

Multi-Level Image Presentation Method to Quickly Know Operation Processes of Students for Finding Erroneous Operation

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Abstract—In this paper, we developed a system that helps teachers to identify the erroneous operations of a student in computer literacy classes quickly. We considered two requirements for the system: (1) recording all operations, and (2) providing summarized information according to teacher's requests. For the first requirement, the system records screen image for all operations that are acquired by global hook events. For the second requirement, we proposed the multi-level image presentation method. First, all captured images are grouped hierarchically according to their contents. Then, teachers browse captured images by controlling the level of grouped images. Consequently, they reduce the number of images to be confirmed and find erroneous operations quickly. We confirmed the effectiveness of the proposed method through the experiment. Subjects try to find erroneous operations from more than 700 images. Subjects using the proposed method decreased the time for finding erroneous operations by 60%.

Keywords—Compute-assisted instruction; Operation Process

I. INTRODUCTION

Recently, classes in which students use their personal computers are spreading. For classes of a freshman in college, students do some kind of work, programming, writing a report and so on, by using their computers according to a teacher's guide. Some students cannot do the same operation as the guide by the teacher and sometimes cause undesired results. Since students do not understand operations enough, they cannot be aware of erroneous operations, which are causes of undesired results. They would be aware that something was wrong, only after being aware of an undesired result. But they cannot identify the erroneous operation since they did many operations before the undesired result and they believe that their operations were correct. So, they would be confused and ask for help to the teacher. The teacher identifies the erroneous operation by inquiring the operations or by his/her experience. Identifying by inquiring would be hard for the teacher since the student was already confused. So, teachers want to retrace operations to the erroneous operation with a supporting system.

To retrace students' operations, some supporting systems were developed. They record students' operations and provide the teacher with the recorded operations. For example, some methods recording the screen of the student in video format and finding the operation process by seeing the video have been proposed [1]-[3]. By using these methods, the teacher can know all operations that the student performed. However, the teacher would waste time by using these methods, because it is necessary to confirm the video regardless of presence or

absence of student's operation. There are several methods that capture the screen each time a student operates, rather than always recording [4][5]. The teacher can know the operation process of the student by confirming the captured images one by one. However, since most captured operations are correct operations, looking at all the operations takes time to identify the erroneous operation. To reduce the time for checking student's operations, it is necessary to reduce the number of images that the teacher checks furthermore. On the other hand, reducing the number of images would cause the shortage of information to identify the erroneous operations. The shortage would be serious for Teaching Assistant(TAs) who are not familiar with the operation to identify the erroneous operation by only seeing the limited operations. So, it is necessary both to record all operations and to easily detect

In this paper, we describe a system to help teachers identify the erroneous operations of the student quickly. The system records all operations and provides the operations so as to be grasped by them quickly. Recording all operations is similar to the one from [5], and quickness for grasping is done by providing hierarchically grouped operations. If the teacher wants to grasp the operation process roughly, the he/she checks the images containing only the main operations. Also, the teacher looks at all the images if the teacher wants to grasp the operations in detail. By using this method, the teacher can quickly grasp the student's operation process without missing the operations and can identify the erroneous operations of the student as soon as possible.

This paper contains the following flow. Section II describes the method underlying the proposed method. In Section III, we consider how to present the operation information. We discuss the effectiveness of our proposed method in Section IV. Section V presents the conclusion and future work.

II. PREVIOUS METHOD USING GLOBAL HOOK

This section briefly describes the student's screen recording method which is one of the previous methods using a global hook [4]. This method detects students' operations, captures the screen of the student each time the student operates and provides captured images in order to the teacher.

To detect the student's operation, a mechanism called the global hook, which is provided by an operating system is used. The global hook can intercept messages sent by the operating system to an application. Messages intercepted by the global hook include messages generated by a keyboard or a mouse. These messages are sent at the moment each event occurs.

