A implementation of Humanoid Vision
--Analysis of Eye movement and Implementation to Robot--

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Abstract: In this paper, we propose “Humanoid Vision”. Humanoid robots are becoming like human and imitating human behavior. They usually have camera, then we consider that eyes for humanoid robot have to be “Humanoid Vision”. Humanoid Vision is the vision system which is focused on human actions of the robot, and emulation of human beings. Therefore, we analyzed the human action of tracking an object by the eyes and implemented the obtained features to the robot.

Keywords: Eye Movement, Analysis, Humanoid Robot, Humanoid Vision.

1. INTRODUCTION

In this paper, we propose “Humanoid Vision”. Nowadays, humanoid robot’s exterior and features are becoming as similar as human [1-2]. They usually have cameras [3] on their eyes. Then we consider that “the humanoid robot has to have humanoid functions”, and also eyes for humanoid robot have to be “Humanoid Vision” [4].

We propose the vision system that is new user friendly interface between and robot. We consider that robot has to act more real human actions to feel the human-like in human and robot communication. Therefore, in the first step, we analyzed human actions of tracking an object as similar as human beings.

2. HUMANOID VISION

Humanoid Vision is the vision system which is focused on human action of the robot, and emulation of human beings. We considered that the human beings is optimized for human frameworks, thus the humanoid vision will be the best vision system for humanoid which has human like. We used a humanoid robot “YAMATO” which is installed two cameras on his eyes.

2.1. Introduction of YAMATO

Our humanoid robot “YAMATO” is shown in figure 1 to implement the humanoid vision. Its height is 117cm, and it has 6 DOF on the arms, and 9 DOF on the head. Table 1 shows the detail of DOF on the arm and the head [5]. It can act various expressions with all 21 DOF.

The humanoid robot has twelve SH2 processors and one SH4 processor. Twelve SH2 processors control motors, and one SH4 processor is main control unit. We can control the robot by a PC through the RS-232C. Then we send the angle of each joint to make him posture or motion.

| Part | Degree of Freedom |
|------|-------------------|
| Arm  | Shoulder 3        |
|      | Elbow 2           |
|      | Hand 1            |
| Head | Eye 3             |
|      | Neck 4            |
|      | Mouth 2           |

Magellan Pro is used in the lower body. It has sixteen sonar sensors, sixteen IR sensors and sixteen tactile sensors. Its size is 40.6 cm in diameter and 25.4 cm in height. Linux is installed on it. It can move forward and backward, and traverse.
3. ANALYSIS OF EYE AND HEAD MOVEMENT

3.1. Camera setting

First, we analyzed how to move eyes and head to track an object. Figure 2 shows overview of our system setting. In this setting, we set two screens. The moving marker is projected by a projector on a screen (screen1). Another screen (screen2) is used to observe the head movement.

Figure 3 shows a camera which can take only eyes movement even if his/her face moves. We call this camera as “Eye coordinate camera”. This camera system consists of a small camera and a laser pointer which are mounted on a helmet. A laser points on screen2 surface. We can observe the head coordinate by using this screen as shown in figure 4. Lines on this screen are written every 10 degrees from center of screen. We took the movement of laser by using another camera. We call this camera as “Head coordinate camera”.

Figure 5 shows the moving marker that is presented for subjects. This is projected on the screen1. To capture human movement, moving marker is moved left or right after stop for several seconds. Its movement speed is 20, 30 and 40 deg/s. Its movement range is set from +60 degrees to -60 degrees.

3.2. Analysis of Eye and Head Movement

Each image as shown in Figure 6 is corresponding to image as shown in Figure 7. Figure 6 shows images that were taken from the head coordinate camera. White point of images is a point which is illuminated by the laser. From these images, we can understand that the laser pointer is moved on the screen 2. Figure 7 shows images that are taken from the eye coordinate camera of figure 3. The face doesn’t move in these images. Head coordinate images obtain only changes of eyes and background.
We analyzed how to track an object from these images. Facial movement was analyzed a position that the laser illuminates on the screen. Eyes movement was analyzed center of the right iris. Eyes movement is assumed that both eyes are same movement. In this analysis, we extracted only x-coordinate of left and right movement. X-coordinate is head angle or eye angle.

