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Design of robotic behavior that imitates animal consciousness -Development of Method for Pursuing or Escaping from an Object-

Kouichirou Kurogi Eiji Hayashi

Department of Mechanical Information Science and Technology
Faculty of Computer Science and Systems Engineering, Kyushu Institute of Technology
680-4, Kawazu, Iizuka-City, Fukuoka Prefecture, Japan

***Abstract*:** In this research, in order to aim at "user affinity," a trial to give a robot "consciousness" like a person or an animal is performed. User affinity here includes the function of providing healing, being easy to be with or providing a sense of closeness to a user, or not being boring to a user. Our "the discovery mechanism model of consciousness and action" was built as a trial intending to provide "consciousness" first. For it, we developed a software architecture whereby the system controls the action of an artificial animal based on this model. This architecture is called Consciousness-based Architecture (CBA). Moreover, our newly built "motivation model" is based on the assumption that a certain motive exists in action of an animal; this gives a robot the motive of action. The dopamine generating mechanism of an animal is modeled and included in the the robot arm, thus combining the CBA and the motivation model. Book research has determined how a robot's motivation is affected by a change in the dopamine amount in emergencies. In addition, a system for pursuing a missing object was built.

***Keywords*:** CBA, consciousness of the robot, Motivation of the robot

I. INTRODUCTION

In recent years, the development of non-industrial robots in such fields as medical care and welfare and for life in general has flourished. The function of these robots requires not only the basic functions of robots, such as a high level of intellectual activity, but also the function of user compatibility or affinity so that a user can feel close to the robot as a result of its appearance and behavior. User compatibility includes being able to easily use a robot, not getting tired from this use, and easily developing a sense of closeness with it; it also indicates the function of receiving healing from the use of a robot.

However, although a robot may achieve user compatibility by genuinely modeling a face, it is far more difficult to achieve user compatibility by behavior and actions. User compatibility in this case entails ease of use, non-fatiguing control, robot "friendliness" (i.e., sympathetic use), and human-like capricious behavior. The attempt to give robots "consciousness" such as that identified in humans and animals is a part of these requirements.

In our laboratory, we studied an animal's adjustment to its environment in an attempt to emulate its behavior. We constructed a hierarchical structure model in which consciousness and behavior were related. In regard to this, we developed a software architecture we call Consciousness-based Architecture (CBA). We also made a program to imitate a state with dopamine as the motivation of the robots and included it in CBA. The CBA introduces an evaluation function for behavior selection and controls the robot's behavior.

In the present study, we developed a robotic arm that has six degrees of freedom, with the aim of providing the robot with the ability to autonomously adjust to a target position. Fig. 1 shows an overview of the robotic arm. The robotic arm that we used has a hand consisting of three fingers in which a small monocular Web camera is installed. A landmark object is detected in the image acquired by the Web camera, enabling the robot to perform holding and carrying tasks. In an autonomous action experiment, CBA was applied to a robot arm and its behavior then inspected.

In addition, a system that pursues and escapes from an object was built.

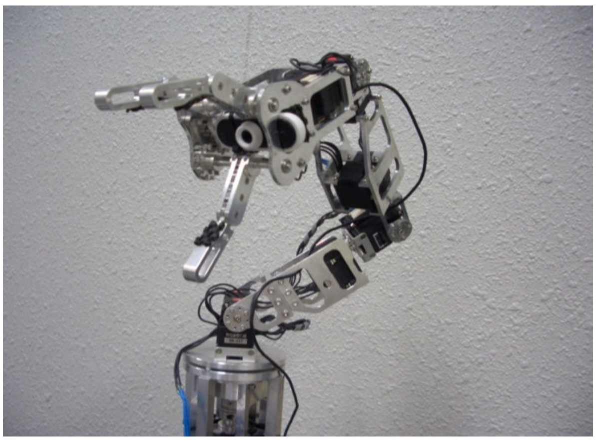

Fig. 1. Overview of Robotics arm

II. SYSTEM STRUCTURE

Fig. 2 shows an arrangement plan of the degree of freedom of the robotic arm. Figs. 2- and 3 show a configuration diagram of the experimental system. The robotic arm manufactured by the Kihara Iron Works is 450 millimeters long and has 6 degrees of freedom. The robotic hand part of the robotic arm has 3 fingers and 1 degree of freedom. Additionally, there is a small Web camera in the robotic hand.

