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Research paper

Feedback Effects for Epiduroscopy Education based on Serious Game

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Abstract

Efficient surgical education is required because epiduroscopy is difficult to learn and need a high-level surgical skill. Recently, serious game has been used in specialized areas such as medical assistance and learning (surgical education). Serious game in surgical education provides a trainee with opportunities to learn a surgical skill outside OR (operating room). Pre-operative virtual experience allows the trainee to be adapted to the patient and OR environment. In this paper, feedback effects for epiduroscopy education based on serious game are studied. The feedback effects (visual, auditory, and tactile feedbacks) were examined for the epiduroscopy education based on serious game with respect to three methods.

Keywords: *Feedback effects, Epiduroscopy education, Serious game, Visual feedback, Auditory feedback, Tactile feedback*

1. Introduction

Epiduroscopy is a MIS (minimally invasive surgery) performed popularly as an effective treatment for lumbago patients. Efficient surgical education is required because the MIS need a high-level surgical skill.

A trainee learns skill and knowledge in OR (operating room) because typical surgical education is based on Halsted's apprenticeship model [1]. The apprenticeship model-based surgical education has a disadvantage that requires a high cost by the OR and actual operation [2]. The disadvantage reduces the trainee opportunity to observe the operation and overburdens the trainee learning complex surgical skills in short term.

In order to overcome the disadvantage of the typical surgical education, recent surgical education uses serious game. The serious game-based surgical education provides the opportunity for the trainee to learn surgical skills outside the OR [3-5]. The serious game can provide a trainee-centered education environment different from the typical education environment [6, 7] because it provides high-level interaction (feedback to induce learning) [8]. Pre-operative virtual experience allows the trainee to be adapted to the patient and OR environment.

In order to effectively use the serious game in the surgical education, the trainee should be actively involved in knowledge accumulation. For these, efficient feedback is essential. The feedback for the serious game makes change learning results according to educational objectives and methods [9, 10].

The feedback effects are to identify educational-level of trainee and motivate. The methods for providing feedback have used visual, auditory, and tactile (vibration) feedback [11]. However, there are few studies on the effect of the method for providing feedback.

In this paper, the feedback effects (visual, auditory, and tactile feedbacks) for epiduroscopy education based on the serious game are studied. The feedback effects are examined for the epiduroscopy education based on the serious game with respect to three methods.

2. Feedback for Epiduroscopy Education Based on Serious Game

The serious game aims to educate specific knowledge, skill, and attitudes rather than enjoyment and fun [12, 13]. In other words, the serious game should reflect correct knowledge and information in the field [14, 15]. The serious game-based surgical education is one of the representative application of the serious game and has (1-3) game factors [16, 17]:

(1) Visual modeling of a patient and surgical instrument for realistic and immersive environment
(2) Trainee's skill-level assessment
(3) Providing feedback considering input and output device

This chapter describes the feedback for the serious game-based epiduroscopy education. Section 2.1 (included (1-2) game factors) introduces a serious game-based epiduroscopy education method to apply feedback. Section 2.2 (included (3) game factor) introduces methods to provide the feedback effects (visual, auditory, and tactile feedbacks).

2.1. Serious Game-based Epiduroscopy Education

The serious game-based epiduroscopy education method uses epiduroscopy simulator (EpiduroSIM™) [18, 19]. EpiduroSIM™ consists of input part, processing part, and output part as shown in Figure 1. The input part transmits the position and rotation data received from the controller [19] to the processing part. The processing part controls a surgical instrument (catheter) in a virtual environment according to the position and rotation data. The cont-

