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Estimating Activity Conditions of Students in Class by Measuring Leg Movement

Tatsuya HAMADA[a*], Yuuki TERUI[a] & Hironori EGI[a]
[a]*Graduate School of Informatics and Engineering, The University of Electro-Communications, Japan*
*h2230112@edu.cc.uec.ac.jp

Abstract: In this study, we propose a method for estimating students' activity conditions in a class by measuring their leg movements. Grasping students' activity conditions are important for teachers to adjust the class progress. The optimal progress will improve understanding of the students. However, measuring students' activity conditions in a class is challenging because it may interfere with their studies. Thus, we introduce a method that measures students' leg movement to estimate their activity condition in a class. Consequently, we found that the variation in the leg movement was often peaked at the time of activity switching in an actual class. Meanwhile, the leg movement did not continue to increase as it would increase the students' fatigue. The results that students' activity conditions in a class can be estimated by measuring students' leg movement. We conducted experiments in the actual class and focused on detecting multiple students' activity conditions. Measuring students' activity will enable us to estimate individual activity conditions.

Keywords: Leg movement, classroom sensing, learner's activity

1. Introduction

This study presents a method for estimating students' activity conditions by measuring their leg movements in a class. Most classes at universities in Japan are conducted as a concurrent lesson that has one teacher and many students. Each student has a different activity condition and grasping the lesson under such conditions is ideal for education. However, a concurrent lesson is selected due to efficiency. To solve this problem, we propose a method in which a teacher can grasp students' activity conditions. The system aids teachers in adjusting the class progress by providing integrated information about each students' progress.

Grasping the activity condition should not disturb the regular classes. A previous study has estimated learners' mental fatigue by measuring their leg movement (Aikawa, Asai, & Egi, 2019). They obtained a significant correlation between the number of transitions in a learner's leg posture and the subjective degree of fatigue. Measuring the leg movement does not disturb learners' activity and distract his/her attention. We hypothesize that there is a relationship between students' activity conditions and their leg movement in a class.

2. Related Works

Goldberg et al (2021) estimated students' engagement from classroom videos. Using the proposed manual annotation, they obtained a correlation between students' engagement and visible indicators; for example, students raise a hand and ask questions. Consequently, they found that analyzing classroom videos enables us to estimate students' engagement. However, students' face photography has problems that an invasion of privacy and interfere with concentration.

Another study grasps students' activity conditions by recording their progress with the teaching materials (Shimada, Konomi, & Ogata, 2018). They attempted to visualize students' learning context by recording page numbers read by students and creating a heat map in a class using e-learning and e-books. Using the proposed system, the page numbers that the teacher is explaining and the page numbers that the students are reading are delivered to the teacher. However, the format of materials is restricted to

e-learning which requires preorganized teaching materials with an equal amount of content per page. This method cannot be adapted to a wide range of teaching formats without modification.

3. Methods

This study investigates students' activity conditions in a class estimated by measuring their leg movements. Especially, we focus on the time of activity switching. The time of activity switching is the start time and end time of each activity in the class, including multiple activities, such as a lecture, an exercise, and a test. In a class of typical length, some activity switching is intended, such as answering exercises and asking questions, even if the class consists mainly of lectures.

We introduce a leg movement measurement device to measure leg movement. The leg movement measurement device is placed on the backside of a top plate of the desk at which the student studies. It measures the leg movement of the student sitting in the chair from above. Figure 1 shows the installation of the leg movement measurement device.

Figure 1. The leg movement measurement device (left) and installation (right).

The leg movement measurement device comprises a passive infrared ray (PIR) sensor (EKMC2609112K), a single-board microcontroller (Arduino Nano Every), and a single-board computer (Raspberry Pi 4). The sensor and microcontroller are placed on a breadboard. The single-board microcontroller and single-board computer are connected via a USB connection cable.

4. Experiment

4.1 Procedure

An experiment was conducted to measure students' leg movement during classes practically held in a university of science and technology. The measured data were collected after the classes and analyzed all students' data in the same class at once. The experiment was conducted with 34 university students in a total of seven classes. Data could not be collected for some students due to problems, such as the sensor falling from the desk during the experiments. Then, 28 leg movement measurement data, excluding incomplete data, were analyzed. The classes lasted for 90 minutes. Lecture and exercise sections are provided alternatively. The time of switching lectures and exercises in each class was observed and recorded.

4.2 Analysis

The leg movement amount and range are used as indices for analysis. The leg movement amount is defined as the moving standard deviation per minute. The average leg movement amount per class is used in the analysis. The leg movement range is defined as the difference between the maximum and minimum values of the leg movement amount per minute. In this study, we calculated the leg movement range for the average of the leg movement amount.

5. Result

Figure 2 shows the result of the leg movement measurement of five students in a class. The top shows the average amount of leg movements; the bottom shows the leg movement range; the vertical line shows the time of activity switching. The topic of the class is "Various types of dynamic programming," and the main content is about the pointers of the C programming language. Peaks of the leg movement

range mean significant changes in leg movements. The more significant changes in leg movement are at the start of class(14:50), 15:05, 15:12, 15:24 and 15:35. When the leg movement change significantly, students might switch their activities.

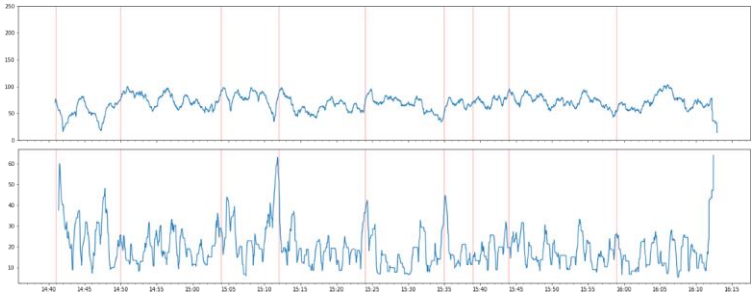

Figure 2. Result of leg movement measurement.

6. Discussion

According to our previous study, we predicted that fatigue would accumulate with learning, and the leg movement amount by students would also increase. The results show that leg movement amount during class did not continue to increase, but rather increased and decreased repeatedly.

The observation of the leg movement range shows that the graph peaked at the time of activity switching. It also shows that there is a larger change than at other times. This suggests that the leg movement range may show a characteristic value at the time of activity switching.

7. Conclusion

In this study, we developed an activity condition estimating system based on students' leg movement measurements in a class. We investigated the activity conditions that can be estimated by analyzing student' leg movement measurements in a class. The experimental result shows that students' leg movement fluctuated more during activity switching than other times. Thus, we can estimate the time of activity switching by measuring the student's leg movement. However, the result of measuring leg movement in class showed that the leg movement was not increasing.

In future studies, we will consider measuring individuals' leg movements related to their activity conditions. We did not follow each students' activities in this study. Therefore, the detail of comparing the leg movement and the activity conditions is necessary.

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