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Wire-driven two fingers robotic hand for operating a touch-sensitive panel

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Abstract: Previously, we developed a robotic system in collaboration with the Graduate School of Information, Production and Systems, Waseda University, and Shanghai Jiao Tong University. This system, named Ninomiya-kun, can read a book. It is a child-sized humanoid whose head that is equipped with two cameras, and it can communicate with humans via sounds voice and gestures. The image of a printed document, such as a picture book, textbook, or magazine, each of which has a large number of characters, is captured by the cameras, and the characters are extracted from the captured image. Using a built-in computer with character recognition software, the robot translates the extracted characters into spoken words, which are produced by a voice synthesizer. In this paper, we propose a wire-driven robotic hand system for the operation of tablet computers such as the Apple iPad and Sony Tablet, and electronic book readers such as the Amazon Kindle. It has two fingers, each of which has a wire-driven region and a touch pen at the fingertip for operating touch-sensitive panels. We describe the system configuration and wire-driven architecture herein.

Keywords: A wire-driven control, touch-sensitive panel operation, embedded software, robotic hand, two-finger hand

1 INTRODUCTION

Japan has a long and distinguished history of developing robot technologies, and robots reflect certain cultural aspects of Japan. Next-generation robot technologies are expected to be highly advanced; hence, the demand for robots for medical care and living assistance is expected to increase accordingly. Previously, we developed a robotic system in collaboration with the Graduate School of Information, Production and Systems, Waseda University, and Shanghai Jiao Tong University. This system, named Ninomiya-kun, can read a book (Fig.1) [1, 2]. It is a child-sized humanoid whose head is equipped with two cameras, and it can communicate with humans via sounds and gestures [3]. However, it has no legs; hence it cannot move around. The image of a printed document, such as a newspaper, magazine, or catalog, each of which has a large number of words, is captured by the cameras, and the words are extracted from the captured image [5, 6]. Then, the robot reads these words out loud using a voice synthesizer. In addition, it is able to turn the pages of a book. An electronic book reader with a touch-sensitive panel is extremely thin, like a magazine. It is smaller than most paperback books, and it can store hundreds of titles. Moreover, it can potentially revolutionize the struggling newspaper and magazine publishing industry. The objective of the proposed robotic hand system is to operate tablet computers such as the Apple iPad and Sony Tablet, and electronic book readers such as the Amazon Kindle. In this paper, we propose a wire-driven robotic hand system for the operation of tablet computers. It has two fingers, each of which has a wire-driven region and a touch pen at the fingertip for operating touch-sensitive panels of tablet computers. The system consists of three wire-driven actuators (pulse motors), and it is controlled using a personal computer [4, 7]. Some motions of the hand are achieved by embedded software. Each finger consists of three diarthrodial joints. A wire is fastened to each fingertip, and it is driven by each actuator. The fingertips are used for pinch-zoom, tap, and flick operations on a tablet computer in order to read words in a printed document. In this paper, we present the system architecture for realizing flexible wire-driven control, and we describe how the system achieves flexible motions.

Fig. 1. Robotic system Ninomiya-kun

2 SYSTEM STRUCTURE OF NINOMIYA-KUN'S HAND

The robotic system Ninomiya-kun is equipped with a mechanical hand in order to turn the pages of a book. This hand system is driven by a gear, and it has a mechanism of a suction pump for extracting the contents of a page. Figure 2 shows the hand of Ninomiya-kun. Further, a page whose contents are extracted by one hand is turned over, and the page turned over is held with the other hand. However, the following problems are encountered.

1. Unexpected behavior due to transient response.
2. Book damage due to metallic hand operation.
3. In turning a page by the suction pump, we looked like an unique behavior.

Solving these problems will enable us to realize flexible behavior of the robotic hand system.

(a) (b)

