Consideration on Feature Extraction of Skill Level by Insertion Angle of Injection Technique

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Abstract— *Since many nursing skills can be acquired by practical experience, it is difficult to put skills that can be obtained by such experiences into words. Therefore, many researchers have been studying on the nursing tacit knowledge. Recently, research on data analysis utilizing sensor devices has attracted researchers and developers interest, various data analysis methods and devices have been proposed. This study proposes an algorithm to analyze the injection techniques of users at inserting injection needle from moving image.*

Keywords: Nursing skills, insertion angle, feature extraction, SVM

1. Introduction

Many nursing skills are said to be difficult to verbalize, and research to analyze the implicitness of nursing skills is being conducted. In the study on tacit knowledge, the SECI model [1] famous in the field of knowledge management is widely used. Knowledge management means to sharing and utilizing individual knowledge and information in an organization throughout the organization. Knowledge management has attracted attention in the field of nursing care and medical welfare, and many research had been reported. Knowledge and information in nursing skills are sometimes hard to understand only by seeing and listening. In this study, we consider a method to quantitatively evaluate an injection skills by targeting the angle of insertion in intravenous injection. Many conventional researches has been conducted to convert tacit knowledge into formal knowledge, but most of those studies cover qualitative data [2], [3], [4]. Research on nursing skills is diverse. The paper [5] studied on the skills on involving the transfer of patients from beds to wheelchairs. The paper [6] had developed a system that acquires the coordinate data of the finger joint of the injection technique and reproduces the movement by CG. Furthermore, the paper [7] had proposed a method to analyze the difference between experts and beginners by visualizing hand movement data. This research cuts out the image data at the time of insertion from the moving image data recorded in the experiment of [7] [8], analyzed the difference between the expert and the beginner, and proposed an algorithm to learn skills of experts. As for the data analyzed in this paper, there was a clear difference in data between students and experts. This difference is thought to appear because an arm model is used, however, it is also an important point of focus in the analysis of nursing skills.

2. Injection Skill and Insertion Angle Data

This paper analyzes the hand movement data in vein blood sampling. The data of the hand with the injection is the object. The following points should be noted in the venous blood sampling procedure.

- Determination of vein to puncture
- Avascularization
- Disinfection of puncture site
- Skin extension for venous fixation during puncture (3 to 5 cm below the puncture site)
- Angle between the skin and the blood collecting needle is 15 to 20 degrees, and insert about 3mm into the blood vessel
- Remove the needle after removing the tourniquet while inserting the needle

These technologies need to respond to the situation, it is difficult to express details only by words. Therefore, it is considered difficult for nursing students to acquire such techniques before practice. In addition to that, these technologies are also issue when people who have been away from the workplace for a long time return to work. An arm model is used to practice such an injection technique. There is also an opinion that the texture of the arm model is different from human skin. However, it is considered possible to analyze expert data under certain conditions. This study will analyze the insertion angle of the injection technique from the image data. Fig.2 and 3 are the part of image data used for analysis. Fig. 2 shows an image at the time of needle insertion by a nursing student, and fig. 3 shows an image at the time of needle insertion by an expert. It is difficult to find the difference between experts and nursing students simply by looking at these image data. Let us binarize the image in order to analyze the image data at the time of needle insertion.

Fig. 4 and 5 are the binary image of fig. 2 and 3, respectively. We can see that the expert's needle is linear, but the nurse student's needle is not linear. It is conceivable that the needle is not linear because nursing students may put in

