Feedback-Based Self-training System of Patient Transfer

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Abstract. In this paper, we propose a self-training system to assist nursing students to learn nursing skills. The system focuses on the task of transferring a patient from a bed to a wheelchair. In the system, two Kinect sensors were applied to measure the posture of the trainees and patients and an automatic evaluation method was used to classify the trainees' performance in each skill as correct or incorrect. A feedback interface based on a checklist was designed to help the trainees check whether they performed correctly. The system is designed for the trainees to operate by themselves. A control test was performed to measure the training effects of the system. The results show that the growth rate of the group that trained with feedback (79%) was higher than the group that trained without feedback (48%).

Keywords: self-training system, patient transfer, Kinect sensor, nursing skills, feedback.

1 Introduction

In a nurse's daily work, many physical tasks are related to lifting or moving patients, such as bathing, dressing, and transferring a patient from a bed to a wheelchair [1]. In carrying out these heavy-workload tasks, it is easy to cause injury to both the patient and the nurse [2–4]. In order to avoid these problems, nurses need to concentrate on the patient and also apply their nursing skills. However, it can be difficult for nursing students to master the many complicated skills required. As a result, it is important to find an efficient way to help nursing students to learn these skills. One solution is to provide a self-training system that can monitor the performance of trainees automatically and then instruct them to improve their nursing skills.

Previous studies of nursing skills have focused mainly on the analysis of nurses' motion [5], economic evaluation [6, 7], or patient comfort [8], but none have involved the construction of a self-training system. However, training systems have been proposed for a variety of other physical tasks such as worker posture [9], aerobics

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[10], dance [11], and Tai Chi [12]. Yet these systems were limited as they were designed for a single person. Currently, no research focuses on a physical multiperson task.

To achieve our long-term goal, and focusing on the nursing skills of transferring a patient from a bed to a wheelchair, we initially developed a sensor system to measure and evaluate the performance of trainees based on Kinect sensors [13, 14]. However, a feedback method and interface were not involved. Therefore, the aim of this study was to provide a feedback method for instructing trainees to improve their nursing skills when transferring a patient from a bed to a wheelchair. In addition, an interface was proposed to enable trainees to operate the system themselves. Thus, the trainees could train themselves with the system.

The paper is structured as follows: Section 2 details the proposed the system composition, automatic evaluation method, the interface and the feedback method; Section 3 describes the experimental setup and the results; and Section 4 is our conclusion.

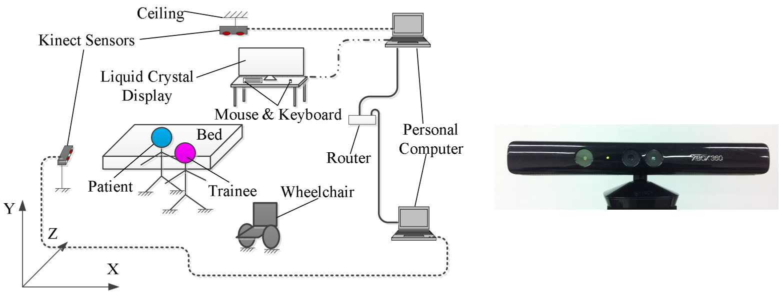
2 Methods

2.1 Overview of the Self-training System

A prototype self-training system for patient transfer was proposed (Fig. 1(a)). The system comprised a multi-Kinect sensor system, a liquid crystal display, a mouse, and a keyboard.

The multi-Kinect sensor system was designed to measure the posture information of trainees and patients, and the states of the wheelchair. The sensor system contained two Kinect sensors (Microsoft, Fig. 1(b)), two computers, and a router. One sensor was installed on the ceiling, and the other was set up at the side of the bed. The connected computers recorded and processed the data of each Kinect sensor, respectively. In order to synchronize the image data from the two sensors, the computer was connected to a router and communication was based on the Transmission Control Protocol / Internet Protocol.

The liquid crystal display, the mouse, and the keyboard constituted the operation interface for trainees to manipulate the system and to review the feedback results.



