High-speed Human / Robot Hand Interaction System

Rock-Paper-Scissors Robot System with 100% Winning Rate

Yugo Katsuki
Graduate School of Information Science, The University of Tokyo
Hongo 7-3-1
Bunkyo-ku, Tokyo 113-8656, Japan
yugo_katsuki@ipc.i.u-tokyo.ac.jp

Yuji Yamakawa
Graduate School of Information Science, The University of Tokyo
Hongo 7-3-1
Bunkyo-ku, Tokyo 113-8656, Japan
yuji_yamakawa@ipc.i.u-tokyo.ac.jp

Masatoshi Ishikawa
Graduate School of Information Science, The University of Tokyo
Hongo 7-3-1
Bunkyo-ku, Tokyo 113-8656, Japan
masatoshi_ishikawa@ipc.i.u-tokyo.ac.jp

ABSTRACT

We propose an entirely new human hand / robot hand interaction system designed with a focus on high speed. The speed of this system, from input via a high-speed vision system to output by a high-speed multifingered robot hand, exceeds the visual recognition speed of humans. Therefore, the motion of the interaction system cannot be recognized by the human eye. As an application, we created a system called "Rock-Paper-Scissors robot system with 100% winning rate", based on this interaction system. This system always beats human players in the Rock-Paper-Scissors game due to the high speed of our interaction system.We also discuss the future possibilities of this system.

Keywords

High-speed vision; high-speed multifingered robot hand

1. INTRODUCTION

Recently, the demand for high-speed interaction systems between humans and robots has been increasing. Such interaction systems have a possibility of enhancing efficiency in various fields, such as industrial factories, by cooperating with humans on tasks swiftly.

There have been some studies on human / robot hand interaction systems. However, to the best of our knowledge, there are no studies that place as much emphasis on high speed as we did. For example, Hoshino et al.[1] developed a robot hand that can imitate the hand motions of humans, but when a movie of the robot was checked, the system was found to have some latency, from the input of a hand motion to the corresponding output by the robot, which humans can notice [2].

The goal of the work described in this paper is to achieve a human / robot hand interaction system that operates at extremely high speed to the extent that humans cannot recognize the latency. As an application of this interaction system, we built a system called "Rock-Paper-Scissors robot system with 100% winning rate", which is described in detail in Section 3.

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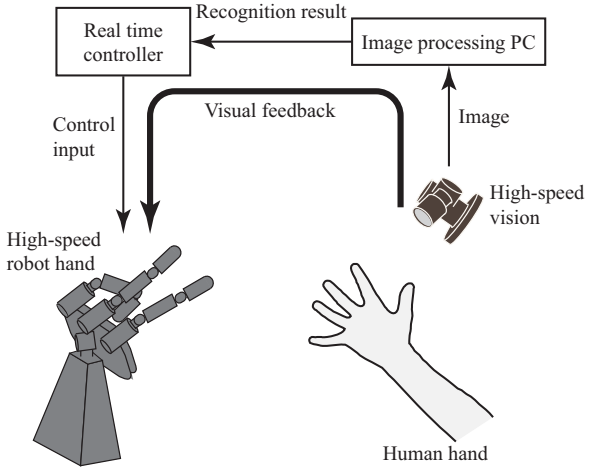

Figure 1: Overview of robot system.

2. THE DESIGN OF THE PROPOSED SYSTEM

2.1 High-speed multifingered robot hand [3]

A small harmonic drive gear® and a high-power mini actuator are used in each finger link. The motors are brushless and have high responsiveness because the gears have no backlash. This actuator is designed based on the new concept that the maximum power output should be improved. Thus, the hand can close its joints at 180 deg per 0.1 s.

2.2 High-speed vision system

In order to perform visual feedback control, we used a single high-speed camera (Eosens, MC1362, Mikrotron). Its resolution was 1280×1024 pixels. Real-time processing was

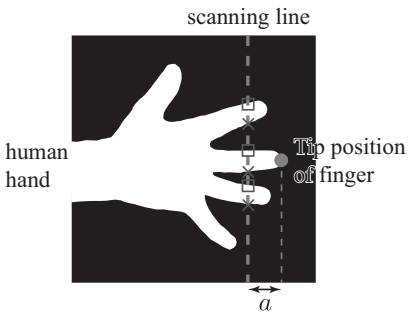

Figure 2: Image Processing for Rock-Paper-Scissors robot system with 100% winning rate.

