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DRIVING CONTROL OF A VISUAL SYSTEM

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Abstract We developed a visual system that is able to track the moving objects within a certain range of errors. The visual system is driven by two DC servo motors that are controlled by a computer based on the visual data obtained from a CCD video camera. The software to track the moving objects is developed based on the PWM of the DC motors. Also, the problems how to implement a fuzzy logic control method and a neural network in this system, are also considered in order to check the control performance of tracking.

The fuzzy logic algorithm is a powerful control technique for nonlinear dynamical system and also the neural network could be implemented in this system. In this paper, we present configuration of tracking system developed in our laboratory, the control methods of the visual system and the experimental results are shown.

Keywords visual system, PWM, fuzzy logic, neural network, tracking system

1. INTRODUCTION

With the recent rapid development of computers,the practical application of PID control and optimal control theories has progressed and its effectiveness is being demonstrated. Many Robots controlled by a computer are used in the manufacturing process and accomplish remarkable advance. In the future, development to the field that robots assist human beings, for example office, medical care, the welfare, is expected. In these fields, many sensors understanding environment are necessary for the robots. Robots must can deal with task given at real-time. An information processing system of robots is constituted by three subsystems. One subsystems the sense information processing series that extract the quantity of a characteristic from environment data obtained from some sensors. More one is the exercise control series that it works for environment and moves some actuator. Last one is environment understanding and action plan series that connected two subsystems mentioned above.

In our laboratory, we developed a tracking system of moving objects that used visual sensor as sense information processing series.

In addition, we discussed how to implement artificial neural network system in this system and considered how to implement a fuzzy-logic control. This paper explains briefly the method and results obtained in the experiments. The configuration of the recognition and tracking system developed is introduced in Section 2. Section 3 explains the processing of the image data from the CCD camera for tracking is briefly explained. In Section 4 the tracking controls methods are discussed. Finally, conclusion follows in Section 5.

2. VISUAL SYSTEM

2.1 The configuration of visual system

The configuration of tracking system developed in our laboratory is shown in Fig.1 and the general view of the system in shown Fig.2.

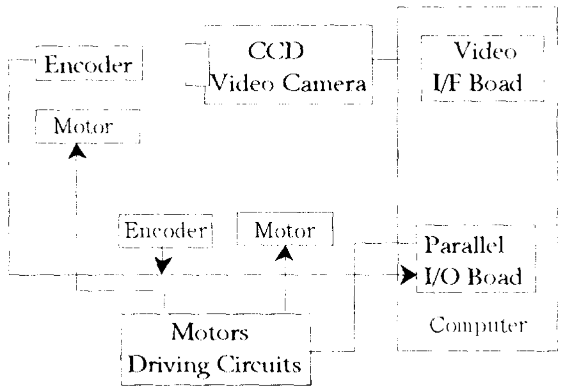

Fig. 1. The configuration of visual system

As shown in Fig.2 the system consists of two DC motors with encoder, one CCD video camera. One DC motor with encoder that moves in up and down direction is located in the upper sphere. The other DC motor with encoder that moves in right and left direction is located in low box. The horizontal and vertical DC motors are driven by the PWM controller of electric circuits and the velocity of tracking is selected appropriately by considering both the hardware limitations and the velocity of an objects to be tracked. Namely, the duty ratio of the amerture current is changed.

The CCD video camera is able to move 60 degree in right and left directions from the center and is able to move 45 degree in up and down directions from the center. The movement of DC motors is locked from hardware in the outside of the region stated above even if the PWM controller received on-signal from the microcomputer. The hexadecimal values from 00h to FFh are assigned for the values from 0 degree to 360 degree in the revolutional angles of the visual system along the clockwise direction in horizontal and vertical directions where the center of the visual system is assumed to be located at 00h. Therefore the movable angle is equal to 360 degree/256 bits and 1.40625 degrees correspond to 1H. In decimal digit the visual system is able to move from ±60 degrees/1.40625 degrees=±42.667 in right and left directions of horizontal axis, respectively and is able to move from ±45 degrees/1.40625 degrees=±32 in up and down directions of vertical axis, respectively.

The image data of a picture with 16×12 (low×column)=192 pixels are taken by the CCD video camera at one sampling and has values of six bits, namely, 64 degrees of intensity. The value of the image data is expressed as hexadecimal digit.

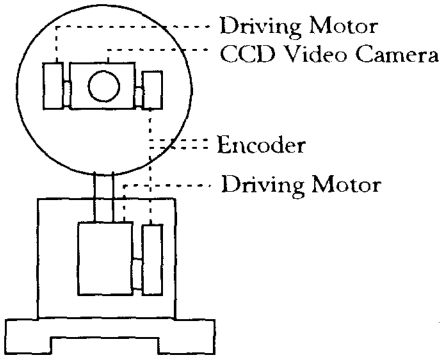

Fig. 2. The general view of the system

2.2 *Artificial Neural Network System*

The structure of the artificial neural network system is shown in Fig.3. This system has four layers. The duty ratios of PWM of horizontal and vertical direction are learned by neural network system using the back propergation method beforehand. The numbers of units in hidden and input layer, output layer in the artificial neural network system depend on the number of patterns to be learned. That number of units in the hidden layer depends on the number of units in the output layer. To obtain high learning ratio of the patterns, a large number of the hidden layers is required. However, from a computational point of view it is desirable that the number of units in the hidden layer is as small as possible.

It is studied that there is an effective learning technique based on the back propergation method to obtain higher recognition ratio in classifying the slightly different patterns or characters.

