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Finger Actions Sensing-Based Robot Motion Authoring System

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Abstract

This paper proposes a finger actions sensing-based robot motion authoring system. Based on finger actions sensing and their recognition, the proposed robot motion authoring system allows users easily to create and control robot motion according to the number and events of fingers. Furthermore, the system can be used to simulate user-created robot contents in the 3D virtual environment. This allows the users to not only view the authoring process in real time but also transmit the final authored contents. The effectiveness of the proposed motion authoring system was verified based on various motion authoring simulations of an industrial robot.

Keywords: *finger actions sensing, robot motion authoring*

1. Introduction

As the increasing number of applications adopts intelligence, and thus robot requires a new type of robot software environment that allows user to author various commands for robots. Robots must become easier to use for general users in order to expand the scope of applications of intelligent robots in our everyday life. Based on this request, a number of studies are being conducted regarding new types of user-friendly and intuitive robot motion authoring that can render various motions [1-2]. Most of user-made robot motions are based on authoring (the robot motion created and edited by user) using motion capture data [3-4]. There have been studies on how to define a framework for automatically finding primitives for human body gestures [5]. Also, there are research projects actively taking place in human-robot interaction, thanks to the progress that has been made in vision technology [6-8]. In particular, research on gesture recognition using kinect and camera sensor based remote human-robot interaction system is actively being carried out [9-10]. And there are other studies proposing algorithms to improve hand gesture recognition [11-12].

However, user-intuitive or user-friendly robot command authoring system that focus on facilitating general users are still rare. The lack of user-intuitive or user-friendly tools is likely to create a barrier for providing robot services that correspond with the preferences and demands of general users including children, the elderly and housewives, who are expected to be the major clients in the service robot industry.

This paper proposes a finger actions sensing-based robot motion authoring system. Based on finger actions sensing and their recognition, the proposed robot motion authoring system allows users easily to create and control robot motion according to the number and events of fingers. Furthermore, the system can be used to simulate user-created robot contents in the 3D virtual environment. This allows the users to not only view the authoring process in real time but also transmit the final authored contents. The effectiveness of the proposed motion

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authoring system was verified based on various motion authoring simulations of an industrial robot.

2. Proposed Robot Motion Authoring System

This paper proposes a robot motion authoring based on finger actions sensing. The proposed robot motion authoring system consisted of a PC camera, a robot motion authoring tool, and an actual robot. Figure 1 illustrates the overall process of the robot motion authoring implemented for this study.

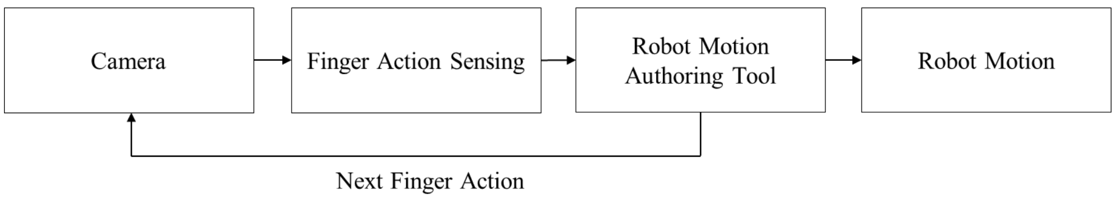


Figure 1. Proposed Robot Motion Authoring Process

There are a number of techniques for finger actions sensing, which is being used in various fields. With the exception of language, the hand is most frequently used for human communication among our body parts such as hands, eyes, mouth, arms and legs. Figure 2 show various finger actions.