(a) (b)

Fig. 1. System architecture: (a) the schematic of the system; (b) the Kinect sensor

2.2 Automatic Evaluation Method for Patient's Performance

To indicate the performance of the trainees as correct or incorrect in each evaluation item, an automatic evaluation method [13, 14] was performed. In the method, color markers were attached to the body joints of both trainees and patients for posture measurement (Fig. 3(c)). First, using the order of the skills and the features of the three-dimensional trajectory of the patients' heads, the trainees' motions were recognized to identify the images where the skills were performed. Second, according to each item, the related posture information of both patients and trainees was measured by combining the color and the depth information. For example, the three-dimensional positions of the trainees' waists were measured for checking whether the trainees lowered the center of gravity of their bodies. Finally, according to the contents of the items, two methods were carried out to classify the performance of the trainees as correct or incorrect. One method was to detect whether the related body joints were inside the predefined region (Fig. 3(a) and (b)), and the other used the thresholds determined in our previous experiment [13] (Fig. 3(c) and (d)).

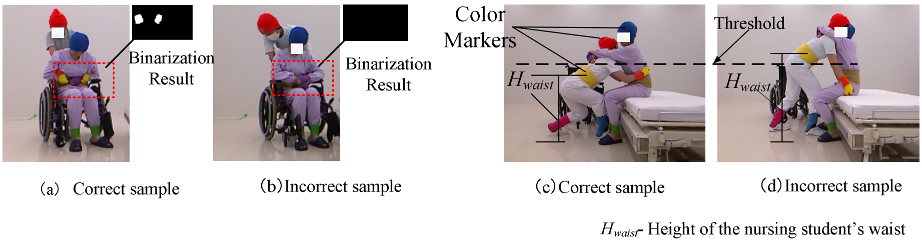


Fig. 2. Examples of the evaluation methods. In (a) and (b), a trainee's performance is classified by detecting whether the target body joints are inside the predefined region; (a) correct sample: the trainee grasped the patient's forearm; (b) incorrect sample: the trainee grasped the patient's abdomen. In (c) and (d), a trainee's performance is judged by a threshold determined in [13]; (c) correct sample: the trainee's waist is low enough; (d) incorrect sample: the trainee's waist is too high

2.3 Operation Interface

The trainees themselves could operate the interface, using the mouse and the "Esc" key to manipulate the system. The interface used five images that indicated the system's five stages. The images were displayed on the screen according to the trainees' operation. Fig. 3 depicts the flow chart of the interface. First, when the system was started, a guidance image appeared describing the system's operation. Next, the trainees clicked the "Start" button on the screen to inform the system that training was to commence. Then the system recorded the image sequences of the training process. When the training process was finished, the trainees went back to the screen and clicked the "Stop" button. Thus, the system stopped recording and started to evaluate the performance of the trainees and display the feedback. When the trainees were ready to train again, they could click the button inside the feedback image and return to the preparation image for the next training session.

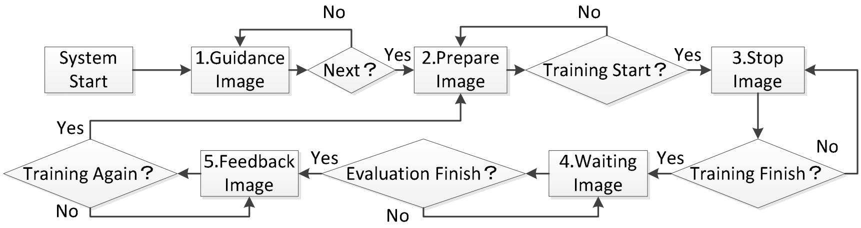


Fig. 3. Flow chart of the operation interface

2.4 Feedback Method

As we described in Section 1, nurses need to concentrate on the patient's state during the transfer process. The feedback should not distract trainees during the transfer process. Therefore, we proposed an asynchronous feedback method based on a checklist and demonstration video. The checklist included 20 skills. All results from the skills' evaluation were provided after the trainees had finished the transfer process.

The feedback image comprised five parts (Fig. 4): 1) the total result (percentage-complete) of all skills to give the trainees an overview of their performance; 2) the evaluation result of each skill to help trainees check whether they performed in the correct way; 3) a list detailing each skill; 4) the buttons, including a "Full Demo"

