Analysis of Gaze Trajectory and Skin Extension Pressure Data in Blood Collection Technology

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Abstract: Up to this time, research on tacit knowledge of blood collection technology has been conducted, but A method for quantitatively evaluating skills related to blood collection technology and a system that implements them have not been developed. For the present study, using a sensor that can measure eye gaze movement and pressure. Collect finger pressure for skin extension and eye gaze trajectory data during blood collection, and analyze characteristics of pressure distribution during puncture and movement range of the eye gaze and then to examine a method to quantitatively evaluate a part of blood collection technique procedure.

1 INTRODUCTION

Blood collection, a fundamentally important medical practice for clinical tests using blood as a sample, is an invasive nursing technique that percutaneously punctures a vein and extracts blood (Japanese Committee for Clinical Laboratory Standard, 2018). Therefore, it requires skill sufficient for precision and consideration for the patient simultaneously (Miki, S. et al., 2011). In fact, the Japan Nursing Association has pointed out the necessity of further strengthening education on intravenous injections (Japanese Nursing Association, 2003). However, because injection techniques entail so much tacit knowledge that cannot be expressed in words, it is difficult to inherit tacit knowledge in learning. An important difficulty is that nursing students have not mastered skilled skills (Naoki, U. et al., 2018). Therefore, it is necessary to formalize tacit knowledge, quantitatively evaluate skills related to blood collection technology, and improve technical skills.

In recent years, sensing technology has become an indispensable technology along with the trend of Internet of Things. Many devices used worldwide already have sensing technology. One of them is a gaze measuring instrument. In earlier studies have attempted to pass on tacit knowledge of skilled workers using gaze measurement (Harumasa, N. et al., 2014) (Mamiko, S. et al., 2005) .These studies are also used in the nursing field, such as feature analysis of skills of skilled nurses (Yasuko, M. et al., 2013) and nursing skills education (Yukie, M. et al., 2018). As sensor technology innovations continue to increase, their accuracy is expected to become greater and devices are expected to become cheaper, and able to acquire widely diverse data. Unprecedented development of systems is expected to occur from effective utilization of these data.

For the present study, the subject wears glasses-type tobii pro / glasses 2 (manufactured by Tobey Technology) as a gaze measuring instrument and a sensor capable of measuring pressure on the finger and then a blood collection experiment was conducted using an arm model. For this experiment, a simulation model arm was used. We attempted to extract the characteristic data necessary to evaluate each procedure by analyzing the pressure data for skin extension and eye gaze data during puncture. As a result, it was found that a characteristic shape appeared in the pressure graph during skin extension and that the gaze movement range during skin extension was smaller than that of other procedures. By looking at these two data in combination, each procedure may be identified automatically.

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2 RELATED RESEARCH

2.1 Tacit Knowledge during Blood Collection

In earlier studies, we explored formalization of tacit knowledge from various viewpoints such as mathematical analysis of finger movement in injection technology (Yutaro, Y. et al., 2017) and calculation method of needle bends (Takeshi, M. et al., 2017). Tacit knowledge was clarified by comparing the skills of nurses and nursing students, particularly addressing skin extension and pressure, which are movements of nurses' auxiliary fingers during blood collection (Naoki, U. et al., 2018) (Takeshi, M. et al., 2018). These studies, we collected data of nursing students and skilled workers. And the studies mainly focus on only skin extension pressure. But in this study, we collected gaze trajectory data and skin extension pressure data. This time, we tried to extract tacit knowledge that is unlikely to make a difference for active nurses.

2.2 Automatic Evaluation of Medical Procedures

Earlier studies examined the development of automated medical procedure evaluation systems using Deep Learning for objective evaluation of medical procedures. Reference (Nao,S. et al. 2018) analyzes the data obtained from kinecct, but this study is different in that the objective is to evaluate blood collection objectively by analyzing skin extension pressure and eye gaze data.

3 EXPERIMENT

3.1 Outline of Experiment

For the present study, we focused on "blood collection technology", which is frequently performed in daily work, among nursing techniques and measure the pressure for skin extension and eye gaze trajectory during puncture. Blood vessel samples were collected using a simulation arm model. A patient role-player was set in front of subjects to give a sense of realism of blood collection. subjects were able to collect blood while talking to the patient. Table 1 shows the experimental locations and periods. Fig. 1 shows the experimental environment. In this experiment, we are also concurrently with a study to see the difference in brain activity between skilled nurses and new nurses based on cerebral blood flow (Takahito, T. et al. 2019).

This research was conducted with the approval of the Ethics Committee of the Graduate School of Sustainable System Sciences, Osaka Prefecture University.