Fig. 1: Arm model

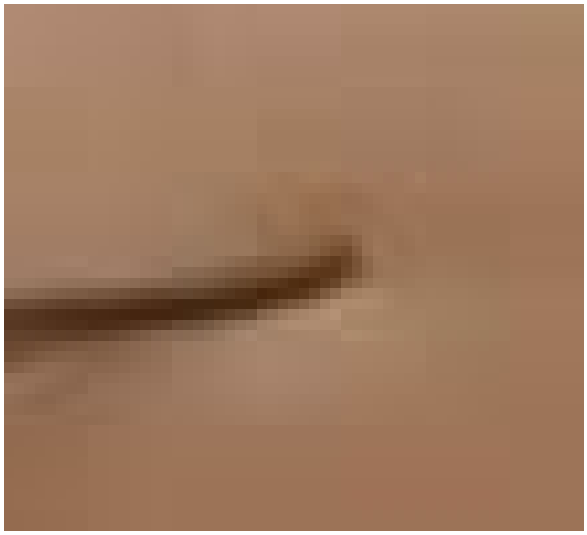

Fig. 2: Image data of a beginer

excessive force. However, since the skin of the arm model is stiffer than the skin of the human body, it is inferred that such a phenomenon will be observed. In the case of penetrating into the actual skin, nursing students may not insert with such a force, but it is clear that they are not conscious in experiments with arm models. This paper will propose an algorithm to learn the feature of insertion angle of needle on experts and nursing students and investigate the difference of procedures between experts and the nursing students.

Fig. 3: Image data of an expert

Fig. 4: Binary image of a beginer

Fig. 5: Binary image of an expert

3. Difference Between Experts and Students

This section analyzes the angle at the time of insertion of the injection needle. The binary image data as shown in Figs.

4 and 5 are used for analysis in this study. As shown in Fig. 6, the data of the upper part and the lower part of the needle are equally divided into four sections, respectively, and the angle of the needle is analyzed by obtaining the equation of the straight line of each section. Table 1 shows data used for experiments. The data in Table 1 uses the data recorded when acquiring the hand motion data of the papers [7] and [8]. Since it takes a considerable amount of time to acquire data like the papers [7] and [8], it is difficult to acquire large amounts of data. The number of data used in this research is small because it used recorded data of the papers [7] and [8]. Therefore, in order to increase the number of experts' data in particular, image data that can be confirmed the insertion site was also used. Fig. 7 is one of such data. The data of

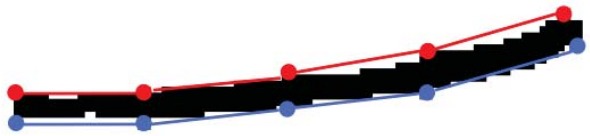

Fig. 6: Feature Extraction of Insertion Angle

Fig. 7: Binary image of another expert

Expert 4 in Table 1 corresponds to the image data of Fig. 7. Table 2 shows the slope of lines of four sections equally divided. We will analyze the data of Table 1 and 2 in the next section.