We applied the Dynamixel DX-117 manufactured by ROBOTIS CO., LTD. as the actuator of each joint of the robotic arm. The DX-117 provides a motor, decelerator, and angular sensor unit. This actuator is able to perform position control by providing the robot with a target angle, torque limit, speed limit, and so on. Its transmission method is RS485. Hard wiring can simplify the system by connecting a daisy chain to each actuator used as a joint of the robotic arm.

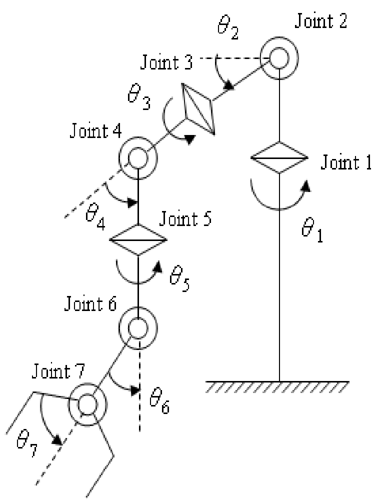

Fig. 2. Arrangement chart of degree of freedom

III. AUTONOMOUS BEHAVIOR

1. The motivation of the robot

Most robots are pleasing to people because of their unique movements. However, because the action choices of robots are too mechanical, those that will resemble human beings and animals are needed to actualize user compatibility. Therefore, at first we considered human actions.

Actions of an animal, including a human being, can be represented in a flow chart by such as "Recognition → Comprehension → Motivation → Action". By contrast, actions of a robot show a simple flow such as "Recognition (Comprehension) → Action".

We considered this simple flow to be one of the causes of "the mechanical action choices of the robot". Therefore, in this study, we incorporated the concept of "the motive" in a robot, and aimed at an action choice that resembled that of a human being or an animal.

2. Imitation of the outbreak mechanism of dopamine

Dopamine is a hormone-like substance in the brain that is related to motivation. When animals, including human beings, take some actions, dopamine is secreted in the brain.

Our laboratory thought that more biologic action choice would be enabled if the outbreak mechanism of motivation by dopamine could be reproduced in a robot.

As a result, a generating model of the dopamine was developed. Fig. 3 shows such a model that expresses a change in the quantity of dopamine outbreak.

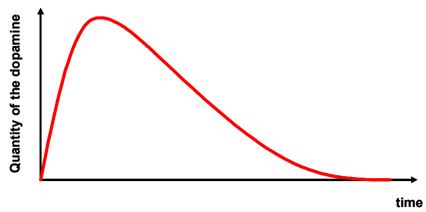

Fig. 3. Traces from outbreak of the dopamine to extinction

Our purpose was for the control model that combined "a second order system" with "a first order system" to output a trace that would show in the figure . First, we used a second order step response for the start of the dopamine. After having arrived at the peak value, we used a primary delay reply that assumed a peak value input. The system expresses a trace of various amounts of dopamine by setting the natural frequency ωn, damping ratio ζ, and time constant Tc of the variable appropriately included in this control model. In this study, we view a trace of this dopamine as the motivation of the robots and will call this function a "Motivation model" in future. Fig. 4 shows the Motivation model

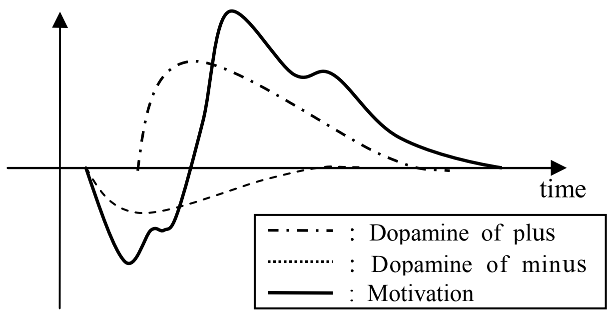

Fig. 4. Motivation model

4. Consciousness architecture (CBA)

Fig. 5 shows a diagram of a hierarchical structure model called CBA (Consciousness-based Architecture) which relates consciousness to behavior. The characteristic of this model is that a consciousness field and a behavior field are built separately. In a dynamic environment, this model relates the consciousness level to the environment that a robot must strongly consider, and the robot then selects a behavior corresponding to that consciousness level and performs the behavior. This model is characterized by the consciousness level reaching an upper level at which the robot can select an advanced behavior when certain behaviors corresponding to the consciousness level are discouraged by the external environment.

Additionally, the robot expressing an upper level behavior can choose a lower level behavior. The mechanism of this model is that it selects the most comfortable behavior within the lower level behaviors at pleasure, so that the robot aims for goals.

