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# Implementation of a Gesture Recognition Signage Platform for Factory Work Environments

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***Abstract***

*This paper presents an implementation of a gesture recognition platform that can be used in a factory workplaces. The platform consists of signages that display worker's job orders and a control center that is used to manage work orders for factory workers. Each worker does not need to bring work order documents and can browse the assigned work orders on the signage at his/her workplace. The contents of signage can be controlled by worker's hand and arm gestures. Gestures are extracted from body movement tracked by 3D depth camera and converted to the commands that control displayed content of the signage. Using the control center, the factory manager can assign tasks to each worker, upload work order documents to the system, and see each worker's progress. The implementation has been applied experimentally to a machining factory workplace. This flatform provides convenience for factory workers when they are working at workplaces, improves security of techincal documents, but can also be used to build smart factories.*

**Keywords:** *Gesture Recognition, 3D Depth Camera, Digital Signage, Smart Factory*

## 1. Introduction

With the interest in smart factories, various types of technologies have been developed to improve the factory environment and provide convenience to factory workers. However, these new technologies almost have not been applied to the fields called Root (Ppuri) Industry of Korea. In this work, we implemented a platform that provides convenience to workers and managers in factories where workers mainly do machining according to work orders. Using this platform, managers can assign works to each worker and register work orders at the control center, and workers can easily view the contents of work orders assigned to them through signage in the workplace. When changing the content displayed on the signage, the 3D depth camera recognizes the worker's gesture and executes the associated command. Since the screen is not touched by hands or additional input devices are not used, it is suitable for workplaces with dirt and grease, and can be controlled without leaving the workbench during work, which can help increase work efficiency. It also prevents information leaks by eliminating the need to print out technical documents such as work instruction sheets. However, in order to apply the platform to factory workplaces practically, it is necessary to improve reliability

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and robustness of the system.

The rest of this paper is organized as follows. Section 2 presents the background and related work, and Section 3 discusses the implementation of gesture recognition interface. Section 4 describes the implementation of the factory work management platform, and Section 5 gives conclusion and future works.

## 2. Background

### 2.1 Gesture Recognition Technologies

Gesture recognition technologies are currently used in diverse areas, such as human computer interaction, driver assistance, sign language recognition, action/gesture recognition for content retrieval and categorization, and surveillance [1]. Several types of devices can be used for gesture recognition. Examples of devices used for gesture recognition include mobile devices with GPS and accelerometer, inertial sensors with accelerometer and gyroscope, Google Glasses for egocentric computing, thermal imagery for action recognition, active gloves, passive gloves, and 3D depth cameras [1].

In order to control the displayed content as in this work, it is appropriate to analyze the image using 2D video or track the movement of the human body using 3D sensor. As a research using 2D image, a method extracts the hand region from real image and creates augmented object by hand marker from hand-gesture is proposed [2], and a solution for gesture analysis using the embedded 2D camera of a mobile device is introduced [3]. On the other hand, some researchers adopted 3D sensors like Kinect and Leap Motion. Ren et al. presented a hand gesture recognition system with Kinect sensor, which operates robustly in uncontrolled environments and is insensitive to hand variations and distortions [4]. The work of Aliprantis et al. describes implementation procedure of free-hand gestures using the Leap Motion sensor in an augmented reality framework [5]. Kim et al. developed a hand gesture control system that tracks a hand using a Kinect sensor and provides tactile feedback to the hand [6].

### 2.2 Gesture Recognition for Smart Factory

Gesture recognition technologies are being used in factories. There are some experimental approaches of using gesture recognition in factories. A gesture-based interaction prototype was developed for controlling the loading station of a factory automation system [7]. Augmented reality smart glasses (ARSG) are expected to be a vital technology supporting operators in the smart factories of the future [8]. User interactions based on visual contexts and gesture interactions are classified and evaluated using ARSG [9].

However, workers cannot wear ARSG when they do a specific kind of work, such as welding, because wearing a protection mask is necessary. It is also inconvenient to wear smart glasses while doing other kind of work in the factory workplace. We need a method for recognizing gestures without using smart glasses or additional devices for worker's convenience.

Gesture recognition can be used for various purposes, such as operating a machine or manipulating a virtual or real display. For the system where machine operations are controlled by gestures, reliability and safety are very important issues because a serious accident may occur due to an incorrect operation.

## 3. Implementation of Gesture Recognition Interface

In this work, Kinect sensor is used as 3D depth camera, which can track motion of human body joints. Although Leap Motion that tracks hand and finger motion can recognize sophisticated gestures, we decided to use Kinect because distance between a workbench and a signage is normally over one meter. Kinect recognizes the human body as 20 joints. In this study, the range of gestures was limited to hands and arms. Gestures are recognized by separating the position of hands and arms over time into 50 to 100 frames.