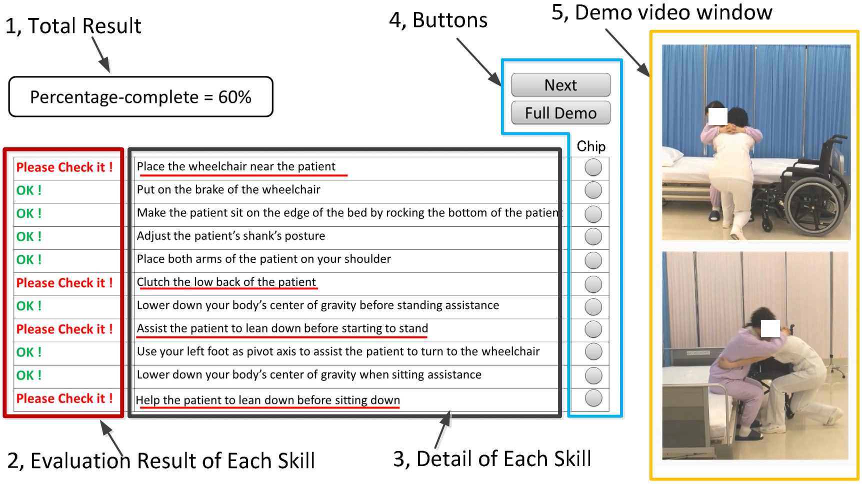


Fig. 4. The feedback image

button to review the demonstration of the entire process, the “Chip” buttons to review each skill’s corresponding demonstration, and a “Next” button to start the next training; and 5) a window for displaying the demonstration videos. In the checklist, each item was indicated as correct or incorrect. For a correct performance, an “OK!” label was attached to the corresponding skill. If trainees performed the skill incorrectly, a “Please Check it!” label and the underlined in red was attached.

3 Evaluation of the Proposed System

3.1 Purpose

A control test was carried out to examine whether the system helped trainees to improve their skills compared with using a textbook and demonstration videos without any feedback on their performance.

3.2 Participants

Ten freshman nursing students were employed as the trainees. The students were assigned randomly into an experimental group and a control group, each having five students. A woman, 160 cm in height, was employed as the mock patient who was assumed unable to stand up on her own but could maintain a standing posture once she had been assisted to her feet.

3.3 Procedures

The experimental environment was set up in the training rooms of Tokyo Ariake University of Medical and Health Science (TAU) to simulate a patient room. To simulate the self-training, only the trainees and the mock patient were inside the training rooms.

The experiment comprised four sections: i) Learning period; ii) Pretest; iii) Training period; and iv) Posttest. First, each group was given 7 minutes to learn the skills of patient transfer. This amount of time enabled the trainees to watch the demonstration video at least twice. To ensure uniformity of the learning conditions, the textbook and demonstration video from TAU were used as the teaching materials. Next, each group took the pretest to record their initial scores. The students were then asked to perform the patient transfer in 20 minutes. The experimental group trained with the proposed system, while the control group trained without any feedback, but could use the textbook and demonstration video to review the skills freely. Finally, the students took the posttest to record their final scores.

A nursing teacher evaluated the pretest and posttest using the same checklist described in Section 2.4. The teacher evaluated the performance of trainees in each task and indicated whether they were correct or incorrect. Students scored one point for every correct task and no points for incorrect tasks. Thus, the full score of the checklist was 20 points.

3.4 Results and Discussion

Table 1 shows the scores of the pretests and posttests in each group. Fig. 5 depicts the average improvements. In the experimental group, the average score of the pretest was 8.6 (SD = 3.0) and the average score of the posttest was 15.4 (SD = 2.5). In the control group, the average score of the pretest was 9.6 (SD = 4.2) and the average score of the posttest was 14.2 (SD = 2.5).

Equation 1 defines the growth rate, G_r, of the average score:

$$G_r = \frac{\bar{S}_{post} - \bar{S}_{pre}}{\bar{S}_{pre}} . \quad (1)$$

Here, $\bar{S}_{pre}$ is the average score of the pretest and $\bar{S}_{post}$ is the average score of the posttest. The growth rates of the experimental and control groups were 79% and 48%, respectively.

The result of the control test revealed that participants who trained with feedback from the system progressed more quickly than those without feedback. Although the individual score increased in each group, the increase in the experimental group was more stable than that of the control group. In the control group, the improvement in the skills depended more on the individual trainee.