Fig. 2. Ninomiya-kun's mechanical hand

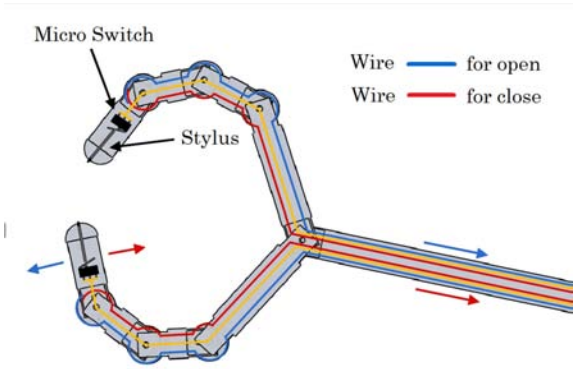

Fig. 3. Wire-driven system used to actuate the hand

Fig. 4. Test model of wire-driven two-fingered robotic system

3 PROPOSED SYSTEM CONFIGURATION

The two fingers of the robotic hand are operated by two wires through actuators, as shown in Fig. 3. We have focused on designing a wire-driven robotic system [8, 9]. Because its performance is highly dependent on the geometry of the structure, we can easily modify it in order to adapt it to various tasks [10, 11]. The ability to vary the minimal and maximal wire length is crucial because these parameters play an important role in the robot workspace, accuracy, and maximal velocities [12, 13]. This has motivated us to design a coiling system based on an actuator and pulleys. We attempt to realize a system that is made from a plastic material and equipped with a wire-driven two-fingered robotic hand. In the future, this system can be used for operating tablet computers with touch-sensitive panels, such as the Apple iPad. We used a readily available plastic material in order to minimize the weight of the system. Wires were used for operating the fingertips to realize flexible behavior of the robotic hand system. Moreover, such a setup can prevent the positioning error due to gear's backlash . Springs were used for opening and closing the fingers. The test model of the robotic system is shown in Fig. 4.

The developed wire-driven two-fingered robotic system consists of a two-fingered hand, a built-in microcomputer, and a personal computer. Figure 5 shows the system configuration, and Fig. 6 shows its hardware components.

The two-fingered hand has three diarthrodial joints driven by a pulse motor whose rotational speed is defined by the number of the pulses fed by the controlling microcomputer. One extremity of the wire is attached to a fixed point of a fingertip, and from this point, the wire goes alternately to pulleys that are attached to the diarthrodial joints and the finger links. The wire goes from the final pulley of the finger to the actuator. The system is controlled by a personal computer with Linux OS, including electronic circuits that are

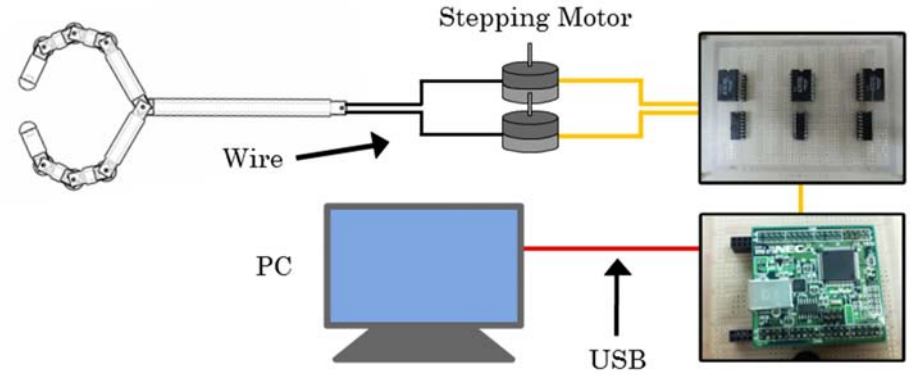

Fig. 5. System configuration

connected to a USB interface.

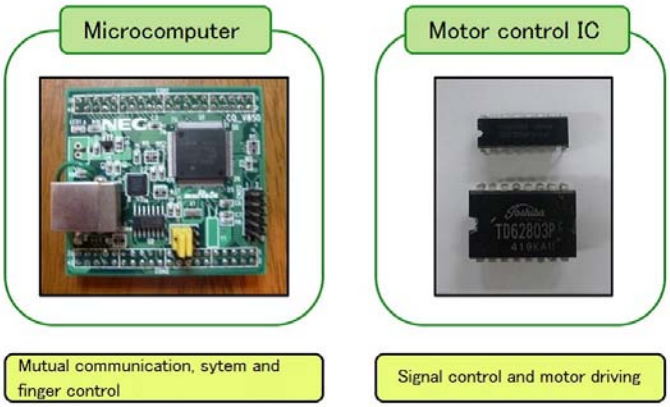

Fig. 6. Hardware components of robotic system

4 EXPERIMENTS

An experiment was conducted using the test model of the robotic system. An iPad and a smartphone placed on a special book stand were operated by the robotic hand. We evaluated the behavior of the driven parts and the system usability for tablet computers. Figure 7 shows a snapshot of the operation. We checked whether the tablet computer could be operated by the motion of the fingers. The following problems were encountered.

1. The finger size is large for operating a tablet computer and a smartphone.

2. The wire-driven mechanism becomes inoperative when the wires break.

3. The restoring force of the springs is insufficient.

5 CONCLUSION

We proposed a wire-driven robotic hand system for the operation of a tablet computer, and we realized a test model made from a plastic material. To evaluate the behavior of the driven parts and the system usability for tablet computers, we devised a strategy based on the light-weight body. This strategy was implemented experimentally using the test model of the two-fingered robotic hand system, and satisfactory results were obtained. Further development of the system is required in order to ensure flexible motion of the fingers. In addition, enhanced behavior of system can be realized by solving the identified problems.

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(a) Operating iPad

(b) Operating smartphone

Fig. 7. Hand system operating a tablet computer

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