Table 1: Feature of Insertion Angle

Student 1 (Upper)	(0, 0)	(23, 0)	(46, 3)	(69, 6)	(92, 13)
Student 1 (Lower)	(0, 0)	(23, -1)	(46, 1)	(69, 4)	(92, 13)
Student 2 (Upper)	(0, 0)	(24, 1)	(48, 3)	(72, 8)	(96, 14)
Student 2 (Lower)	(0, 0)	(24, 0)	(48, 3)	(72, 6)	(96, 13)
Student 3 (Upper)	(0, 0)	(24, -1)	(48, -1)	(72, -3)	(96, 2)
Student 3 (Lower)	(0, 0)	(24, 0)	(48, -3)	(72, -5)	(96, 2)
Student 4 (Upper)	(0, 0)	(18, 2)	(36, 2)	(54, 3)	(72, 4)
Student 4 (Lower)	(0, 0)	(18, -2)	(36, -3)	(54, 1)	(72, 5)
Student 5 (Upper)	(0, 0)	(19, 1)	(38, 3)	(57, 7)	(76, 13)
Student 5 (Lower)	(0, 0)	(19, 2)	(38, 6)	(57, 9)	(76, 16)
Student 6 (Upper)	(0, 0)	(17, 2)	(34, 4)	(51, 6)	(68, 9)
Student 6 (Lower)	(0, 0)	(17, 3)	(34, 5)	(51, 9)	(68, 14)
Student 7 (Upper)	(0, 0)	(18, 1)	(36, 4)	(54, 7)	(72, 12)
Student 7 (Lower)	(0, 0)	(18, 3)	(36, 6)	(54, 10)	(72, 17)
Expert 1 (Upper)	(0, 0)	(12, 0)	(24, 0)	(36, 0)	(48, 0)
Expert 1 (Lower)	(0, 0)	(12, 0)	(24, -2)	(36, -2)	(48, 0)
Expert 2 (Upper)	(0, 0)	(15, 0)	(30, 0)	(45, 0)	(60, -1)
Expert 2 (Lower)	(0, 0)	(15, -1)	(30, -1)	(45, 0)	(60, 3)
Expert 3 (Upper)	(0, 0)	(20, -3)	(40, -3)	(60, -5)	(80, -7)
Expert 3 (Lower)	(0, 0)	(20, -3)	(40, -6)	(60, -7)	(80, -5)
Expert 4 (Upper)	(0, 0)	(4, 3)	(8, 5)	(12, 6)	(16, 9)
Expert 4 (Lower)	(0, 0)	(4, 4)	(8, 6)	(12, 8)	(16, 9)

Table 2: Slope of each interval

Student 1 (Upper)	0.00	0.13	0.13	0.30
Student 1 (Lower)	-0.04	0.09	0.13	0.39
Student 2 (Upper)	0.04	0.08	0.21	0.25
Student 2 (Lower)	0.00	0.13	0.13	0.30
Student 3 (Upper)	-0.04	0.00	-0.08	0.21
Student 3 (Lower)	0.00	-0.13	-0.08	0.30
Student 4 (Upper)	0.11	0.00	0.06	0.06
Student 4 (Lower)	-0.11	-0.06	0.22	0.22
Student 5 (Upper)	0.05	0.11	0.21	0.32
Student 5 (Lower)	0.11	0.21	0.16	0.37
Student 6 (Upper)	0.12	0.12	0.12	0.18
Student 6 (Lower)	0.18	0.12	0.24	0.30
Student 7 (Upper)	0.06	1.67	1.67	0.28
Student 7 (Lower)	0.17	0.17	0.22	0.39
Expert 1 (Upper)	0.00	0.00	0.00	0.00
Expert 1 (Lower)	0.00	-0.17	0.00	0.17
Expert 2 (Upper)	0.00	0.00	0.00	-0.07
Expert 2 (Lower)	-0.07	0.00	0.07	0.20
Expert 3 (Upper)	-0.15	0	-0.1	-0.1
Expert 3 (Lower)	0.15	-0.15	-0.05	0.1
Expert 4 (Upper)	0.75	0.50	0.25	0.75
Expert 4 (Lower)	1.00	0.50	0.50	0.25

4. Consideration and Conclusion

In the previous chapter, the data of the angle of the needle at the time of needle penetration of the injection are summarized. This section will use those data to investigate differences in data between experts and nursing students. It can be seen from Figs. 4 and 5 that the angle of the injection needle of the nursing students are not linear. Similar trends are found in other nursing student data (Fig. 8). If it is only necessary to check whether the needle at the time of insertion is linear, a method of calculating the correlation coefficient from the set of five points in Table 2 is also conceivable. If both the upper and lower correlation coefficients of the needle are close to 1, the needle might be linearly. Table 3 summarizes the calculation results of the correlation coefficients.

The data of Student 6 is judged to be linearly if only the correlation coefficient is considered, but from the inclination of each section of the proposed method in Table 2, it is found that it is not linearly. Besides, it can be considered the method to compute a regression line and its residue as a method of checking whether it is linear or not, but it is difficult to find out which part of the needle is working. It can be determined which part of the needle is bent in the proposed method of this study, but it can not analyze why such phenomenon occurs. Therefore, further analysis is our future work.