Table 1: Experiment place and period.

Implementation period	4 days from November to December 2018
Implementation location	Practice room in Hospital A

Figure 1: Experimental environment.

3.2 Test Subjects

Subjects were 19 active nurses working in hospitals who had consented to research cooperation. Table 2 shows "the ladder levels" and numbers of nurses. "The ladder level" is a nurse development and evaluation system established by the Japan Nursing Association. The five levels, from I–V, represent the nurse ability and career. Higher numbers reflect higher the nursing practice ability.

Table 2: Nurse ladder level.

Implementation category	Ladder level	Number of people	Total
Novice nurse	I	9	9
	II	0	
Skilled nurse	III	4	10
	IV	4	
	V	2	
Total		19	

3.3 Equipment Used

3.3.1 Pressure Sensor

The equipment used to acquire pressure data for the present study includes the following.

- Arduino Uno
- Pressure sensor FSR402 (Fig. 2)

- A/D converter
- 1/4 carbon film resistance
- Small universal board (ICB-90)
- Heat-resistant electrical wire

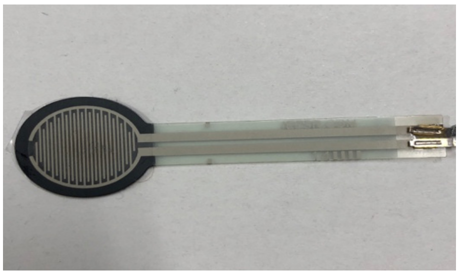

Figure 2: Pressure sensor FSR402.

The pressure sensor was fixed on the finger that extension skin when fixing the blood vessel. As values of 0–1023 acquired from the sensor increase, a stronger force is applied and acquired as time series data.

3.3.2 Eye Gaze Measuring Instrument

For gaze measurement, gaze was measured using a wearable eye tracking system (tobii pro / glasses 2 G2-100; Tobii Technology) (Fig. 3).

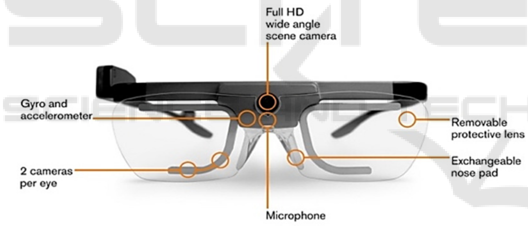

Figure 3: Tobii pro sensors.

3.3.3 Arm Model for Blood Collection Simulation

For the blood collection simulation, we used an arm model (LM-086; Koken Co. Ltd.). For selecting a blood vessel to collect blood, blood vessel models of several types exist. Fig. 4 shows the arm model with the blood vessel model. Fig. 5 shows the type and difficulty of the blood vessel model.

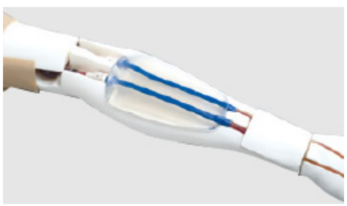

Figure 4: The arm model with the blood vessel model.

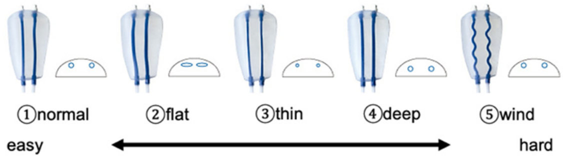

Figure 5: The type and difficulty of the blood vessel model.

We explained in advance that exchanging multiple simulation models. A sample was presented. However, participants do not know from which blood vessel model they will collect blood.

4 ANALYTICAL METHOD

As described in this paper, among the 19 subjects, 4 nurses were selected from nurses who had no data loss and who had pressure sensors on the same finger. After graphing the pressure data and the eye gaze data obtained from the experiment, we tagged the procedures and actions at the time of blood collection one by one while watching the video, and observed their mutual relation. The recorded video is the following (Figs. 6 and 7). The procedure for blood collection is presented below.

(1) Wrap the tourniquet
(2) Blood vessel selection
(3) Wipe the puncture site with gauze
(4) Hold a syringe
(5) Remove the syringe cap
(6) Puncture
(7) Pull the inner cylinder
(8) Take the tourniquet
(9) Hold the puncture site with gauze
(10) Pull out the needle

The procedures were almost identical, but with some differences in the order, depending on the person.

Figure 6: Image of camera.

Figure 7: Wide angle camera from tobii.

5 RESULTS AND DISCUSSION

This study examines characteristics of the changes in pressure during skin extension and the trajectory data of the eye gaze, comparing each procedure and action.