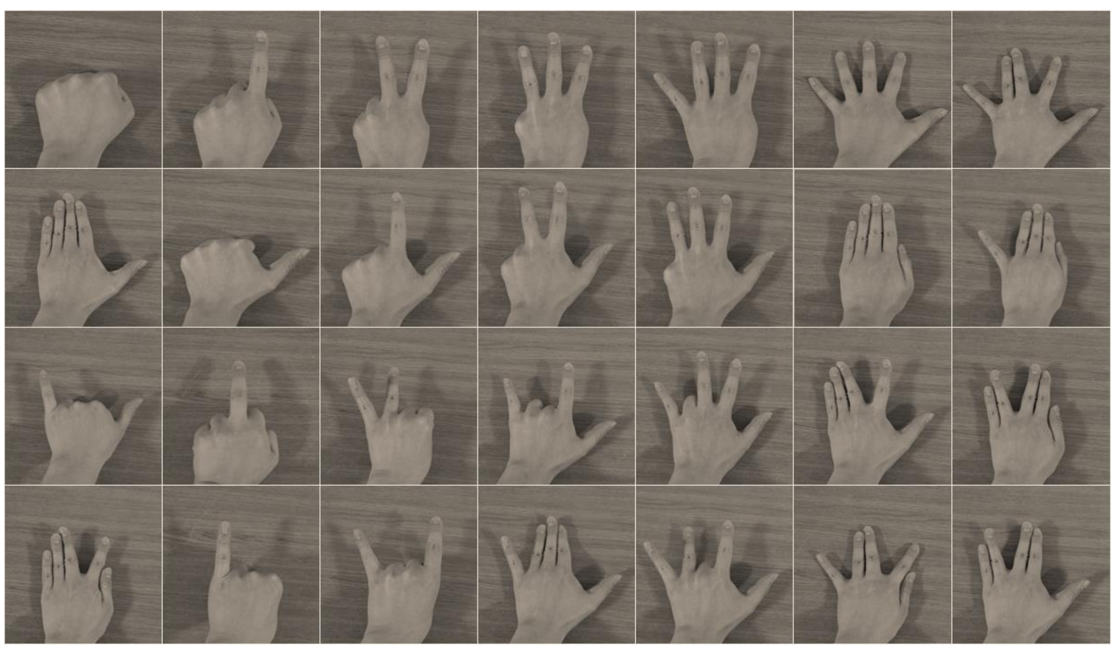


Figure 2. Various Finger Actions

In this study, finger recognition unit is implemented using color values scheme. The finger recognition unit first converts RGB colors into gray scales and YCrCb for binary representation. Then the region inside the hand is filled by masking and noise is removed. The binary image is examined in 25-pixel units. If sum of 1's examined is greater than ten, every digit is set to 1. With the image obtained by masking performed by the finger recognition unit, the center of the hand can be calculated to identify hand's location as well as the hand region furthest from the center. In this paper, a motion authoring tool capable of creating and controlling robot motions is implemented using the finger actions sensing. The motion authoring tool consists of five panels: the finger actions sensing panel, mode panel, view panel, communication panel and data panel (Figure 3).