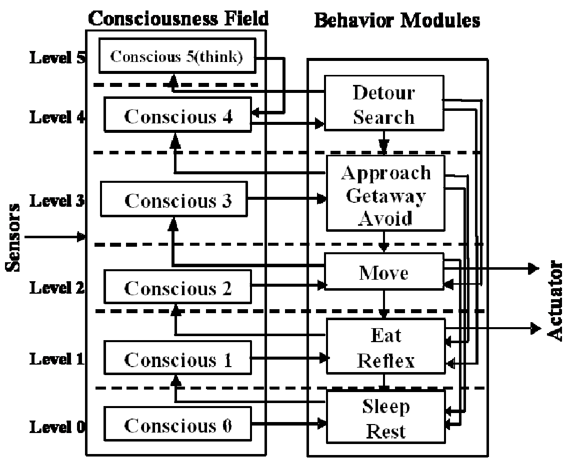

Fig. 5. Consciousness-based Architecture (CBA)

6. Situation recognition with a Web camera

We make a labeling image from an image of a web camera installed in the robot hand. which is divided into green, blue, and flesh colors We divided colors into lumps and determined the shape, size, and center at a gravity position. From this information and the posture of the robot arm, the robot could recognize a position and the distance of a colored object.

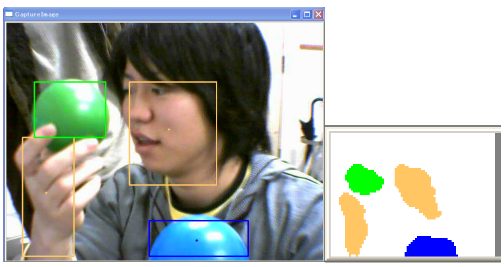

Fig. 6. A Web camera image and a labeling image

Ⅳ. System of Object pursuit and escape

It has been possible for a robot as it has been developed until now to pursue a favorable object if it is in the visual angle, and also for it to escape from a disagreeable object. However, an animal and a human being get interested regardless of a favorite thing or a disagreeable thing. Therefore, our laboratory developed the system which pursues an object. In this system, robot pursues the object which moved to outside of the robot's visual angle from the inside of the robot's visual angle, and the object which passed through the inside of the robot's visual angle. In addition, the "main system" shows the robot's entire system developed until now.

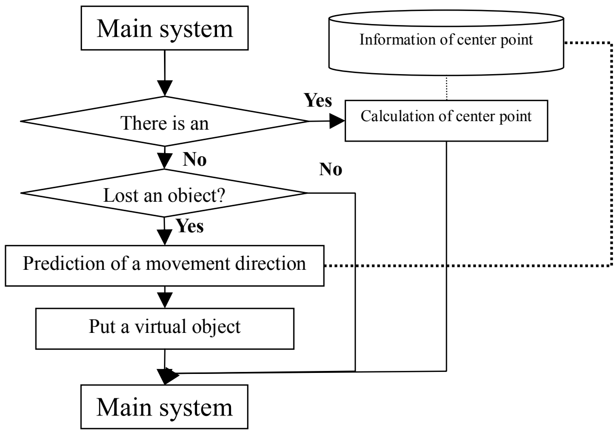

Fig. 7 Flow chart

2. Calculation of the objective central point

At the time of a situation recognition by a Web camera, the maximums and minimums of object's x- and y-coordinates which have been recognized are acquired from the picture to which labeling processing is performed. In order to recognize only the central point of the attentional object, in the object recognized with the WEB camera, a small thing does not obtain the central point of an object as what is not. From the maximum and minimum values of x and y which were acquired, the object was enclosed with a quadrangle and the middle point of an diagonal line of the quadrangle was made into the objective central point. In addition, the system memorizes the central point for three frames.

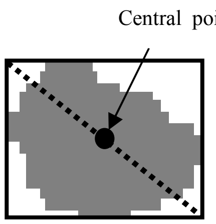

Fig. 8. Central point

3. The objective move direction prediction

The move direction is predicted only when an object is missed at the time of situation recognition. A picture is divided into eight domains in order to predict the move direction. It uses the domain and decides which direction an object moved to. A domain is shown in Fig. 9.

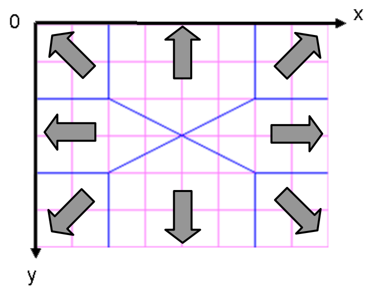

Fig. 9. A division domain and the prediction direction

4. Virtual object creation

The virtual object corresponding to the move direction of the predicted object is created in the visual angle. Since it is possible to pursue the object within the visual angle, a virtual object will be created and it will run after a real object by running after the virtual object.