Gestures were designed to control the content of signage showing work orders in the factory workplace. Gestures using gloves or a separate mobile device can interfere with work, so a hand gesture using a 3D depth camera is appropriate. Even if workers wear thick gloves for safety, it is possible to extract motion because Kinect tracks human body joints. Delicate motions are excluded and less error-prone gestures are used because the main target is machining factories where workers do cutting, grinding, and welding. For worker's safety, gestures that use the entire body are excluded, and five gestures using hands and arms are selected, including *SwipeLeft*, *SwipeRight*, *SwipeUp*, *SwipeDown*, and *DrawCircle*. The gestures were designed and built by using Kinect toolkit. More than 10 persons participated to gesture building process to reduce possibility of misrecognition due to personal characteristics. Figure 1 shows a part of gesture building process using Kinect toolkit. Table 1 shows the key mapping and the corresponding actions of the gestures for the signage interface. Workers use gestures to control displayed content of the signage. The key mapping and corresponding actions can be changed simply if needed.

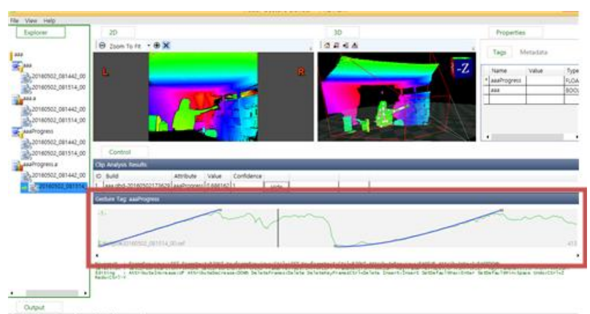

**Figure 1. An example of a gesture building process**

**Table 1. The gestures, key mappings, and corresponding actions**

| Gesture | Key | Action |
|---|---|---|
| SwipeLeft | Left Cursor | Move to the previous page |
| SwipeRight | Right Cursor | Move to the next page |
| SwipeUp | Home | Move to the first page |
| SwipeDown | End | Move to the last page |
| Circle | Esc | Finish |

Since Kinect can track up to six people in one frame, the one-person limited function was implemented to avoid being influenced by others around the workplace. The one-person limited function gives control to the first recognized person and only traces the person's gesture, thereby reducing the possibility of malfunction by others. Figure 2 shows the process of recognizing a gesture by tracking the worker's motion, converting it into a command that controls the content of the signage, and executing it. When a worker thinks that a gesture is not recognized, a duplicate event may be generated by repeating the same gesture. In addition, there are cases where an unwanted gesture occurs in the process of the operator turning back the hand to normal position after making a gesture. In order to handle those cases, a command queue is placed in the command dispatcher so that commands that occur consecutively within a short time are not executed. By adopting this, there may be cases where a worker's intended command is not executed, but a worker rarely feels uncomfortable because the worker who thinks the gesture is not recognized immediately makes a gesture again. On the contrary, if gestures are recognized too sensitively from the worker's perspective, it may be inconvenient because the working action may be translated into a command.

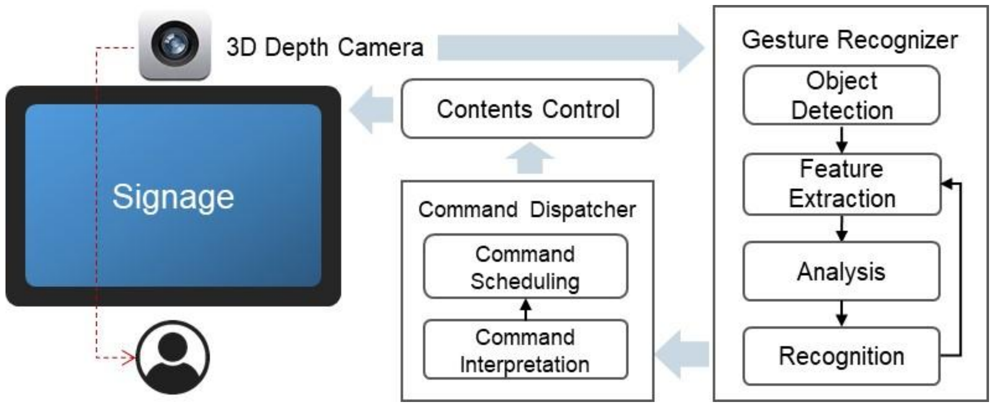


**Figure 2. The process of recognizing gestures and executing commands**

## 4. Implementation of Work Management Platform

In this work, we implemented a factory work management platform in which the manager directs the work by using the work control center in the office and the workers view and work on according to the information displayed on the signage in workplaces, as shown in Figure 3.