The neuro computer has four layer. Neuro computer can be to form neuron of maximum 16 at the each layer. The number of patterns to learn is maximum 64. A network of neuro computer is constituted by an electricity circuit. Even if it inputs same value into a leaned network, a different value is output. But because near learning value are output, learning is done. There is a change of each neuron always, it seems that convergence does not go well. In each pattern, we calculate absolute value of difference between the output value of the output layer and teach signal, add absolute value and calculate the error of pattern. And it decides to use the average error. Where the input layer consists of four units, the first hidden layer and the second hidden layer consist of sixteen units, the output layer consists of one units. Each teach signal of horizontal and vertical direction is same.

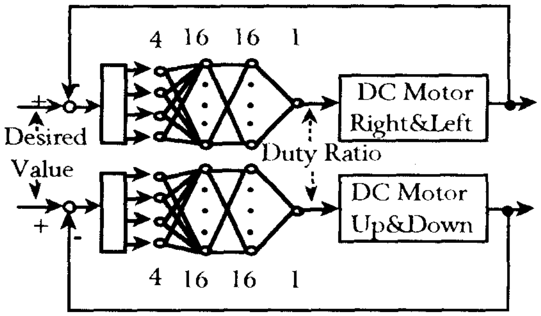

Fig. 3. The structure of the artificial neural network

3. PROCESSING OF IMAGE DATA FROM CCD CAMERA

The image data of moving objects with 16×12 pixels is taken into the microcomputer through the video interface and is stored in the memory. After that, the image data is read from the memory and is printed on the CRT. This processing time is approximately less than 30ms and therefore the sampling period is chosen 30ms in the experiments. For the purpose of tracking, the highest degree of intensity is selected. As to tracking of visual system, the following procedures are repeated:

1. The image data of picture of a moving objects is taken into the microcomputer from the CCD camera.
2. The position (i,j) of the highest degree of intensity of the CCD video camera is detected.
3. The position (i,j) of the highest degree of intensity of the image is detected.
4. The current position of the CCD video camera is read and taken into the microcomputer.
5. The deviation between the position (i,j)stated above and the center of the image is calculated.
6. The camera is moved to this position.

The above procedures are performed repeatedly in order to track the moving objects in a certain range of errors.

The visual field of the CCD video camera is set to be narrow. The CCD camera is able to move about 10 degree at most in right and left directions per one command and is able to move about 7degrees at most in up and down directions.

Therefore, it is not easy to track an objects which moves fast. The software to track the moving objects is developed based on the PWM of the DC motors. The duty ratio employed is decided from the experiments considering the trackspeed of the visual system.

4. CONTROL METHODS

In the control study, conventional proportional control is used at first in order to get the data concerning the fundamental movement of the system designed.

Also, the problem how to implement a fuzzy logic control method and a neural network in this system, is also considered in order to check the control performance of tracking.

4.1 Fuzzy Logic Control Rule

The fuzzy-logic control rule is described by if ~ then form. The rules table which is used in the experiments is shown Table 1.
where

$$e_n = y_n - r_n \quad (1)$$

$$\Delta e_n = e_n - e_{n-1} \quad (2)$$

y_n is the position of visual system, r_n is the position of a moving object, e_n is the deviation, Δe_n is the difference of deviation. The label of fuzzy variables e_n is right(RI), center(CE), and left(LE). The label of fuzzy variables Δe_n is positive(P)and negative(N). The fuzzy reasoning used is min-max method.

TABLE 1. Fuzzy Rule Table

Δe \ e	RI	CE	LE
P	PB	PS	ZO
N	ZO	NS	NB

4.2 Neural Network

We use the artificial neural network system that has four layers as mentioned above. The duty ratios are learned by it using the back propergation method. Where the input layer consists of four units, the first hidden layer and the second hidden layer consist of sixteen units, the output layer consists of one units. Each teach signal of horizontal and vertical direction is same.

The experiment result of tracking control using neural network is shown Fig.4. And the result of fuzzy control is shown Fig.5.

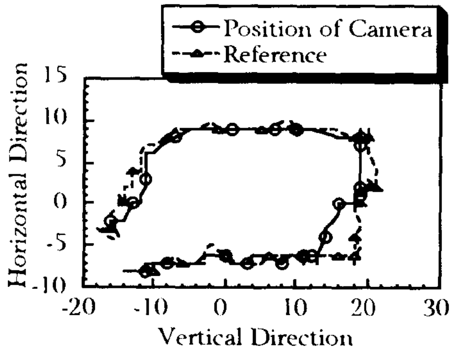

Fig. 4. Experiment result of neural network

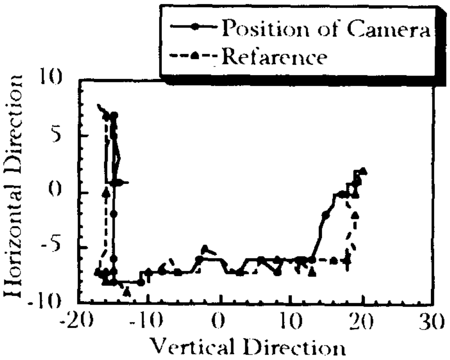

Fig. 5. Experiment result of fuzzy control

5. CONCLUSION

In this paper the tracking system of moving objects developed in our laboratory is introduced and is explained briefly. The method how to track a moving objects, is also shown. It showed that the tracking control using neurò computer is possible. It is seen from the fundamental experiments performed that the system developed is able to track the moving object of slow speed quite satisfactory at this stage and works at a certain degree of satisfaction. Especially more sophisticated control method than proportional control method could be employed in order to achieve smooth and fast tracking. The fuzzy-logic algorithm shown briefly in this paper is a powerful control techinique and also the model predictive control with neuro could be implemented in this system. For a subject of future, finding the teach signal that neural network is most suitable for constituting the control system that it uses neural network in an online and can learn always. This tracking control will be equivalent to mobile recognition vehicle. The control studies other than the approaches presented in this paper are in our future works.

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