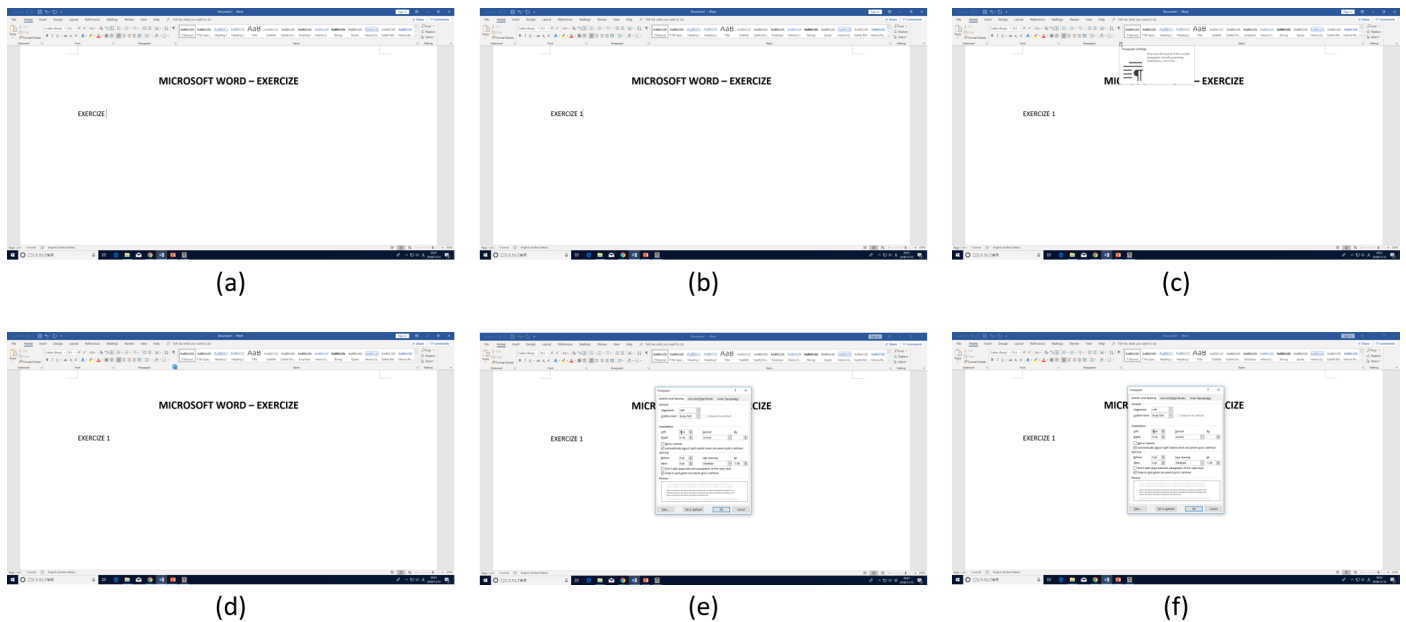


Figure 1. A sample of display by the global hook.

(a) Pressing [space] key, (b) Pressing [I] key, (c) Pressing left click, (d) Releasing left click, (e) Pressing left click, (f) Releasing left click

This method captures the screen when a user's operation is acquired with the global hook. Thereby, the operation process of the student is accumulated in the student's computer as some images.

The captured images are sorted and are provided to the teacher. When the teacher wants to confirm the operation process of the student, he/she sees the captured images one by one in order. By confirming the captured images, the teacher can guess the student's operation. Figure 1 shows images captured by the previous method, arranged in alphabetical order. By looking at these images in order, the teacher finds that the student inputs a sentence, then operates a menu with the mouse, and opens a dialog box.

By knowing the operation process of the student, the teacher can identify the erroneous operations. However, this method has a problem in that it is necessary to confirm all images captured between the moment students started operating and the moment the teacher was asked for help.

III. PROPOSAL

In this section, we propose a method that groups operations hierarchically. With the proposal, the system provides fewer images than the previous system without reducing captured images. As a result, teachers should identify erroneous operations quickly.