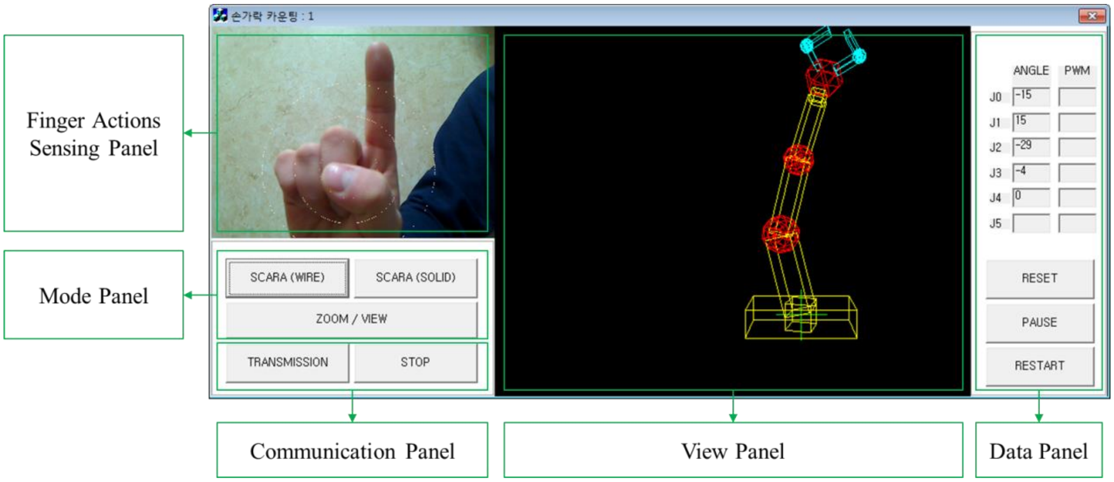


Figure 3. Robot Motion Authoring Tool

The finger actions sensing panel means the finger recognition unit that recognizes the finger actions from the finger images taken by camera. The finger actions recognized by the finger actions sensing panel allows the user to control the industrial robots (such as SCARA, articulated robot, and etc.) displayed on the view panel. The mode panel provides three modes – WIRE, SOLID and ZOOM/VIEW. The WIRE mode allows viewing of robot's internal structure and the SOLID mode only provides robot's external view. In the ZOOM/VIEW mode, the view can be zoomed in/out and rotated, allowing the user to view robot's entire structure in detail. The view panel provides the user with a real time 3D viewing of the robot motion being authored with finger actions sensing. The authored motions can be transmitted to control the robot by clicking TRANSMISSION button, and the actual robot motion can be stopped using STOP button. The data panel provides the virtual robot motion degrees and PWMs to the actual industrial robot in real time. The data panel provides RESET, PAUSE, RESTART button. If the RESET button is clicked, the robot is initialized to the default value. If the RESTART button is clicked, the robot is restarted.

3. Experimental Results and Discussions

3.1. Virtual Robot Motion Authoring Simulation using Finger Actions Sensing

In this section, we present the simulation on a virtual articulated robot motion authoring using the proposed finger actions sensing based robot motion authoring system. The finger actions sensing based robot motion authoring system proposed in this paper was implemented on a personal computer with 1GByte memory, 1.80GHz AMD AthlonTM 64-bit processor CPU and ATI Radeon X1600 graphic card that supports DirectX. As well, Logitech Webcam Pro 9000 was used. The robot motion authoring tool in this paper was implemented with

OPENGL, the open source programming library. As well, the motion ranges and directions of the virtual articulated robot are almost similar to ones of the actual robot. Figure 4 depicts how a robot part is changed in the WIRE/SOLID mode.

(a) WIRE mode (b) SOLID mode

Figure 4. Robot Motion Authoring Tool

Table 1 lists the definitions of finger-value event for WIRE, SOLID mode. In WIRE and SOLID mode, internal and external structures of the robot can be viewed, respectively. In either mode, if the number of fingers recognized by the finger interface is 0 or 4, 1-Axis or 5-Axis rotates around the Y axis. For 1, 2, 3 fingers, 2-Axis, 3-Axis, 4-Axis rotates around the Z axis, respectively.

Table 1. Definitions of Finger-Value Event for WIRE and SOLID Mode

MODE	FINGER	EVENT
A. WIRE B. SOLID	0	1-Axis rotation (base Y)
	1	2-Axis rotation (base Z)
	2	3-Axis rotation (base Z)
	3	4-Axis rotation (base Z)
	4	5-Axis rotation (base Y)
	5	6-Axis rotation (Gripper ON/OFF)

Figure 5 depicts how a robot part is downsized in the ZOOM/VIEW mode when the number of finger is recognized as 1 and 2. The ZOOM/VIEW mode allows the user to zoom in and out of the robot structure and vary the camera angle for a detailed view. Similar to the WIRE mode, the camera is rotated clockwise and counter-clockwise for 3 and 4 fingers, respectively, according to the definitions of Table 2 so that the user can view the robot from a desired angle. Accordingly, the user is able to not only create but control motions for a part of a robot based on the number of fingers recognized.

(a) ZOOM IN (b) ZOOM OUT

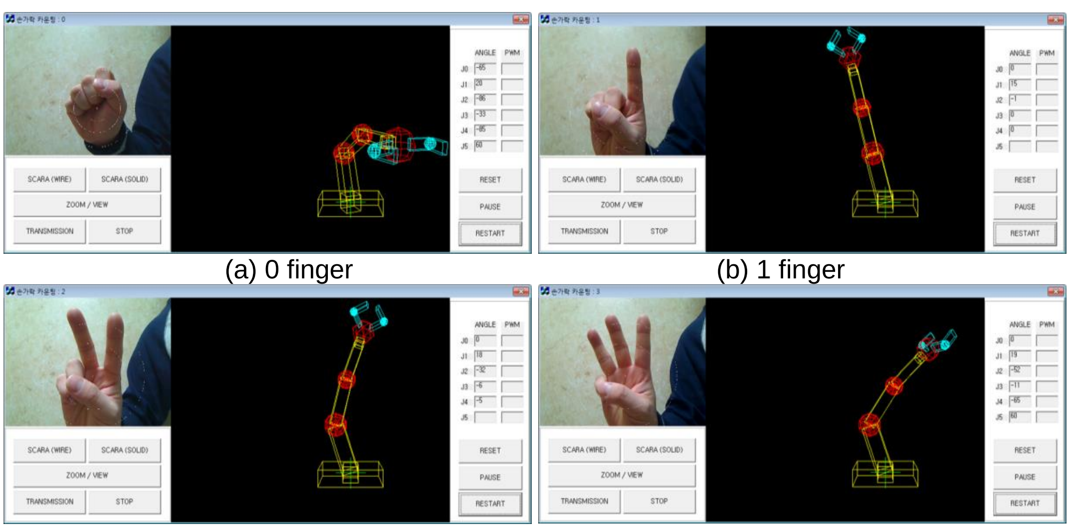
Figure 5. Downsized Robot in ZOOM/VIEW Mode with 1 and 2 Recognized