5.1 Skin Extension Pressure Graph

First, we introduce a graph of pressure during skin extension. Figs. 8–10 show changes in the skin extension pressure with a scatter diagram (smooth line).

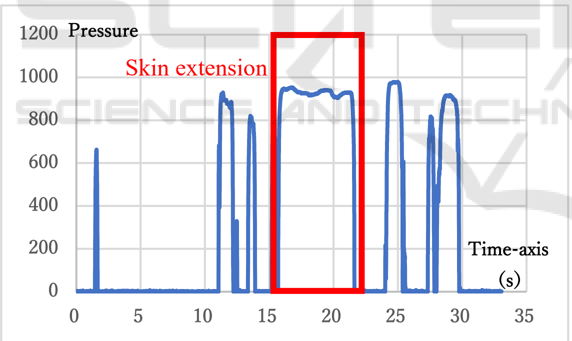

Figure 8: Nurse ID15, Changes in skin extension pressure.

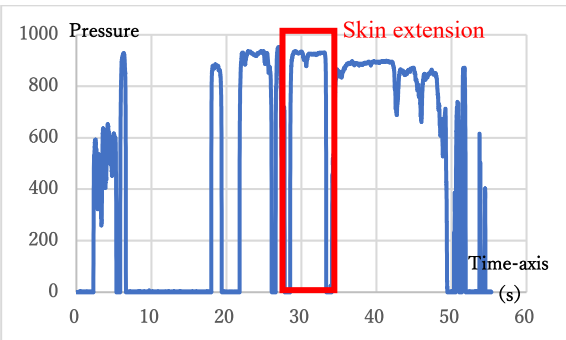

Figure 9: Nurse ID11, Changes in skin extension pressure.

The pressure data include data other than skin extension. They include states such as “having a syringe” and “unscrewing the cap of the syringe”. As shown in Figs. The characteristic shape was visible. Regardless of the success or failure of blood collection, it looked like a rectangle

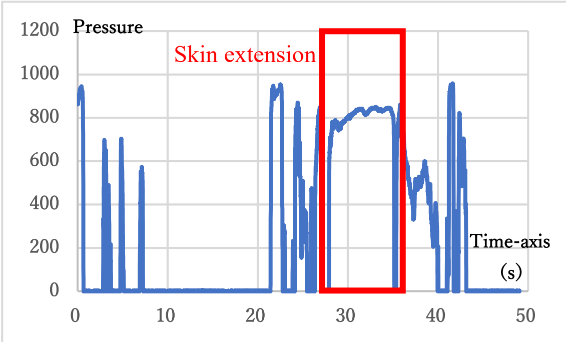

Figure 10: Nurse ID18, Changes in skin extension pressure.

5.2 Gaze Locus Graph

Next, we introduce a gaze locus graph. Figures 11–14 show scatter plots (smooth lines) of the eye gaze trajectory until skin extension. Similar to the pressure graph, this graph includes items other than the eye gaze during skin extension, and also includes behavioral and procedural states. The circled range represents the range of motion of the eye gaze when the skin extension. Throughout the procedure, the range of gaze movement during skin extension and puncture was smaller than that for other procedures. However, As shown in Figures 11 and 12, it can be characterized that failure is bigger than success. Figures 13 and 14 both show data from nurse 18. Nevertheless, but more than individual differences, differences in the range of gaze movement during skin extension are failure is bigger than success. This time, the gaze patterns of four nurses were analyzed based on the dominant arm and the finger attached to the pressure sensor. The relationship between nurses and ladder levels is shown in Table 3. Results showed that the gaze momentum at the time of skin extension or puncture increased when it fails. In addition, it was found that the higher the ladder level has a tendency to the longer moving distance of eye gaze when selecting blood vessels. The table 4 shows the moving distance of the four nurses' eye gaze. This trend that the higher the ladder level, the more moving distance of eye gaze, because the higher the ladder level, the more pondered the injection location after selecting the blood vessels. However, it has been pointed out in post-experiment interviews that the sense of a patient's arm is vastly different from the sensation with this arm model. So, it is likely that there simply is variability in gaze distance among participants, not that there is a trend. Presumably, simple comparison is difficult. In the future study, we will examine the arm model validity and it need to do analysis with more participants.