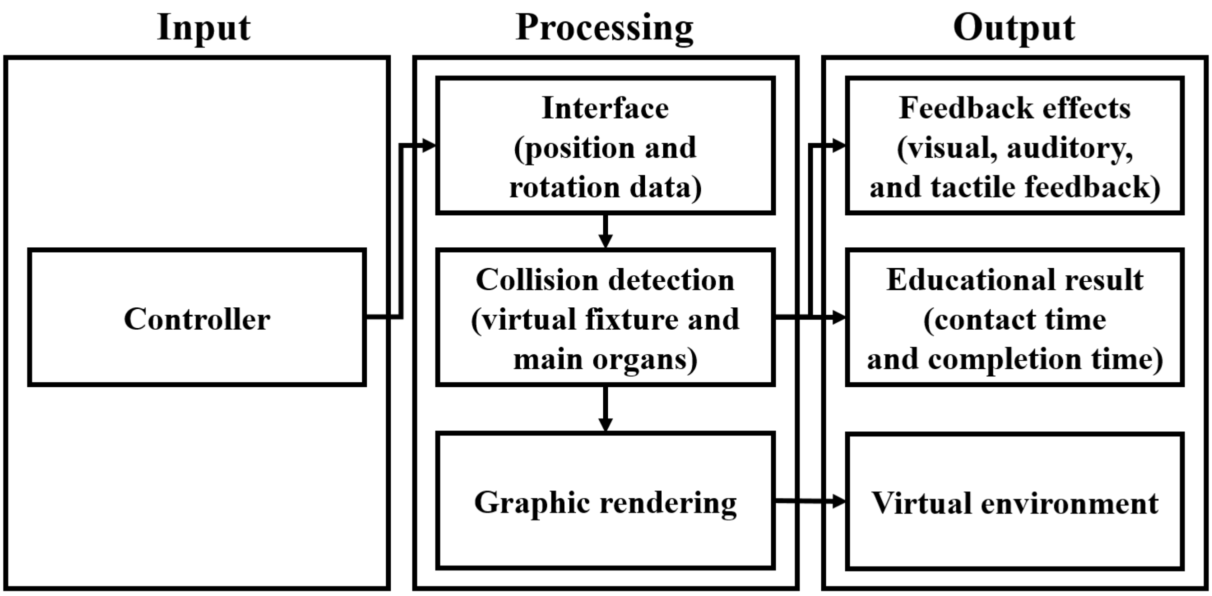


Fig. 1: Blockdiagram of EpiduroSIM™

act time is recorded while the surgical instrument, virtual fixture and main organs are during contact. The output part provides feedbacks (visual, auditory, and tactile feedbacks) and the virtual environment to the trainee, and records educational result to database.

The virtual environment of EpiduroSIM™ was modeled according to consultation with neurosurgeon as shown in Figure 2. The modeled virtual environment is composed of bones, dura mater, and discs. The main process of epiduroscopy consists of local anesthesia, disinfection, anesthetic injection, cannula installation, catheter insertion, and medication or laser treatment. The catheter insertion is the most important procedure in epiduroscopy training. Therefore, the proposed training simulator focuses on the catheter insertion training. The catheter is inserted to disc through the epidural space. In order to educate the catheter insertion path, the guidance virtual fixture [20] is implemented in the epidural space. The catheter insertion path passes sacral by changing direction from dorsal root to ventral root (red circle) at the point between S2 and S3 nerve.

2.2. Providing Feedback Effects

In order to increase educational effect in the serious game-based surgical education, the feedback considering the senses should be provided. Bial [21] studied the tactile feedback using a glove equipped with a vibration motor in navigation task. Rauterberg and Styger [22] studied the visual and auditory feedbacks during assembly task. Akamatsu [23] compared the effect of three feedbacks (visual, auditory, and tactile feedbacks) in mouse click task. Richard [24] and Petzold [25] compared the effect of three feedbacks (visual, auditory, and tactile feedbacks) in assembly task.