Also, a robot rotation part is enlarged in the ZOOM/VIEW mode when the number of finger is recognized as 2 and 3. Table 2 list the definitions of finger-value event for ZOOM/VIEW mode.

Table 2. Definitions of Finger-Value Event for ZOOM/VIEW Mode

MODE	FINGER	EVENT
C. ZOOM/VIEW	0	Default
	1	ZOOM OUT
	2	ZOOM IN
	3	VIEW rotation(CW)
	4	VIEW rotation(CCW)

Figure 6 shows the measured virtual robot motion authoring experimental results. The experimental results confirmed that the finger actions sensing based robot motion authoring system proposed by this study provides general users with an intuitive, fun and easy way to create motions.



(a) 0 finger (b) 1 finger

(c) 2 fingers (d) 3 fingers

(e) 4 fingers (f) 5 fingers

Figure 6. The Virtual Robot Motion Authoring Experimental Results

3.2. Actual Articulated Robot Motion Authoring Simulation using Finger Actions Sensing

The purpose of experiment in 3.2 was to confirm whether or not robot motions authored by the proposed system works with an actual robot well. Actual articulated robot is an miniature-type robot. The maximum height of the used robot is 536mm, and the maximum width is 116.5mm. Also, the maximum arm length is 470mm [13]. 7 RC-servo motors were used. For control, the robot arm can be easily controlled by a computer or embedded board by using NT-SERVO-16CH-1 and NT-USB2UART. The proposed authoring system as shown in Figure 7 consisted of a robot motion authoring tool, a PC camera, and an actual articulated robot. The motions authored by the tool were applied to an actual robot for the experiment. The motion data was transmitted to the robot using serial communication and it was examined how the contents produced by the robot motion authoring tool controlled the robot according to user's intention. Figure 7 shows the experimental environment of an actual articulated robot motion authoring simulation.

