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Analog Motion Detection Circuit Using CCD Camera Based on the Biological Vision System and Its Application to Mobile Robot

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Abstract: We proposed an analog motion detection circuit based on the biological vision system. The charge coupled device (CCD) camera was used as the input part which obtains the input image. By using the CCD camera, it is immediately able to detect the motion of the high resolution images. The unit motion detection circuit is constructed with 8 metal oxide semiconductor (MOS) transistors and 1 capacitor. The unit circuit becomes simple structure. The test circuit was fabricated on the breadboard by using discrete MOS transistors. The measured results of the test circuit showed that the proposed circuit can detect the motion direction. The fabricated test circuit was connected with the microcomputer introduced in the mobile robot. It was clarified from the measured results that the motion detection circuit can control the mobile robot.

Keywords: analog circuit, motion detection, image processing, vision chip**.**

I. INTRODUCTION

It is necessary for robotics vision, monitoring system and other systems to achieve the high speed image processing. However, it is difficult to process the image information for the typical image processing system using Neumann-type computer because the information is processed in time sequential way. In the biological vision system constructed with the retina and the brain, it is able to accomplish the high speed image processing. The processing is performed in massively parallel nerve networks.

The integrated circuits (chip) were proposed based on the biological vision system [1]-[6]. The circuit can detect the edge and motion of the object in real time. However, there is a problem of the low resolution in the case to add many functions.

In this study, we proposed an analog motion detection circuit based on the biological vision system. The charge coupled device (CCD) camera was used as the input part which obtains the input image. By using the CCD camera, it is immediately able to detect the motion of the high resolution images. The unit motion detection circuit becomes simple structure. The measured results of the test circuit showed that the proposed circuit can detect the motion direction. The fabricated test circuit was connected with the mobile robot. The robot could operate by using the motion signal.

II. MOTION DETECTION MODEL

Figure 1(a) shows the motion detection model based on the biological vision system. We call the model the correlation model. The model is constructed with the photoreceptors P, delay neurons D and correlators C. The arrows show the flow of the signals. The solid line shows the model for detecting the right motion. The dashed line shows the model for detecting the left motion. In this paper, the model for detecting the right motion is described.

Figure 1(b) shows the signals of the motion

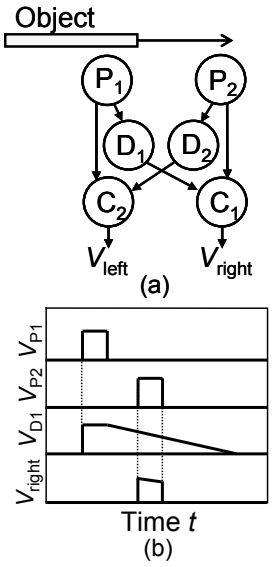

Fig.1. Motion detection model. (a)Model. (b)Transient response of each cell.

detection model when the object moves toward the right side. Firstly, the object is projected on P_1. P_1 generates the signal which is proportional to light intensity. The signal of P_1 is input to D_1. The signal of D_1 decreases. When the object is projected on P_2, P_2 generates the signal. The signal of P_2 is input to C_1 Since the output signal V_{right} of C_1 is proportional to D_1, V_{right} becomes large when the object moves toward the right side. Then, the output signal V_{left} of C_2 is 0.

When the object moves toward the left side, V_{left} becomes large and V_{right} is 0. Thus, the model can detect the motion direction.

III. MOTION DETECTION CIRCUIT

1. Input part

Figure 2(a) shows the relationship between the object and CCD camera. The object is projected on the CCD through the lens.

Figure 2(b) shows the projected image. In this study, it is necessary to generate the signals of P_1 and P_2, as shown in Fig. 1. As shown in Fig. 2(b), the image is segmented. The signals of the segmented image are utilized as those of photoreceptors.