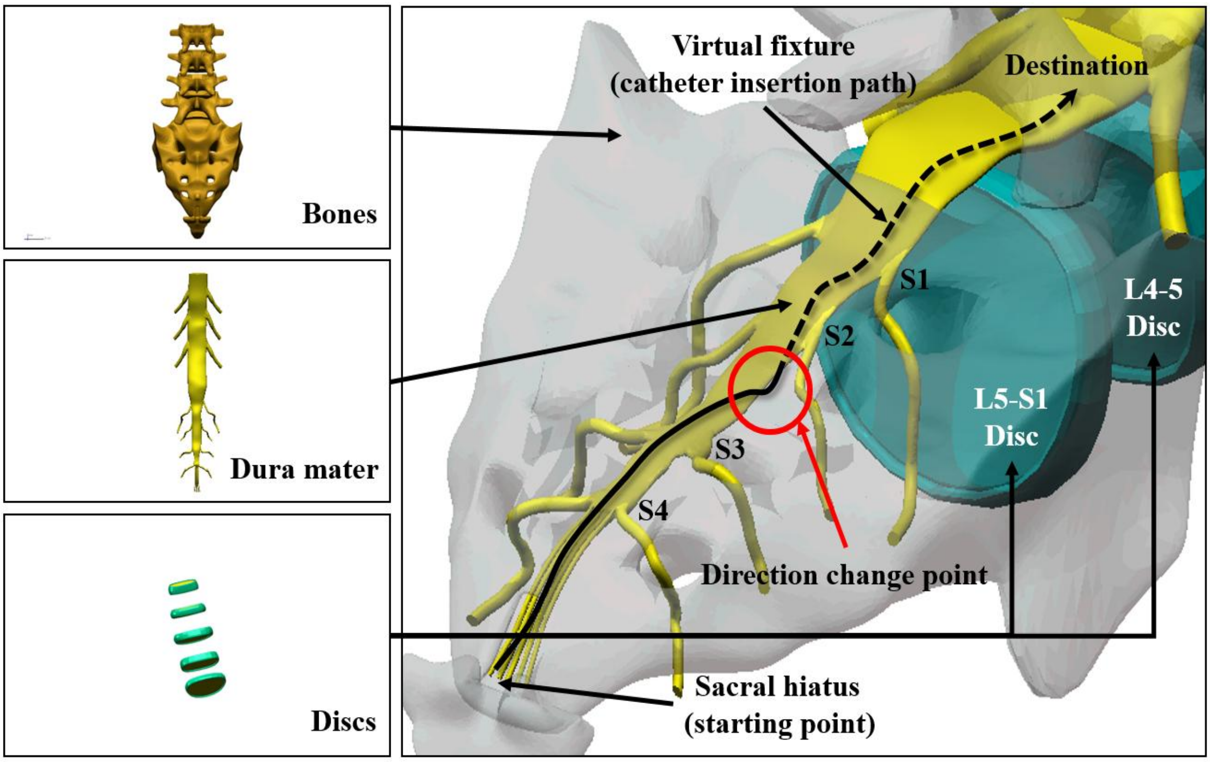


Fig. 2: Virtual environment of EpiduroSIM™

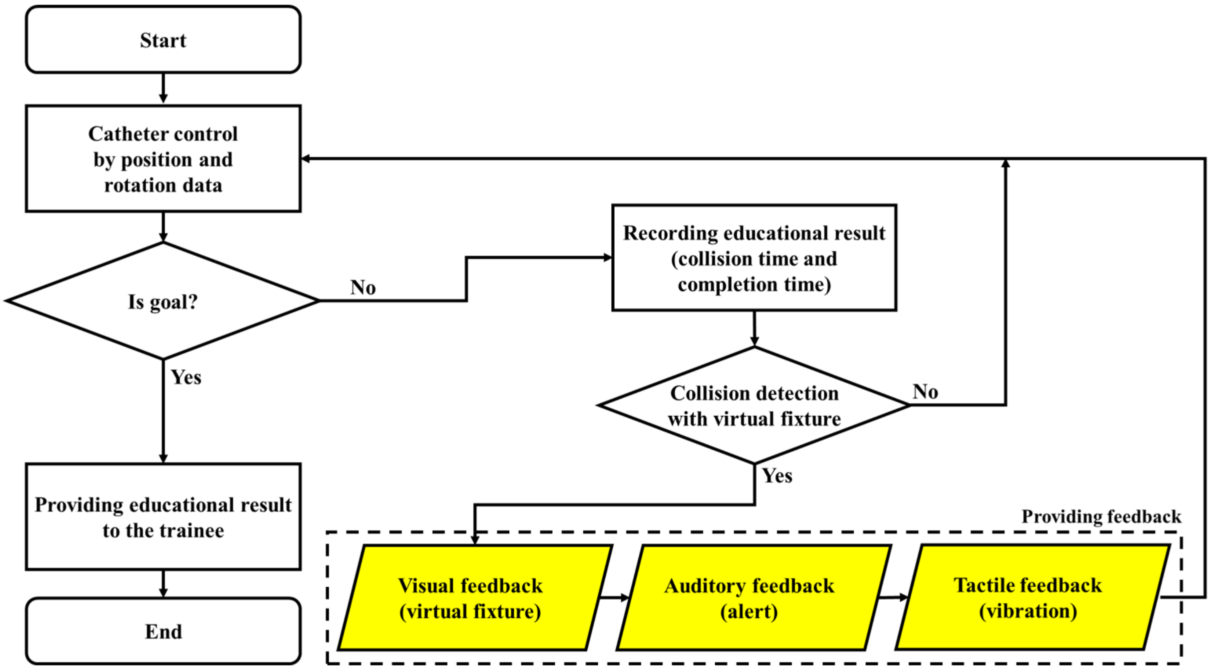
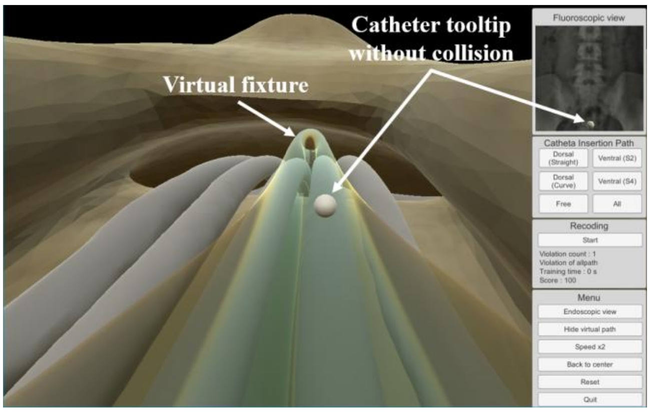


