. pieces identification processing

The pieces identification process is shown in Figure3. The process can be divided into two parts: offline training and online identification. Offline training is the core of the whole processing. Before character training, the image needs to be pre-processed which includes gray-scale processing, segmentation, etc. Training samples use a training method based on neural network to generate the training documents. Eventually, pieces can be easily identified by the use of the training documents online.

B. Character segmentation

Character segmentation is the focus of pretreatment. The main steps of character segmentation are as follows:

Step1: Scan the image from top to bottom until the first black pixel point is encountered and recorded, and then scan the image from bottom to top until the first black pixel is encountered and recorded. Thus the image height range can be determined.

Step2: Use the first black pixel encountered by column scanning in the range of height determined in step1 as the starting point position of character segmentation, and continues to scan until there is no black pixel considered to be the end of the character segmentation, then repeat scanning to the far right of the image. Finally the accurate width of each character can be obtained, and record the width w.

Step3: With the known accurate width of each character, the accurate height of each character can be obtained by using the method in accordance with step1, and record the height h.

C. Extraction of character feature points

The text features include structural features and statistical features. Statistical features can be divided into global statistical characteristics and local statistical features according to the different regions of feature extraction. In this paper, the Moravec operator is used to extract feature points. The basic idea of the Moravec operator is, firstly, calculate the value of each pixel of interest, that is, the square of the level variance of the minimum gray in the four main squares of every direction; secondly, determine the candidate points, that is, to select the points whose value are bigger than the Que given; finally, compare the values in the candidate points to select the local maxima as characteristic points.

D. The training process based on BP network

The pattern vectors based on BP (Back Propagation) network input are:

$$A_k=(a_1,a_2,\cdots,a_m) \qquad k=1,2\cdots,m \tag{3}$$

The desired output vector:

$$Y_k=(y_1,y_2,\cdots,y_q) \tag{4}$$

The middle layer of each unit input:

$$S_j=\sum_{i=1}^{n} w_{i_j j} a_i-\theta_j \qquad j=1,2,\cdots,p \tag{5}$$

S_j is the independent variable for the S function, the S corresponds to the function:

$$f(x)=\frac{1}{1+e^{-\frac{x}{x_0}}} \tag{6}$$

Intermediate j cell's activation value b_j corresponding functions:

$$b_j=f(s_j) \tag{7}$$

Output of each unit of input layer, output layer is:

$$L_t=\sum_{j=1}^{n} v_{jt}\times b_j-\gamma_t \tag{8}$$

$$C_t=f(L_t) \qquad t=1,2,\cdots,q \tag{9}$$

Global error:

$$E_k=\sum_{j=1}^{k}(y_j^k-y_j)^2/2, j=1,2,\cdots,p \tag{10}$$

The correction of error in the output layer:

$$d_t^k=(y_t^k-c_t^k)f'(L_t), t=1,\cdots q; k=1,\cdots m \tag{11}$$

The correction of errors among the middle units:

$$e_j^k=\left[\sum_{t=1}^{q} y_{ji}\times d_t^k\right]f'(s_j), j=1,\cdots p, k=1,\cdots m \tag{12}$$

Adjust the volume:

$$\Delta v_{jt}=\eta\times d_t^k\times b_j^k \tag{13}$$

$$\Delta\gamma_t=\eta\times d_t^k \tag{14}$$

$$\Delta w_{ij}=a\times e_j^k\times a_i^k \tag{15}$$

$$\Delta\theta_j=a\times e_j^k \tag{16}$$

According to formulae (3) - (16), training process is given based on BP (Back Propagation) network. Before training, the variables and parameters should be set, and each weight matrix should be initialized:

Step1: Input the training samples.

Step2: For the input samples, prior to calculating each layer's BP neural network input signal and output signal.

Setp3: Errors are obtained based on actual output and expected output. Complete all the training samples to determine whether to go to the next step, or re-enter the training samples for training.

Step4: Calculate the global errors, if it has met the requirements, then go to the step7; otherwise go to step 5.

Step5: If the maximum number of iterations is reached, then signal that the network can not converge; otherwise calculate the local gradient of each neuron in reverse

Step6: Amend the value of each matrix according to the local gradient, update learning parameters, and go to Step1.

Step7: If the maximum number of iterations is reached, then signal that the network can not converge; otherwise signal that the network has converged, and the training stops.

E. Pieces identification

According to the previous theory, document should be trained first, and the training document is shown in Figure4.

Figure4. Training image

Transform training image into rtf, and then into omc file by using classification function. Finally, use the omc file in application process to identify image files which need to be identified. The result of identification is shown in Figure5.

Figure5. Vehicle Identification

In practice, the distance (central distance) between the pieces should be 6cm at least. The pieces could be placed randomly. Just as the picture 6 and picture 7 shows, we did nearly 50 experiments, and recognition rate was as high as 100%

Figure6. Vehicle Identification

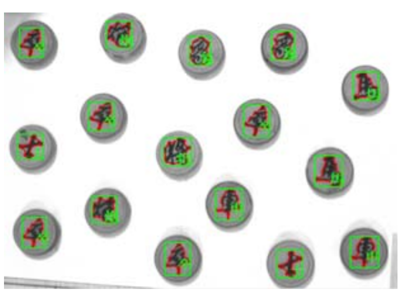

Figure7. Vehicle Identification

VI. CONCLUSION

1）Based on coordinates translation, algorithm which translates form the computer coordinates to the actual plane coordinates and from the camera image coordinates to the actual plane coordinates is given. This work contributes to the control trinity of program, robot, and camera.

2) Offline training uses image process and the method based on BP network to train text, which finally generates training documents. When online, training documents are used directly.

3) The basis of pieces identification is the constructed robot vision system.

REFERENCES

[1] QIAN Na, HOU Qingtao, LI Jingping, "Based on SOM and Triangle Feature Extraction". Journal Of University Of Jinan (Sc.i & Tech·), 2rd ed, vol. 22, pp.128–131, 2008.

[2] SONG Huajun. "Study On Target. Tracking Method Based On SVM". Changchun Institute of OpticsFine Mechanics and phsics, Changchun, 2006.

[3] ZHANG Guohua, MU Jing, WU Qiong, "Application of wavelet analyses in literal recognition", Journal Of Xi'An Institute Of Technology. 3rd ed, vol. 24, pp.226–230, 2004.

[4] LIU Li, PENG Fuyuan, ZHAO Kun,WAN Yaping, "Simplified SIFT algorithm for fast image matching", Infrared and Laser Engineering, 37rd ed, vol. 1, pp.181–184, 2008.

[5] FAQ Of Support Vector Machine, http://biw.jlu.edu.cn/show.php?id=39

[6] YU Zhongdang. Key Technolegies "Research On Comuter Vision Inspection Of Mechanical Parts Based On Support Vector Machine". JiLin University, ChangChun, 2009.

[7] YU Rui. "Medical Image Processing Based On Support Vector Machines", Xi'An University of Science and Technology, Xi'An, 2008.

[8] ZOU Yong. "Research On Image Processing Based On Support Vector Machines",: Xi'An University of Science and Technology, Xi'An, 2006.

[9] TIAN Yong, DUN Jianzheng, MA Yide, XIA Chunshui, WU Jiqun, "The Comparison Between Wavelet Transform and PCNN in Image Processing and Their Combination". Journal of Gansu Sciences, 18rd ed, vol. 4, pp.53–55, 2006.