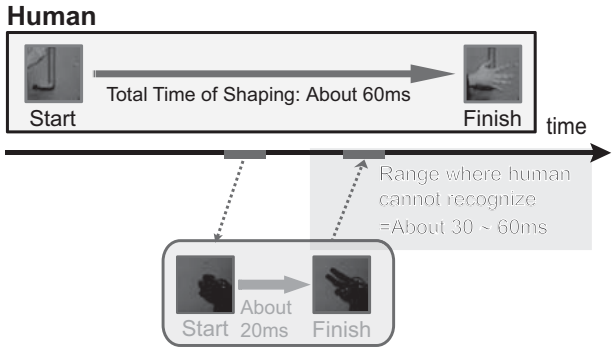

Figure 3: Time Sequence of Rock-Paper-Scissors Robot System.

performed from sensing an image to processing the image. The control PC was a Dell Precision T3400(OS: Windows XP Professional, CPU: Core2Duo 3.16 GHz, Memory: 2.0 GB). Circular infrared LEDs were installed around the camera, and a visible light cutting filter was used in order to cut noise coming from external light.

3. ROCK-PAPER-SCISSORS ROBOT INTERACTION SYSTEM AND EXPERIMENT

As an application of this interaction system, we developed a "Rock-Paper-Scissors robot system with 100% winning rate". Rock-Paper-Scissors is a game used when people want to decide a winner and a loser. This game is often played by two people. Our "Rock-Paper-Scissors robot system with 100% winning rate" always beats humans at this game. The reason is that the high-speed vision system is used to recognizes whether the hand shape is rock, paper or scissors based on the shape of the human hand. Then, the high-speed robot hand plays either rock, paper or scissors so as to beat the human player within 30 ms. It is said that humans' visual recognition speed is about 30 fps [4], and therefore, they cannot recognize this delay.

3.1 Implementation

The implementation of the "Rock-Paper-Scissors robot system with 100% winning rate" is explained in this subsection. The shape of the human hand is recognized every 2 ms by the high-speed vision system. After binarizing the input image, our algorithm detects the number of fingers in the image, and identify the kind of shape.

The algorithm is explained in Fig.2 First, the input image is binarized. Then, the position of the fingertip is detected. A line shifted to the left by a few pixels from the tip position is scanned and the number of value changes of binary image (from white to black or from black to white) is counted. We judge the kind of hand shape from this number. Then, the multifingered robot hand is controlled according to the result of image processing to beat human players, based on PD control aimed at a given joint angle.

3.2 Experimental Results

We confirmed the time sequence of the "Rock-Paper-Scissors robot system with 100% winning rate", as shown in Fig.3, by capturing the process using a Phantom v640 camera system, operating at 3000 fps. It took about 60 ms for the human player to finish changing their hand shape. The robot hand started moving about 30 ms after the human player started changing their hand shape and completed its motion within 30 ms. In this experiment, the time required to complete changing of the human's hand shape was almost the same as that for the robot hand. It is also possible for the robot hand to finish its hand motion faster than the human hand, depending on the timing of recognition using the high-speed vision system. A movie of our system can be seen at our website [5].

4. CONCLUSION

In this paper we suggested an entirely new human hand / robot hand interaction system that focuses on high speed. The speed of this system, from input via the high-speed vision system to output by the high-speed multifingered robot hand, exceeds the visual recognition speed of humans. We created an application system called "Rock-Paper-Scissors robot system with 100% winning rate" based on this interaction system, and confirmed that the speed of the interaction system exceeded the visual recognition speed of humans. If this kind of high-speed human / robot interaction system is introduced into industrial factories in the future, it would enhance efficiency in production processes by cooperating with humans on tasks swiftly.

5. ACKNOWLEDGEMENT

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