Gamer robot for the rock-paper-scissors game by hand motion recognition

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Abstract: This paper presents a gamer robot system for the rock-paper-scissors game by hand motion recognition without any additional units. The proposed system consists of three parts: game management part, hand motion recognition part, and robot hand control part. 1) The game management part decides a motion of robot hand among rock, paper, and scissors. After gaming, it makes a reaction about the result of the game using speech or facial expression. 2) The hand motion recognition part realizes the hand motion of the opponent. It does not use any additional unit on body, and only uses a camera on a robot. 3) The robot hand control part shows the decided motion of robot hand. A robot hand has four fingers which are controlled independently.

Keywords: Hand motion recognition, gamer robot, rock-paper-scissors game, finger design & control**.**

I. INTRODUCTION

Humans usually communicate with computer or robot using additional input devices, such as keyboard, touch screen. To make simple communication environment, many researchers have studied about Human Computer Interaction (HCI) and Human Robot Interaction (HRI) [1-3]. Especially, communication using hand motion, which is the most definite expression in human body, is studied for interaction with robot systems. Moreover, the speech-impaired and the hearing-impaired are able to communicate with robots using sign language [4, 5].

There are various researches about hand motion recognition, for example, motion detecting by wearing glove with sensors, vision processing of hand motion, etc. In the motion detecting by wearing glove with sensors, although it is easy to detect and recognize hand motion in real time, additional input device is needed [6]. On the other hand, in the vision processing of hand motion, although additional input device is not needed, recognition rate is dependent on environment, such as shadow, illumination.

In this paper, we present a gamer robot system for the rock-paper-scissors game by hand motion recognition using vision processing. The gamer robot system consists of three parts; game management part, hand motion recognition part, and robot hand control part. In Section 2, we introduce a hand motion recognition system. In Section 3, we explain a four-fingered robot hand system. In Section 4, we show the experimental results. Finally, we conclude this paper in Section 5.

II. Hand Motion Recognition System

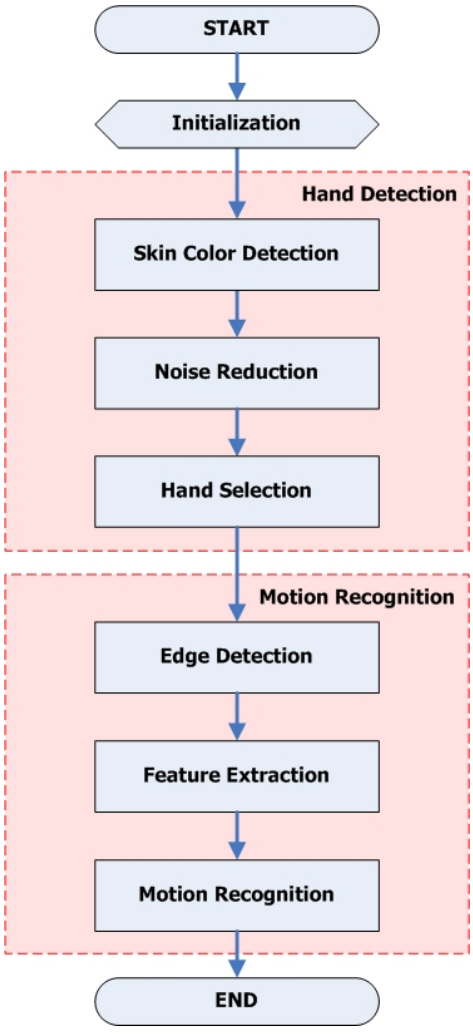

Fig. 1. The diagram of the proposed hand motion recognition system

As humans make various hand motions, it is difficult to understand all hand motions. The hand motion recognition system by vision processing, we introduce in this paper, understands only three hand motions; rock, paper, and scissors. Fig. 1 shows the diagram of the proposed hand motion recognition system. There are two steps; the first step is hand detection and the second step is motion recognition. In the hand detection, we get the biggest hand image from the camera of robot system. In the motion recognition, we classify hand motion among rock, paper, and scissors. We use HSV color space for the hand motion recognition system, because it is conceptualized in human vision in terms of other color-making attributes, such as hue, lightness, and chroma [7].

2.1. Hand Detection

We extract candidate pixels of hand using skin color detection. From Fig. 2 to Fig. 5 shows the results of skin color detection process. 1) We get the input image from the camera of robot as shown in Fig. 2. 2) We set the threshold range for skin color. 3) We get the image shown in Fig. 3 from the hue image of Fig. 2 using threshold range. The white colored pixels are detected pixels as skin color. 4) We get the image shown in Fig. 4 from the saturation image of Fig. 2 using threshold range. The black colored pixels are detected pixels as skin color. 5) We get the skin colored image shown in Fig. 5 by logical operator conjunction between Fig. 3 and Fig. 4. The white colored pixels are detected pixels as skin color. As skin color detection extracts similar colored pixels with skin color, noise is mixed in Fig. 5. Therefore, we reduce noise of Fig. 5 by Morphology algorithm [8]. Then, we classify the candidate pixels of hand by well-known Labeling algorithm. We assume that the biggest lump of pixels is the hand.