4. CONSIDERATION OF EYE AND HEAD MOVEMENT

Figure 8 shows a result graph that is observed 20deg/s of moving marker speed. Horizontal axis shows the frame, and vertical axis shows the head’s and eye’s x-coordinate in each frame. Each coordinate of frame 0 is defined as baseline. If values are smaller than the value of frame 0, it shows that the subject is moved his face to the right. If values are rather than 0, it shows that he moved his face to the left. In this graph, Graph of the head is changed after eye graph is moved. This shows that the moving marker is tracked by using only head after tracking by using only eyes. When the moving marker returned to center, it was tracked by using only eyes again. The moving marker was tracked by using head after eyes returned. From these results, as the moving marker speed was slow, we understood that eyes were used preferentially and tracked it. This velocity is understood that smooth pursuit eye movement is possible.

Figure 9 shows a graph that is observed 30deg/s of moving marker speed. First, the eyes move to some extent, and next the head started to move. This movement shows that the moving marker was tracked by using the head. In this time, the eyes were holding on the left. When the moving marker returned to the center (after frame 50), eyes moved slightly faster than head. In the graph, eye is used preferentially to track. From these results, some features are given corresponding to the moving marker speed.

Figure 10 shows a graph that is observed 40deg/s of moving marker speed. In this graph, the eyes move to some extent, and after the head started to move. Between frame 0 and frame 35, change of graphs is similar to figure 8 and 9. This shows that the moving marker is tracked by using only head after tracking by using only eyes. But when the moving marker returned to center (after frame 35), head and eye values are changed at the same time. It shows the human uses both face and eyes to track an object [6]. Change of eye movement is smooth because of he used both face and eyes to track an object. From this result, smooth pursuit eye movement [7-8] is possible at 40deg/s.

As the above results, two kind of features of 20–30 deg/s and 30–40 deg/s were obtained.

5. MAKING OF MODEL

We made a model based on features obtained in the previous section. This model is shown in figure 11. We implemented the humanoid vision with this model. In conditions, there is an object in the center of the image, and smooth pursuit eye movement is possible. YAMATO detects an object and determines its speed. In the feature of 20–30deg/s, eyes are used first to track an object, and head is used to do it. When an object is returned, eyes are used again. In the feature of 30–40deg/s, eyes are used first to track an object, and head is used to do it. When an object is returned, eyes and head are used to track it in the same time.
6. IMPLEMENT TO THE ROBOT

We implemented the model introducing at the previous section. We used a ball as the moving marker. A ball was moved sideways, constant speed, and 60 degrees to the left. We repeated it. The distance from YAMATO to a ball was around 1m. Figure 12 shows a scene of an experiment.

Figure 13 shows images of movement that YAMATO expressed features of 20~30deg/s. In these images, YAMATO moved his eyes in the first. After he finishes to move his eyes, then head is moved. When a ball was returned to the front, the head and eyes were moved in the sideways. Figure 14 shows a graph that describes the model of figure 11.

Figure 14 shows images of movement that YAMATO expressed features of 30~40deg/s. In these images, YAMATO moved eyes and head. These results show that YAMATO expresses the implementation model. Also, we can understand figure 16 that shows features of our model. From above results, we can implement humanoid vision.

Fig. 12 A scene of an experiment.

Fig. 13 Expression of 20~30deg/s

Fig. 14 Expression of 30~40deg/s

7. CONCLUSION

In this research, we considered that “the humanoid robot has to have humanoid functions”, and eyes for humanoid robot have to be “Humanoid Vision”. Therefore, we analyzed the human action of tracking an object by the eyes and implemented the obtained features to a humanoid robot “YAMATO”. From implementation results, we showed the effectiveness of humanoid vision. Our future works are analysis of longitudinal movement and complicated movements to movement of a robot.

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