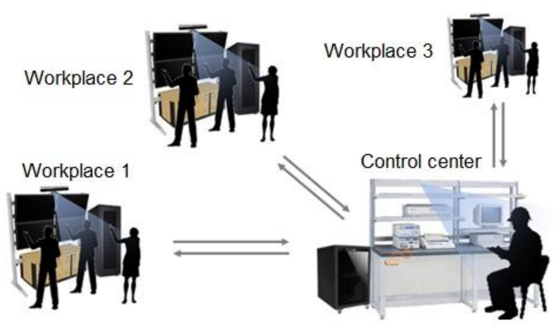


**Figure 3. A control center and workplaces in a factory environment**

The production manager assigns tasks to workers and uploads work order sheets to the system. When the worker authenticates himself/herself in front of the signage in the workplace, he/she can see the list of tasks assigned. It is also possible to authenticate the worker using face recognition [10]. The worker selects a task to do from the list, and if it is the first time to do the task, a page for signing the work agreement form is displayed. After signing the form, the work order will be shown. If the worker selects a task previously worked on, the last page worked on is shown. The worker uses the gesture to change the content displayed on the signage. When the work is done, the manager will be notified that the worker has completed the task. Figure 4 shows the overall process of work management. Using such a procedure has the advantage of reducing the risk of loss or information leakage because it is not necessary to print and carry a work order sheets, and it is easy to manage work progress assigned to each worker. Workers can also check the tasks assigned to them in the workplace, which can help manage their schedule. Since the work agreement is kept in the system, it is also helpful to be prepared for legal issues that may arise in the future. Figure 5 is the work agreement signing form and the first page of the work order that appears after signing the form displayed on the signage. The following pages of the work order consist mainly of machining instructions and the worker can move through the pages displayed on the signage using gestures while staying at the workbench.

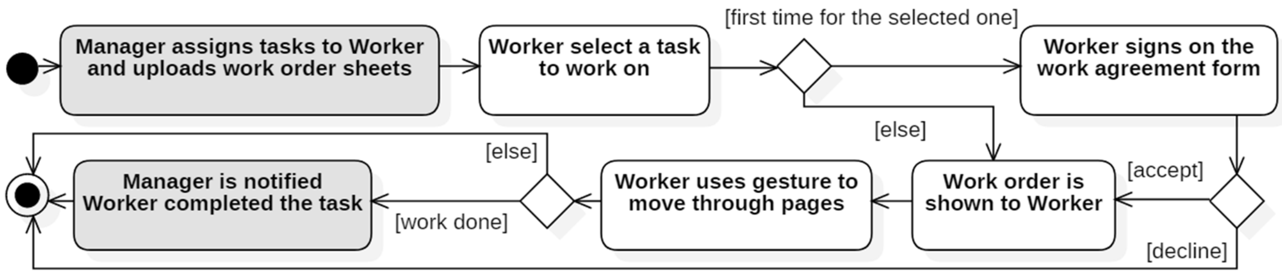


**Figure 4. The overall process of work order management**

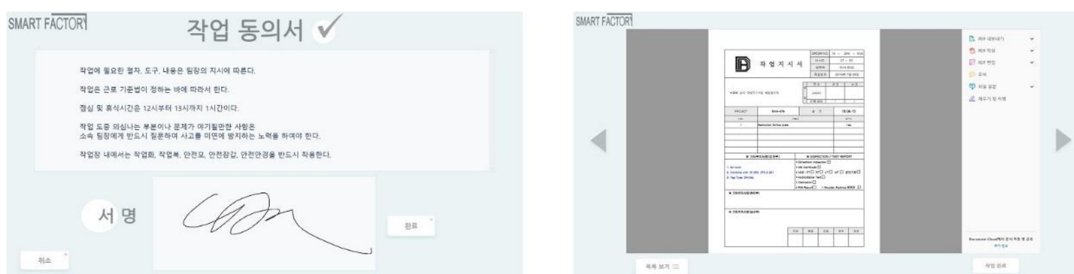


**Figure 5. The work agreement form (left) and the first page of a work order (right)**

Figure 6 shows the control center and signage arrangements in the factory offices and workplaces. The practical tracking distance of Kinect is one to three meters, and it uses infrared rays to measure distance, so workers can be tracked regardless of lighting or brightness in the workplace. Kinect continues to track workers, but the computing load is not high. Workplace signage can also be used to display useful information when not displaying work orders.

**Figure 6. The control center (left) and the workplace signage (right)**

## 5. Conclusion

In this work, a signage system on which workers can view work orders in the display and control the displayed content by using gestures was implemented. Workers can easily browse content in the workbench with bare or gloved hands using gestures. In addition, a system in which a production manager can assign tasks to workers and manage work orders was implemented. These systems help both managers and workers manage their work and building a smart factory environment. The signage consists of a 3D depth camera, a display screen, and a mini PC. Since the computing overhead for gesture recognition is not so high, extra computing power can be used for other purposes like face recognition [10]. Adding safety monitoring function to the signage using 3D coordinates of human body joints is considered as a future work.

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