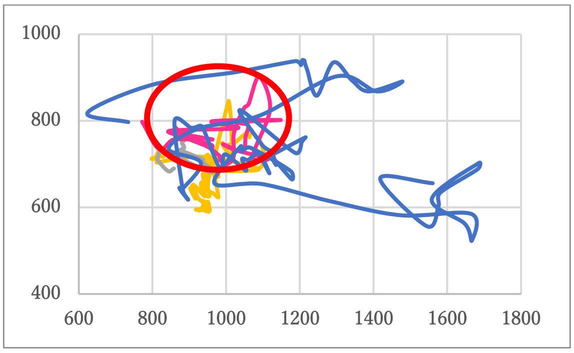

Figure 11: Nurse ID11-Success, the eye gaze movement range for skin extension.

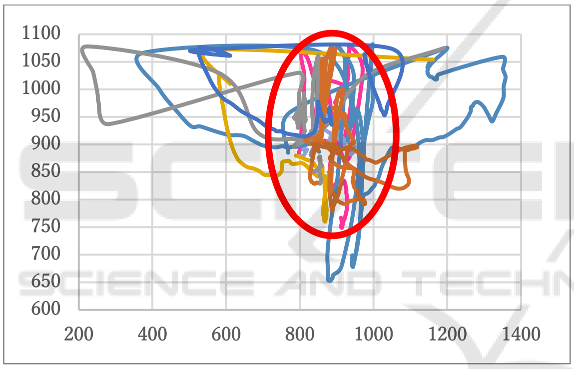

Figure 12: Nurse ID10-Failure, the eye gaze movement range for skin extension.

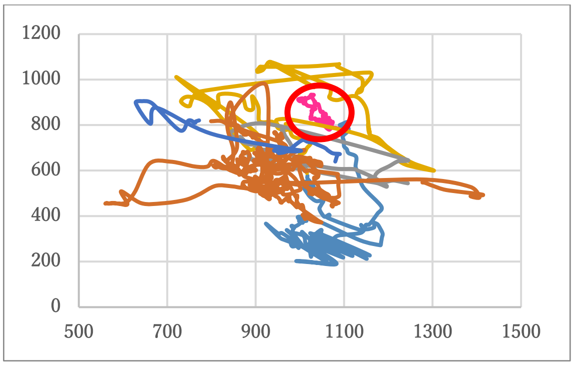

Figure 13: Nurse ID18- Success, the eye gaze movement range for skin extension.

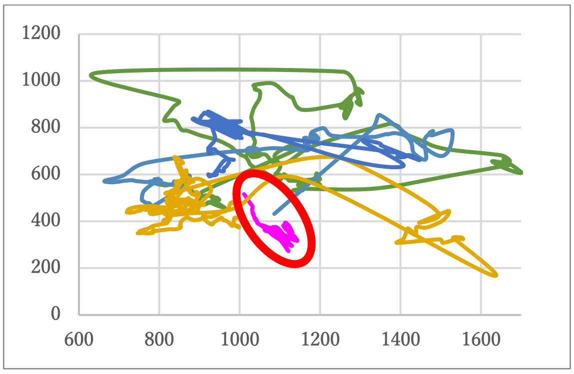

Figure 14: Nurse ID18-Failure, the eye gaze movement range for skin extension.

Table 3: Experiment place and period.

NurseID	Ladder level
10	III
11	IV
15	I
18	V

Table 4: moving distance of the eye gaze.

Ladder Level	NurseID	The Moving Distance (pixel)
I	15	1399
III	10	2654
		3324
IV	11	11597
		18114
V	18	7726

6 CONCLUSION

In this analysis, a characteristic pressure distribution appeared in the skin development pressure during blood collection. We also found that the range of motion of the gaze at the time of skin extension and the puncture was smaller than the range of motion of the eye gaze during other procedures.

7 FUTURE WORK

Based on these results, we can consider the construction of a general-purpose evaluation system for procedures. Results of the nurses analyzed this time tended to show similar characteristic shapes in pressure during skin extension. However, some

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nurses have shapes appearing twice in a single procedure. In such cases, it is impossible to determine which of the two is the skin extension pressure just before puncture. but the range of motion of the eye gaze during skin extension and puncture is smaller than that for other procedures such as “wrapping a tourniquet” and “blood vessel selection.” Therefore, it is possible to estimate the skin extension and puncture work by combining the two data of the pressure data and the gaze data. Furthermore, the range of gaze movement at the time of skin extension and insertion be larger at the time of failure than at the time of success. This feature will be important for judging success or failure of the technique.

8 SUMMARY

This study was designed to extract the characteristic data necessary to evaluate each blood collection procedure, and to clarify the characteristics of pressure and the eye gaze movement range for skin extension during blood collection. Results show that each procedure can be identified automatically examining these two data types in combination. Further study is required for developing quantitatively evaluating the relationship between pressure and gaze data in order to realize an automatic evaluation.

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