Fig. 2. The input image from camera

Fig. 3. The hue image of skin color (white)

Fig. 4. The saturation image of skin color (black)

Fig. 5. The candidate pixels of hand (white)

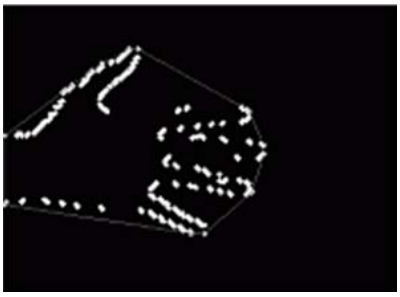

Fig. 6. The edge image of hand (white)

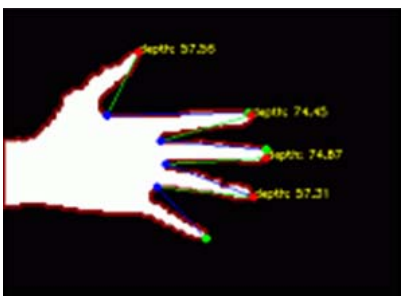

Fig. 7. The significant features of hand

2.2. Motion Recognition

We detect the edge of the hand to recognize hand motion as shown in Fig. 6. Then, we extract significant features such as convex points for the end points of fingers and concave points for the interdigital points of fingers as shown in Fig. 7. We calculate the length of fingers using convex points and concave points of fingers. We classify the hand motion using the calculated result among three candidate hand motions; rock, paper, and scissors.

III. Four-Fingered Robot Hand System

We design the four-fingered robot hand system for playing the rock-paper-scissors game. The robot fingers are designed using small gears instead of wires to accurate control without compensation. Each finger is able to control independently to express scissors. Fig. 8 shows the designed four-fingered robot hand system. Fig. 9 shows the 3 DOF (Degree Of Freedom) designed robot finger with three knuckles and three robot fingers are designed identically. Fig. 10 shows the 4 DOF designed thumb with three knuckles. Thumb has one more DOF due to the saddle joint to lift some objects.

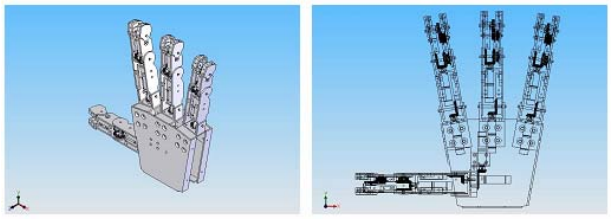

Fig. 8. The four-fingered robot hand system

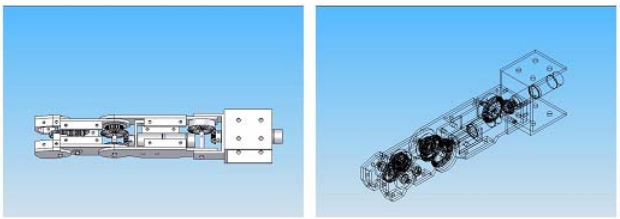

Fig. 9. The designed robot finger

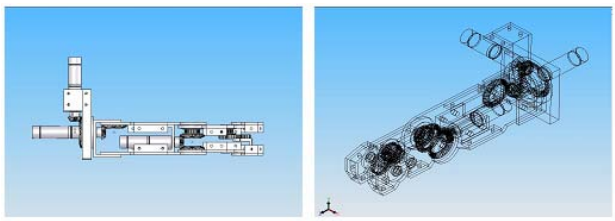

Fig. 10. The designed thumb

VI. EXPERIMENTS

We tested the explained hand motion recognition system. Fig. 11 shows the recognition result about rock. Fig. 12 shows the recognition result about scissors. Fig. 13 shows the recognition result about paper. Although background is disordered, the explained hand motion recognition system recognized correctly.

Fig. 11. The recognition result about rock

Fig. 12. The recognition result about scissors

Fig. 13. The recognition result about paper

We implemented the designed four-fingered robot hand system based on the heterogeneous reconfigurable modular architecture [9]. Fig. 14 shows the expression of rock. Fig. 15 shows the expression of scissors. Fig. 16 shows the expression of paper.

Fig. 14. The expression of rock

Fig. 15. The expression of scissors

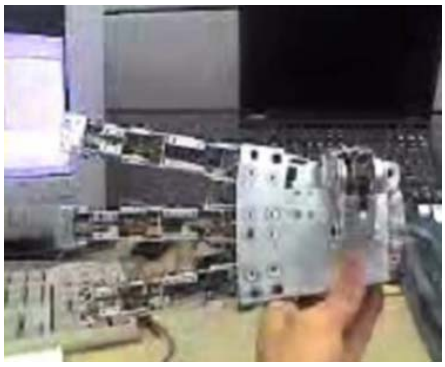

Fig. 16. The expression of paper

V. CONCLUSION

As hand of human is the most definite expression part in human body, it can be useful way for the interaction between human and robot. In this paper, we proposed the hand motion recognition system and introduced the four-fingered robot hand system. In the hand motion recognition system, we found hand by skin color detection and then, recognized the hand motion by edge detection and analysis. As the proposed hand motion recognition system classified hand motion into three categories, it had high recognition rates in our experiments.

In the four-fingered robot hand system, we designed palm, thumb, and finger using small gears instead of wires to accurate control without compensation. Then, we implemented the designed robot hand system of their fingers are controlled independently. Two systems are integrated based on the heterogeneous reconfigurable modular architecture for playing the rock-paper-scissors game. In the future, we will research about recognition of sign language.

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