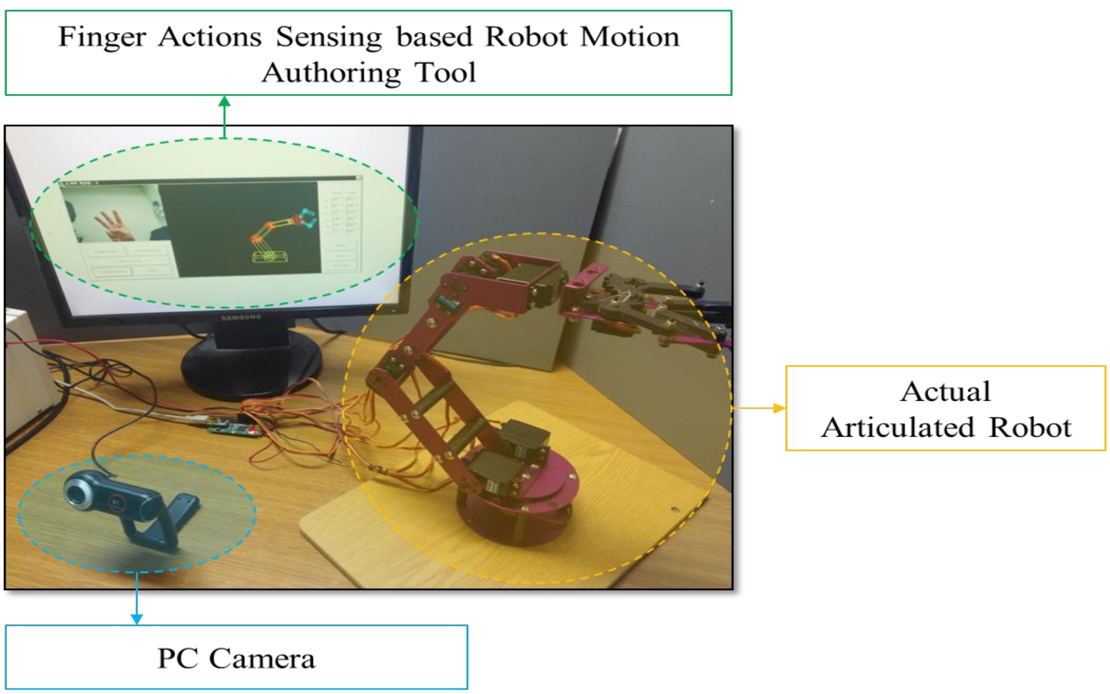


Figure 7. Experimental Environment of an Actual Articulated Robot Motion Authoring Simulation

The following figures show actual articulated robot motion authoring simulation results on various motions. Also, the following tables show the measured robot motion data for the transmission. In this section, simulation was conducted to measure the robot motion data based on various motions (such as motion #1, motion #2, motion #3, and motion #4). Figure 8 shows the experimental result of an actual articulated robot motion #1.

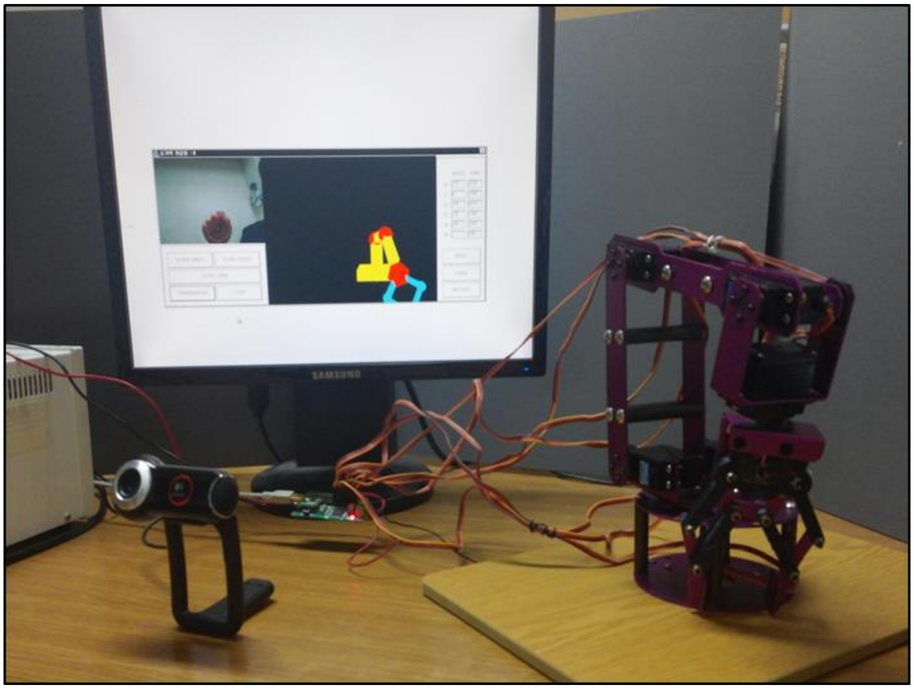


Figure 8. Experimental Actual Articulated Robot Motion #1 Result

Table 3 shows the degree of the joint value, and the corresponding PWM value to drive the torque of the brake proportionally to the torque sensed by the proposed finger actions sensing based robot motion authoring system in experimental motion #1. From the experimental result, we confirmed both the degree and PWM values for motion #1 authoring using the proposed authoring system.

Table 3. The Result Data of Actual Articulated Robot Motion #1

CHANNEL	DEGREE	PWM(0700-2300)
Ch0	-70	1970
Ch1	0	1600
Ch2	-80	2216
Ch3	-55	1326
Ch4	-60	1864
Ch5	0	700

Figure 9 shows the experimental result of an actual articulated robot motion #2.