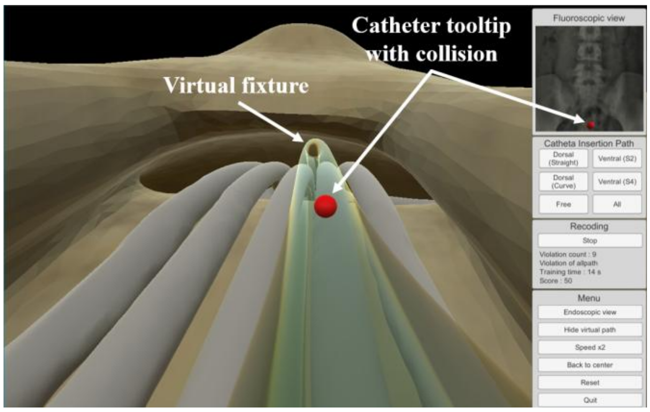
Fig. 3: Flowchart providing feedback effects of EpiduroSIM™

In this paper, various feedbacks are provided to trainee based on visual, auditory, and tactile feedbacks as shown in Figure 3. Visual feedback is provided as a virtual fixture to educate the catheter insertion path. The auditory feedback is provided as an alert to indicate course deviation. The tactile feedback is provided as vibration to maximize immersive feeling during contact in the serious game.

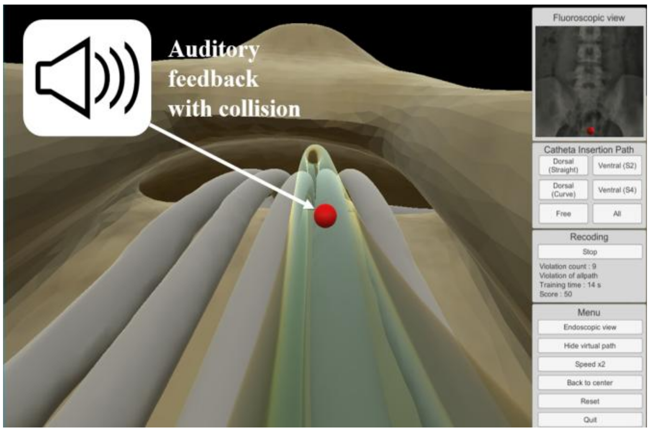
Figure 4 shows the feedback screen applied to EpiduroSIM™. The visual feedback is provided to the trainee by changing the catheter's color (white to red) during contact as shown in Figure 4 ((a) to (b)). The auditory feedback is provided as the alert (sound) to the trainee during contact with the virtual fixture as shown in Figure 4 (c). The tactile feedback is provided to the trainee by the vibration of the controller during contact with the virtual fixture, as shown in Figure 4 (d).