In addition, the data used in this study includes data as

Table 3: Coreration coefficient

Student 1 (Upper)	0.93
Student 1 (Lower)	0.86
Student 2 (Upper)	0.95
Student 2 (Lower)	0.93
Student 3 (Upper)	0.17
Student 3 (Lower)	-0.06
Student 4 (Upper)	0.96
Student 4 (Lower)	0.66
Student 5 (Upper)	0.95
Student 5 (Lower)	0.98
Student 6 (Upper)	1.00
Student 6 (Lower)	0.99
Student 7 (Upper)	0.97
Student 7 (Lower)	0.98
Expert 1 (Upper)	- -
Expert 1 (Lower)	-0.29
Expert 2 (Upper)	-0.70
Expert 2 (Lower)	0.67
Expert 3 (Upper)	-0.97
Expert 3 (Lower)	-0.80
Expert 4 (Upper)	0.99
Expert 4 (Lower)	0.97

Fig. 8: Binary image of another student

shown in Fig. 8. From the binarized image of figure, it is possible to observe that pressure is applied to the lower portion of the insertion site as the force increases. This corresponds to the portion where the inclination of the upper side and the lower side of the same interval are significantly different. Since there are several characteristic patterns in nursing student data in this way, it is also our future work to investigate what type of binary image is generated by how force is applied.

Finally, we investigated whether the data in Table 2 can be classified by SVM. We selected 7 data randomly from Table 2, Table 4 shows the classification result of all the data of Table 2. We had used Gaussian kernel $\sigma = 3$.

Since the data of Expert 4 is misclassified, further investigation is necessary. Increasing data is also our future work.

Table 4: Classification Result by SVM

Label	Prediction
Student 1	Student
Student 2	Student
Student 3	Student
Student 4	Student
Student 5	Student
Student 6	Student
Student 7	Student
Expert 1	Expert
Expert 2	Expert
Expert 3	Expert
Expert 4	Student

References

[1] I. Nonaka and H. Takeuchi, *Laser Assisted Microtechnology*, Oxford Univ Pr (Txt), 1995.

[2] Z. Huang et al., *Self-Help Training System for Nursing Students to Learn Patient Transfer Skills*,IEEE Transactions on Learning Technologies, Volume: 7, Issue: 4, pp.319-332, 2014.

[3] A. Ueda et al.,*Corporeality in nursing practice of elimination care âĂŞ a qualitative meta-synthesis of practical case studies in the Japanese literature*, Journal of Chiba Academy of Nursing Science, 15(1), pp. 68-75, 2009.

[4] L. Bowtell, C. Moloney, A. Kist, V. Parker, A. Maxwell and N. Reedy, *Using Remote Access Laboratories in nursing education*, 9th International Conference on Remote Engineering and Virtual Instrumentation (REV), pp.1-7, 2012

[5] Z. Huang, C. Lin, M. Kanai-Pak, J. Maeda, Y. Kitajima, M. Nakamura, N. Kuwahara, T. Ogata and J. Ota, *Impact of Using a Robot Patient for Nursing Skill Training in Patient Transfer*, IEEE Transactions on Learning Technologies (Volume: PP, Issue: 99) p.1, 2016

[6] Y. Majima, Y. Maekawa, and M. Soga, *Learning Support System Reproducing Finger Movements in Practicing Nursing Techniques*, Proceedings of the 11th International Congress on Nursing Informatics, pp.278-282, 2012

[7] T. Matsuda, T. Maedab and Y. Majima, *Feature Extraction of the Nursing Techniques from Hand Motion Data*, 9th International Conference on Remote Engineering and Virtual Instrumentation (REV), pp.1-7, 2012

[8] T. Noguchi, K. Otani, T. Matsuda and Y. Majima, *Analysis of hand motion in injection technique by vector field*, Proc.78th National Convention of IPSJ, pp.1-461, 1-462, 2016