Table 1. Results of the pretest and posttest for each group

Experimental Group				Control Group			
Participant	Pre	Post	Increase	Participant	Pre	Post	Increase
1	11	17	8	1	10	14	4
2	9	14	5	2	4	10	6
3	6	14	8	3	13	16	3
4	12	19	7	4	14	16	2
5	5	13	8	5	7	15	8

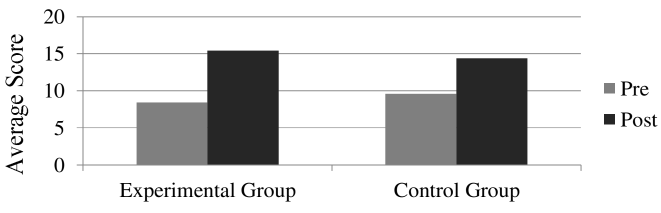


Fig. 5. The average pretest and posttest scores for each group

4 Conclusion

In this paper, a self-training system was proposed for assisting nursing students to improve their skills with a focus on transferring a patient from a bed to a wheelchair. The system was able to check automatically as correct or incorrect the performance of trainees in each skill. The nursing students could view their evaluation results using the feedback method, which was based on a checklist. In addition, the system was designed to be operated by the students themselves. The control test results highlighted the benefits of the proposed self-training system. In the experimental group (utilizing the system), the growth rate of the average score was up to 79%. This rate was higher than that for the control group (48%), where students trained without any feedback.

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References

1. Garg, A., Owen, B.D., Carlson, B.: An Ergonomic Evaluation of Nursing Assistants' Job in a Nursing Home. Ergonomics 35, 979–995 (1992)
2. Menzel, N.N., Brooks, S.M., Bernard, T.E., Nelson, A.: The Physical Workload of Nursing Personnel: Association with Musculoskeletal Discomfort. Int. J. Nurs. Stud. 41, 859–867 (2004)
3. Smedley, J., Egger, P., Cooper, C., Coggon, D.: Manual Handling Activities and Risk of Low Back Pain in Nurses. Occup. Environ. Med. 52, 160–163 (1995)
4. Hignett, S.: Work-related Back Pain in Nurses. J. Adv. Nurs. 23, 1238–1246 (1996)
5. Hignett, S.: Posture analysis of nursing work. Appl. Ergon. 27, 171–176 (1996)
6. Garg, A., Owen, B., Beller, D., Banaag, J.: A Biomechanical and Ergonomic Evaluation of Patient Transferring Tasks: Bed to Wheelchair and Wheelchair to Bed. Ergonomics 34, 289–312 (1991)
7. Garg, A., Owen, B., Beller, D., Banaag, J.: A Biomechanical and Ergonomic Evaluation of Patient Transferring Tasks: Wheelchair to Shower Chair and Shower Chair to Wheelchair. Ergonomics 34, 407–419 (1991)
8. Kjellberg, K., Lagerstrom, M., Hagberg, M.: Patient Safety and Comfort During Transfers in Relation to Nurses' Work Technique. J. Adv. Nurs. 47, 251–259 (2004)
9. Ray, S.J., Teizer, J.: Real-time Construction Worker Posture Analysis for Ergonomics Training. Adv. Eng. Inform. 26, 439–455 (2012)
10. Davis, J.W., Bobick, A.F.: Virtual PAT: A Virtual Personal Aerobics Trainer. In: Workshop on Perceptual User Interface (1998)
11. Chan, J.C.P., Leung, H., Tang, J.K.T., Komura, T.: A Virtual Reality Dance Training System Using Motion Capture Technology. IEEE Trans. Learn. Technol. 4, 187–195 (2011)
12. Chua, P.T., Crivella, R., Daly, B., Hu, N., Schaaf, R., Ventura, D., Camill, T., Hodgins, J., Pausch, R.: Training for Physical Tasks in Virtual Environments: Tai Chi. In: Proceedings of 2003 Virtual Reality, Pittsburgh, pp. 87–94 (2003)
13. Huang, Z., Nagata, A., Kanai-Pak, M., Maeda, J., Kitajima, Y., Nakamura, M., Aida, K., Kuwahara, N., Ogata, T., Ota, J.: Development of a Nursing Self-training System for Transferring Patient from Bed to Wheelchair. In: Proceedings of the SICE Annual Conference, Akita, pp. 246–254. SICE (2012)
14. Huang, Z., Nagata, A., Kanai-Pak, M., Maeda, J., Kitajima, Y., Nakamura, M., Aida, K., Kuwahara, N., Ogata, T., Ota, J.: Posture Study for Self-training System of Patient Transfer. In: Proceedings of IEEE International Conference Robotics and Biomimetics (ROBIO 2012), Guangzhou, pp. 842–847. IEEE (2012)