The proposed system makes groups from all captured images. In the lowest level (level 0), each group consists of one captured image, which represents one student's operation. In the higher level (level n), each group is a series of some groups of the level below (level $n-1$) and represents a meaningful operation. The representative image of each group is the last captured image in the group.

The proposed system provides grouped images hierarchically. First, the system shows representative images of the

groups only at the highest level. The teacher grasps the student's operations roughly and identifies the group to be focused. Then, the system shows representative images of the groups in the below level of the focused group. The teacher narrows the area to be focused. The teacher repeats them until he/she identifies the erroneous operation.

With the proposed system, teachers can identify the student's erroneous operation quickly, since they can concentrate only on a subset of images. And they do not miss the erroneous operation since they can look all captured images if necessary.

The effectiveness of the proposed system is decided by the rule for grouping. The rule should be decided by the application, target students and target teachers. Here, we show an example for Microsoft Word. When working in Microsoft Word, this method intercepts mouse and keyboard messages given to the operating system. Because messages in software can not be intercepted by proposed system in current state of the art, groups operations similar to messages in software from keyboard and mouse messages. In level 0, each group consists of only one captured image. In level 1, each group consists of a series of groups of level 0 images that represent a primitive operation: typing a word, operating a keyboard shortcut, clicking/double clicking a left/right button of a mouse, and so on. Typing a word is identified by the sequence of key inputs except for space or enter key. Clicking the left mouse button is identified by pressing/releasing event of the left button of the mouse. Other operations are grouped in the same manner. In level 2, each group consists of a series of groups of level 1 that represent a more-abstracted operation: typing a sentence, a combination of keyboard short-cut, selecting a menu by the mouse, and so on.

Figure 2 illustrates the grouping result for Microsoft Word in Japanese. These were taken at the time of writing a report in Japanese. From the level 0 to 1, the first (typing a character) to the third (typing enter key) images in the level 0 are grouped

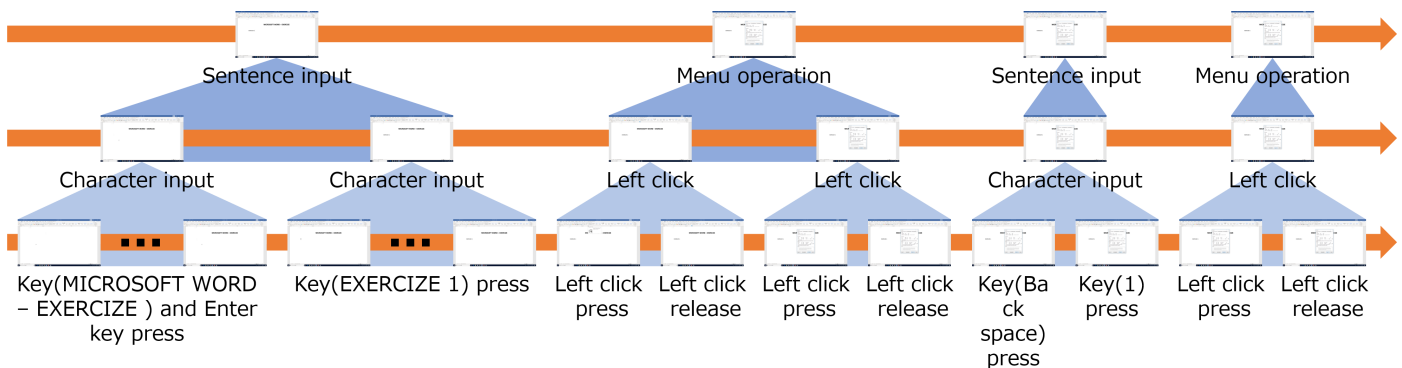


Figure 2. A sample of multi-level image presentation.

as character input. And the fifth (pressing the left mouse button) and the sixth (releasing the left mouse button) images are grouped as left clicking. From the level 1 to 2, the first (character input) and the second (character input) images in the level 1 are grouped as typing a sentence. And the third (left clicking) and the fourth (left clicking) images in the level 1 are grouped as operating a menu.