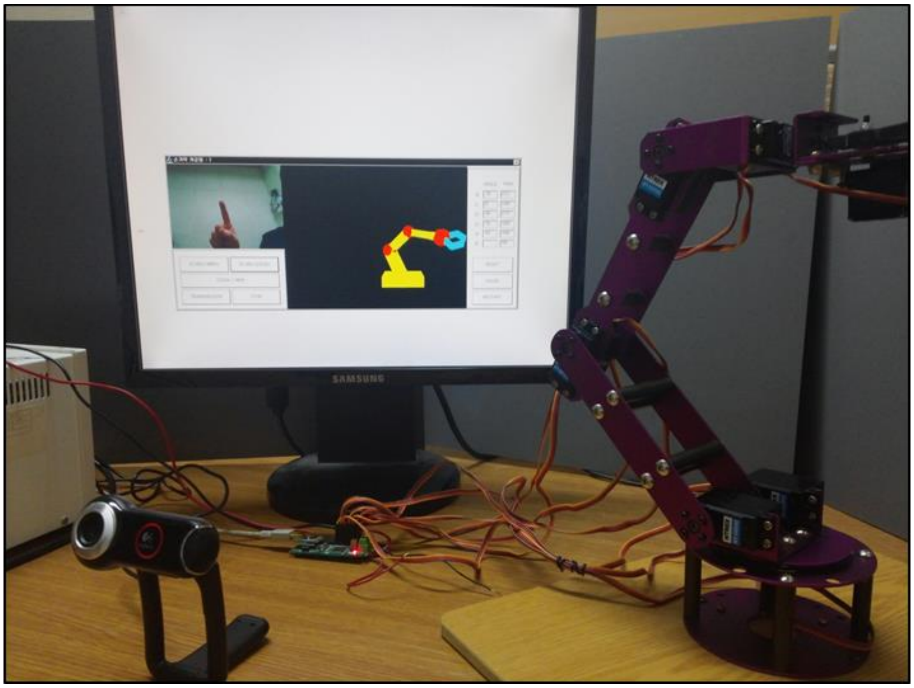


Figure 9. Experimental Actual Articulated Robot Motion #2 Result

Table 4 shows the degree of the joint value, and the corresponding PWM value to drive the torque of the brake proportionally to the torque sensed by the proposed finger actions sensing based robot motion authoring system in experimental motion #2. From the experimental result, we confirmed both the degree and PWM values for motion #2 authoring using the proposed authoring system.

Table 4. The Result Data of Actual Articulated Robot Motion #2

CHANNEL	DEGREE	PWM(0700-2300)
Ch0	-30	2212
Ch1	30	1948
Ch2	-80	2177
Ch3	-50	1680
Ch4	-60	1644
Ch5	0	700

Figure 10 shows the experimental result of an actual articulated robot motion #3.

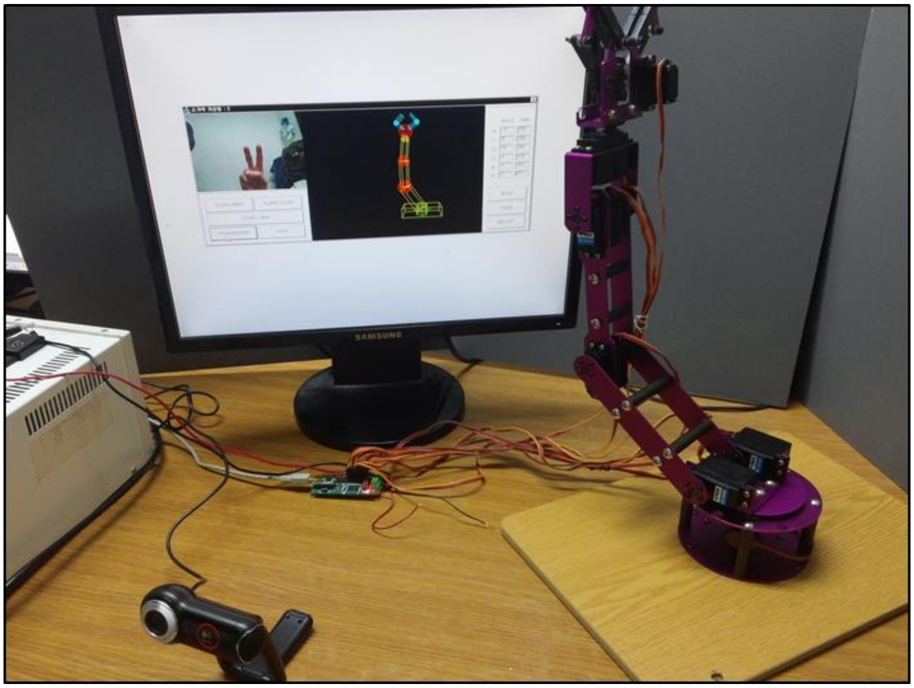


Figure 10. Experimental Actual Articulated Robot Motion #3 Result

Table 5 shows the degree of the joint value, and the corresponding PWM value to drive the torque of the brake proportionally to the torque sensed by the proposed finger actions sensing based robot motion authoring system in experimental motion #3. From the experimental result, we confirmed both the degree and PWM values for motion #3 authoring using the proposed authoring system.