Ⅴ. INSPECTION OF AUTONOMOUS BEHAVIOR

We applied the motivation model and CBA for a robot arm which we showed in Chapter III, and we inspected the autonomous behavior.

1. Condition setting

The built object pursuit system was incorporated, and the experiment for the robot arm in operation was conducted.

・When a green object (favorite thing) is moved out of the visual angle from the inside of the visual angle.

・When a blue object (disagreeable thing) is moved out of the visual angle from the inside of the visual angle.

Action of a robot arm is shown in Figs. 10 and 11.

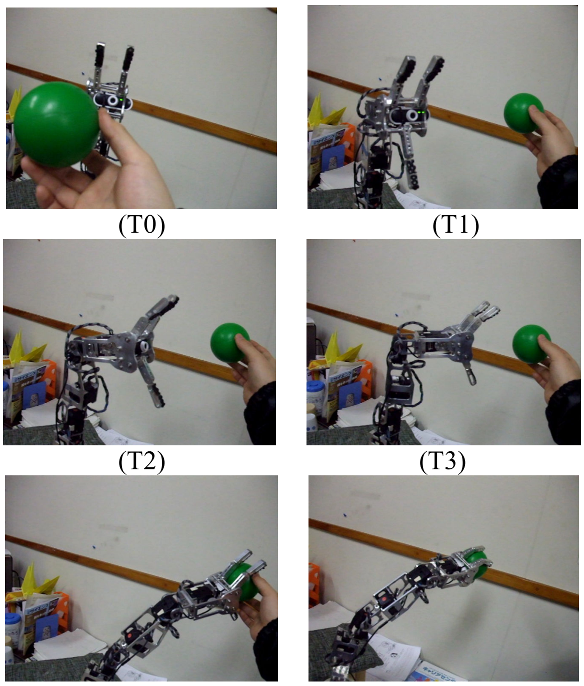

Fig. 10 Behavior of the robot arm

If a green object is moved from the (T0) position to (T1), the system will recognize that the green object passed inside of the robot's visual angle. At this time, the robot arm judges which direction an object moved to. Then, although pursued to the (T2) position, since the green object had not been recognized, it is pursued to the (T3) position. Furthermore, since the green object has been recognized, robot held the object (T5).

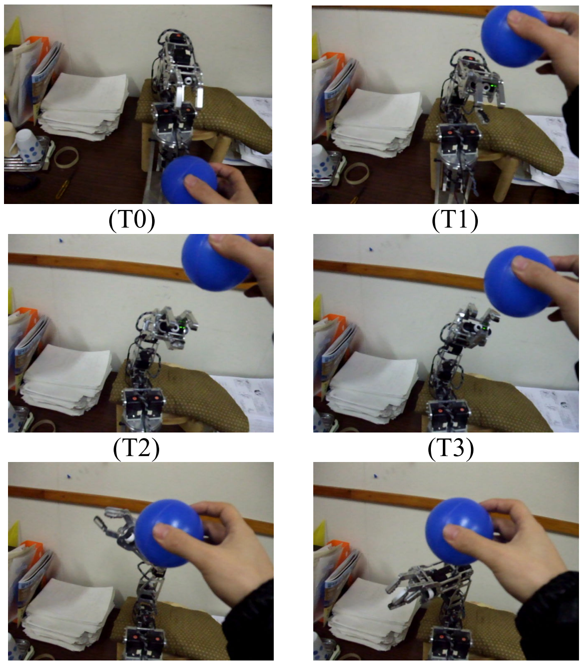

Fig. 11 Behavior of the robot arm

If a green object is moved from the (T0) position to (T1), the system will recognize that the green object passed the robot arm in the visual angle. At this time, it is being judged like the green object to which the robot arm moved. Then, although pursued to the (T2) position, since the green object had not been recognized, it is pursued to the (T3) position. At (T3), since the green object had been recognized (T4), the operation which the robot dislikes, as shown in (T5), was performed.

VI. CONCLUSION

In this research, We built the system of method for pursuing or escaping from an Object. Pursuing an object which moved to outside of the visual angle from the inside of a visual angle has been checked in an experiment by placing a virtual object according to the direction of movement

VII. Acknowledgement

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VIII. REFERENCES

[1] Motoki Shimono, Eiji Hayashi, Design of robotic behavior that imitates animal consciousness (AROB 13th ' 08)、Oita, Japan, 2008