When browsing the results shown in Figure 2, the system provides images of level 2 first. Then, a teacher selects an image on level 2. Then the system shows images on level 1 that are components of the selected image. And the system shows images on level 0 in the same manner if necessary.

IV. EXPERIMENTS

In this section, we compare the proposed method with the previous method and confirm the effectiveness. We

A. Experimental Setup

Our aim is that teachers can quickly find an erroneous operation of student. To confirm the effectiveness, we measured the time that it takes testing subjects to find an erroneous operation and compared the case using the proposed method with the case using the previous method. The number of subjects is six. We explained only the contents of the exercise to the subjects. And we asked them to identify the operation error without informing the contents of the operation error. Subjects confirmed the operation process in Microsoft Word exercise. The content of the exercise in this Microsoft Word is preparation of materials, there are operations such as text input, size of letters, typeface change and indent adjustment. The images presented to the subjects were prepared by reproducing the operation error when the student made a mistake in selecting the item in the dialog box before. The operation recorded in this experiment corresponds from the start of the exercise to the student himself made an operation mistake. There are 744 recorded operations, and the erroneous operation is in the 725th. The content of the erroneous operation was to select First line instead of selecting Hanging. The number of captured images was 744, and the number of images presented at each level of the proposed method is shown in Table I.

B. Result

We divided subjects in half and asked each group to discover operation errors by either proposed method or previous

method. The table II shows the average time it takes for the subjects to specify the operation mistake when using the proposed method or using the previous method. Comparing the two average times, we found that, in the case of the proposed method, the subjects identified erroneous operation in about half the time of the case of the previous method. We got the following comments from the subjects.

- Even for the TA, who is not familiar with the operation to the application, it is possible to grasp the point where the operation error is likely to be somehow. There is a possibility that he can also find a mistake by looking closely around the point which is likely to be bad.
- In the previous method, it is hard to find an operation mistake because there are a lot of images to be confirmed.

We observed how to check captured images of the subject. As a result, we found that the subjects confirmed the image in order from the image of the operation start regardless of the method. The subjects confirmed the images one by one and grasped the operation process of the student. And, when the subjects found an image when an operation error occurred, they re-examined the previous image and found an erroneous operation.

In the case of the proposed method, the subjects used high level display to grasp the operation process roughly, when the subjects found an image when an operation error occurred, they used low level display and found an erroneous operation. From this, we fathomed that subjects could roughly grasp the operation process of student even using the proposed method. Since the proposed method can present the image of

TABLE I. NUMBER OF IMAGES PRESENTED BY THE PROPOSED METHOD.

Display level	Number of presented images
Level 3	255
Level 2	288
Level 1	744

TABLE II. TIME TAKEN TO IDENTIFY ERRONEOUS OPERATION.

Method	Average time(s)
Proposed method	167.3
Previous method	284.6

the moment the student erroneously operated earlier than the previous method by using the high level display, it is possible to quickly find the erroneous operation.

From these considerations, we can affirm that the proposed image display method is effective.

V. CONCLUSION

In this paper, we developed a system that helps teachers identify the erroneous operations of the student quickly. We considered two requirements for the system: (1) recording all operations, and (2) providing summarized information according to teacher's requests. For the first requirement, the system records screen images for all operations that are acquired by global hook events. For the second requirement, we proposed the multi-level image presentation method. First, all captured images are grouped hierarchically according to their contents. Then, teachers browse captured images by controlling the level of grouped images. Consequently, the system reduces the number of images to be confirmed and find erroneous operations quickly. In the future, we will try to increase global hook events: not only keyboard and mouse operations but also other types of information, and discuss strategies for grouping captured images.

The recording system has privacy concerns. For that reason, we will implement recording on / off in the future and investigate how the student's behavior, such as whether the student can install this system, is affected.

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