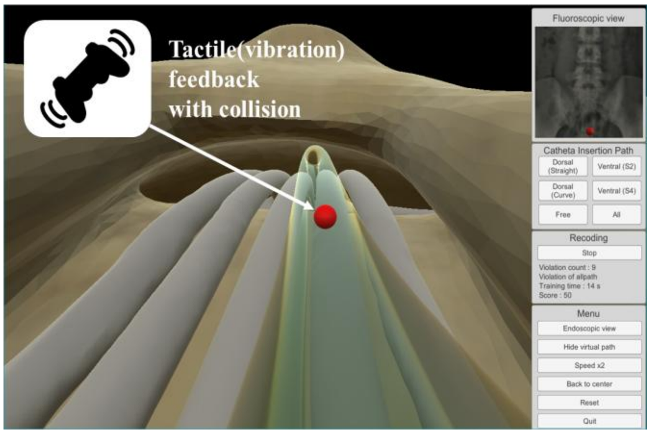
(a) Without feedback



(b) Visual feedback

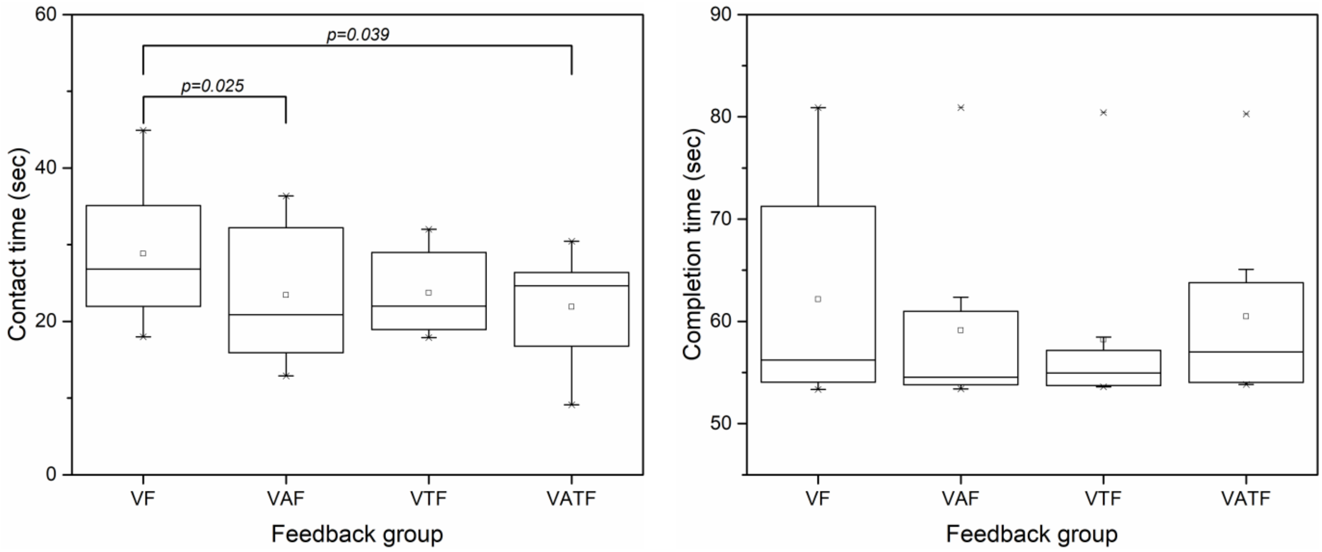


(c) Auditory feedback



(d) Tactile (vibration) feedback

Fig. 4: Feedback effects applied to EpiduroSIM™



(a) Contact time (b) Completion time

Fig. 5: Experimental result (VF: Visual feedback, VAF: Visual and auditory feedback, VTF: Visual and tactile feedback, VATF: Visual, auditory, and tactile feedback)

3. Experiment and Discussion

In this chapter, we performed the experiment and discussion with respect to feedback effects for the serious game-based epiduroscopy education. The experiment was designed to focus on examining the surgical education effect applied three feedbacks.

The experiment was performed on eight subjects. The experimental group consisted of four groups through a combination of three feedbacks:

- VF (Visual feedback)
- VAF (Visual and auditory feedbacks)
- VTF (Visual and tactile feedbacks)
- VATF (Visual, auditory, and tactile feedbacks)

The experimental environment consists of EpiduroSIM™ and gamepad controller. The gamepad controller is an input device with higher precision and user preference than a mechanical control device or joystick [26]. The experiments were repeated five times in groups to ensure reliability and the average values of the experimental data were used. Also, the experiments were performed in randomized manner. Experimental results were compared through statistical analysis (paired t-test). The paired t-test was conducted in order to examine the feedback effects between the feedback groups in the serious game-based epiduroscopy education, and data were statistically analyzed using SPSS version 20, differences were considered statistically significant at a p-value<0.05.

The experimental result is shown in Figure 5. Figure 5 (a) shows the average contact time of four groups. The average contact times of VF, VAF, VTF, and VATF groups were 28.83, 23.41, 23.72, and 21.90 seconds, respectively. Figure 5 (b) shows the average completion time of four groups. The average completion times of VF, VAF, VTF, and VATF groups were 62.17, 59.13, 58.22, and 60.48 seconds, respectively.

From comparison on average completion time, no significant difference was found between the feedback groups. Whereas, a significant difference was found between the VF-VAF and VATF groups in comparison on average contact time ($p<0.05$). This means that the VAF and VATF effects are highly effective in the serious game-based epiduroscopy education.

4. Conclusion

In this paper, feedback effects for epiduroscopy education based on the serious game were studied. The feedback effects (visual, auditory, and tactile feedbacks) were examined for the epiduroscopy education based on the serious game with respect to three methods.

Experiment was focused to examine the feedback group (VF, VAF, VTF, and VATF) by comparing the completion time and contact time of four groups. From experimental result, it was shown that the VAF and VATF groups were the highly effective in the serious game-based epiduroscopy education. In the future, we expect that the feedback effects examined in this paper will be utilized as basic data for surgical education studies.

Acknowledgement

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