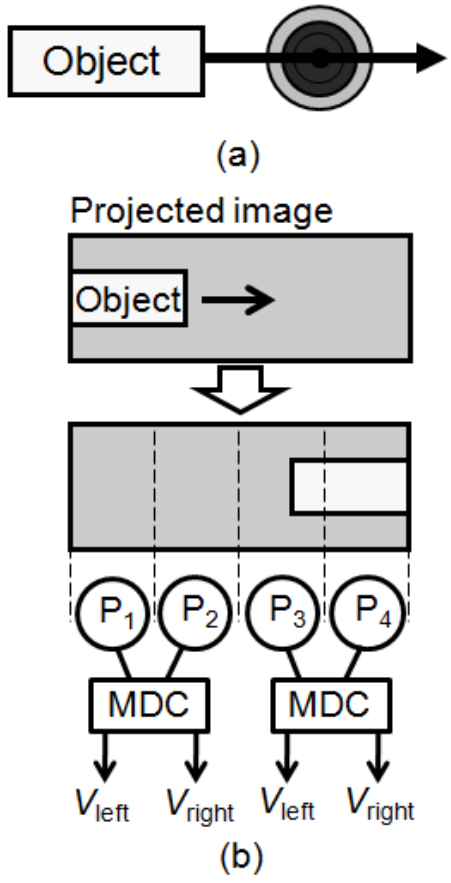

Fig.2. Relationship between the object and CCD camera.

2. Unit circuit

Figure 3 shows the unit motion detection circuit. V_{P1} and V_{P2} are input voltages. V_{P1} corresponds to the signal of P_1 in Fig. 1. V_{P2} corresponds to the signal of P_2. V_{right} is the output voltage. In this circuit, the constant currents V_{th1}, V_{th2} and V_{th3} are set.

The delay neuron D in Fig.1 is realized by 1 metal oxide semiconductor (MOS) transistor and 1 capacitor. The correlator is constructed with 5 MOS transistors. The unit circuit is constructed with 8 MOS transistors and 1 capacitor. The circuit is simple structure.

In the case of the circuit for detecting the left motion, the output voltage becomes V_{left}. Thus, the motion direction can be detected by using 2 unit circuits.

IV. MEASURED RESULTS OF CIRCUIT

The test circuit was fabricated with discrete MOS transistors on the breadboard. C was set to 100 nF. V_{th1}, V_{th2} and V_{th3} were set to 2.18 V, 1.2 V and 1.36 V, respectively. The supply voltage V_{DD} was set to 5 V.

Figure 4 shows the measured results of the test circuit when the object moved toward the right side. V_{right} became 5 V. Then, V_{left} became 0.

Figure 5 shows the measured results of the test circuit when the object moved toward the left side. V_{left} became 5 V. Then, V_{right} became 0.

Thus, the test circuit can detect the motion direction.

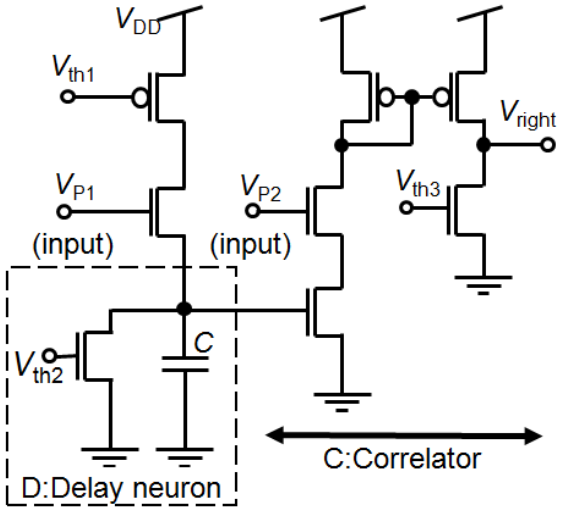

Fig.3. Unit motion detection circuit.

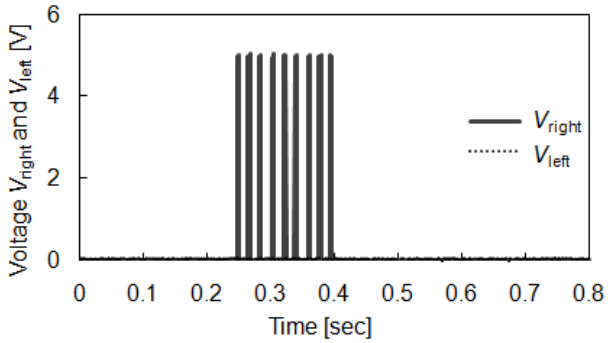

Fig.4. Measured result of test circuit (right side).

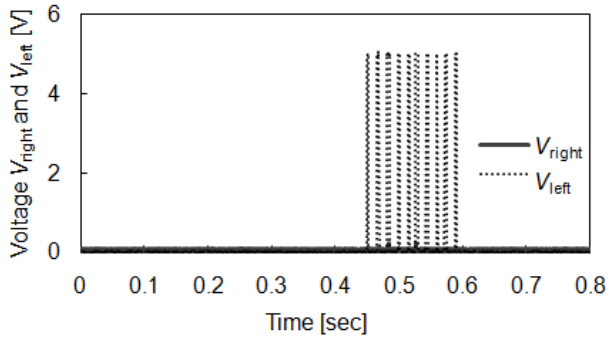

Fig.5. Measured result of test circuit (left side).