Table 5. The Result Data of Actual Articulated Robot Motion #3

CHANNEL	DEGREE	PWM(0700-2300)
Ch0	-10	2256
Ch1	35	2006
Ch2	-34	1861
Ch3	-6	2193
Ch4	-5	1622
Ch5	10	877

Figure 11 shows the experimental result of an actual articulated robot motion #4.

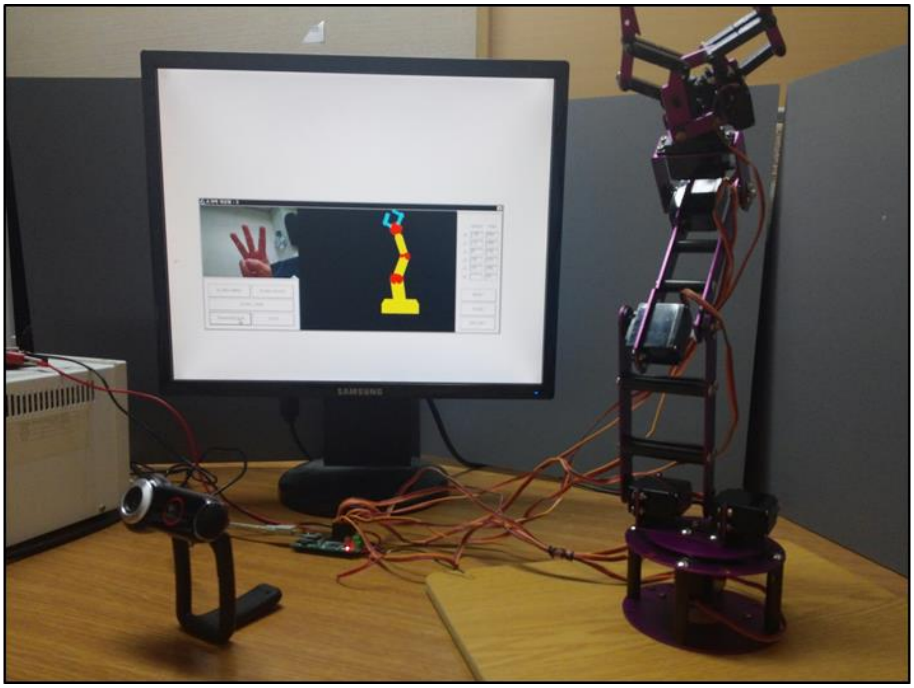


Figure 11. Experimental Actual Articulated Robot Motion #4 Result

Table 6 shows the degree of the joint value, and the corresponding PWM value to drive the torque of the brake proportionally to the torque sensed by the proposed finger actions sensing based robot motion authoring system in experimental motion #4. From the experimental result, we confirmed both the degree and PWM values for motion #4 authoring using the proposed authoring system.

Table 6. The Result Data of Actual Articulated Robot Motion #4

CHANNEL	DEGREE	PWM(0700-2300)
Ch0	-140	1684
Ch1	10	1484
Ch2	35	1330
Ch3	-50	1415
Ch4	-65	1886
Ch5	0	700

4. Conclusion

This paper proposed an authoring system capable of creating and controlling motions of industrial robots based on finger actions sensing. The proposed system is user-friendly and intuitive and facilitates motion authoring of industrial robots using fingers, which is second only to language in terms of means of communication. The proposed authoring system also uses graphic motion data to simulate user-created robot contents in a 3D virtual environment so that the user can view the authoring process in real time and transmit the authored robot contents to control the robot. The validity of the proposed robot motion authoring system was examined based on simulations using the authored motion robot contents as well as experiments of actual robot motions. The proposed robot motion authoring method is expected to provide user-friendly and intuitive solutions for not only various industrial robots, but also other types of robots including humanoids.

Acknowledgments

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