V. APPLICATION TO MOBILE ROBOT

We tried to control the mobile robot by using our motion detection circuits. The fabricated test system is shown in Fig. 6. In the robot (ROBONOVA-I, Hitec Multiplex Japan), the microcomputer (MR-C3024) is introduced. The output terminals of the test circuits, i.e., V_{right} and V_{left} were connected with input terminals of the microcomputer.

In this study, we programmed that the robot hands up the right arm when the object moves toward the right side, i.e., when V_{right} becomes V_{DD}. We programmed that the robot hands up the left arm when the object moves toward the left side, i.e., when V_{left} becomes V_{DD}.

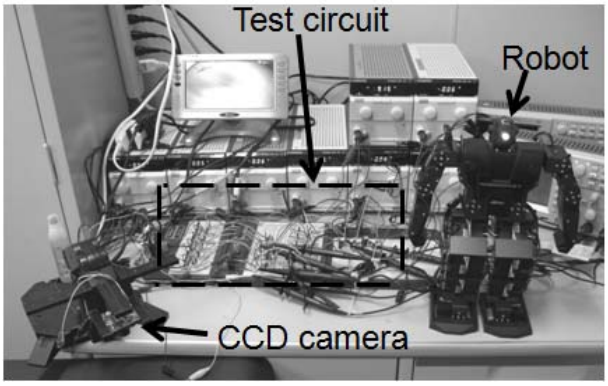

Fig.6. Photograph of the fabricated test system.

Figure 7 shows the measured results of the test system when the object moved toward the right side. The robot handed up the right arm.

Figure 8 shows the measured results of the test system when the object moved toward the left side. The robot handed up the left arm.

Thus, it is able to control to the robot by using our proposed circuit.

VI. CONCLUSION

An analog motion detection circuit was proposed based on the biological vision system. By using the CCD camera as the input part, it is able to detect the motion of the high resolution images. The unit circuit becomes simple structure since the unit circuit is constructed with 8 MOS transistors and 1 capacitor. The measured results of the test circuit showed that the proposed circuit can detect the motion direction. The

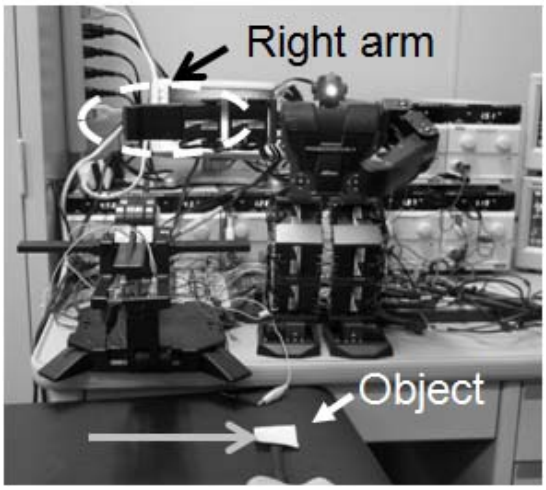

Fig.7. Measured result of test system (right side).

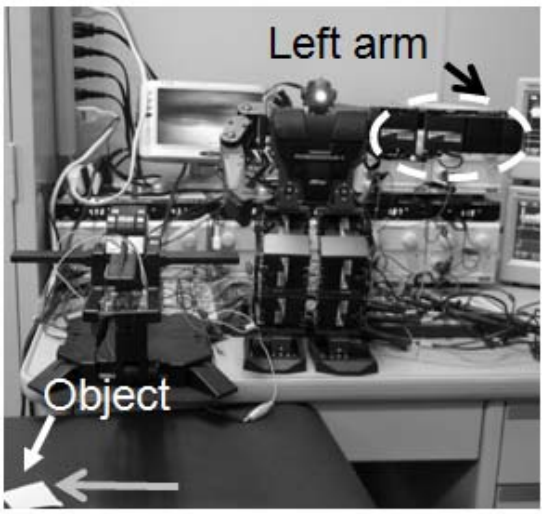

Fig.8. Measured result of test system (left side).

test circuit was connected with the mobile robot. It was clarified from the measured results that our proposed circuit can control the robot. In the future, by applying the proposed motion detection circuit, it is able to use as the motion sensor such as the robotics vision.

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