

## A TIME SERIES ANALYSIS OF THE RELATIONSHIP BETWEEN TEACHER'S WRITING ON THE BLACKBOARD AND STUDENT'S NOTETAKING

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### ABSTRACT

In this paper, we propose a time series analysis for student's notetaking in lectures. In the proposing method, we use an electronic notebook to know student's writing duration in the lecture. Then, we define a degree of similarity between a teacher's writing on the blackboard and a student's notetaking by using DP matching. In the experimental results for 8 students, we showed that our method could correctly measure student's writing duration and non-writing one. Also, we obtained that those students are divided into two types of the notetaking by a threshold of our similarity. The first type of students has a long non-writing duration which doesn't exist in the teacher's writing on the blackboard. The notetaking behavior of the second type has similar to the teacher's writing on the blackboard.

### 1. INTRODUCTION

Many methods to improve lectures in large-scale classrooms have been based on students' impressions obtained by questionnaires or subjective evaluation of teachers [1]. However, questionnaires to students are often carried out after the lecture. As a result, students often tell a rough impression of the lecture to depend on memory. For this reason, their answers sometimes can't be used as information to improve the detailed contents of the lecture. On the other hands, to know a degree of difficulty of each lecture's content in real time, a system has been proposed [2]. The system investigates and analyzes students' questionnaires by using Tablet PCs during lectures. However, those answers are sometimes unstable by setting of teacher's questions. Therefore, we don't always obtain objective data.

Recently, many studies have taken a video of lecture scene and measured the concentration rate of each student from the behavior. Those proposed methods analyze the movements such as faces, gazes and mutters of students. Then, they estimate subjective impressions of the difficulty to course materials [3]. However, it still remains a problem that each student's learning behavior sometimes can't be obtained correctly. It is caused by video's angles or states of the illumination when we use image analysis.

Recently, new electronic tools such as electronic notebooks have been developed. When using those electronic notebooks, we can measure each student's writing movement during lectures in real time. For

example, it's possible to know the time when student writes something in the lecture from the description timing of an electronic notebook. If a teacher can know the information in detail during the class, it can be used for judgement when the teacher makes the speed of writing on the blackboard slowly or needs repeat explanation. In the paper [4], it showed that the writing method of the students is divided into two types from the interview. The first type is a student who transcribes the contents of the blackboard after hearing the explanation of his lecturer carefully. Another type is a student who transcribes the contents of the blackboard immediately if his lecturer writes something on the blackboard.

In this paper, we propose a method to measure the degree of similarity of synchronosness between each student's notetaking and teacher's writing on the blackboard by using DP matching method. Then, we determine the criterion for separation of the above two noting types from the obtained values.

### 2. ELECTRONIC NOTE

Using a digital notebook, it's possible to record the lecture's contents written by students as digital data. Usually, those digital data are saved as picture elements. However, in this study, we use a digital notebook which can record handwriting lines as the data of strokes in time series. Fig. 1 shows an example of such a digital notebook [5]. We can record '1' as the mode when a pen touches a notebook by this digital note. It means that the student is writing something. On the other hand, it takes '0' as the mode when a pen is away from the notebook.



Fig. 1: A Digital Notebook (ACECAD: DigiMemo A402).

For example, Table I shows the data of some strokes. The location of the pen is expressed by (x, y) but we don't use the location data in this study. In this table, the first line of the data shows the time as "133021928" and

the mode as '1'. This means that a pen touched a notebook at 13:30:21 and 928 milliseconds. On the other hand, a pen is away from the notebook at 13:30:25 and 257 milliseconds. When using such data, we can know in detail what time a student is writing in the digital note.

TABLE I: THE DATA OF SOME OBTAINED STROKES.

Time	Mode	x	y
133021928	1	90	26
.....	...		
133025241	1	194	42
133025257	1	192	41
133025257	0	192	41
133025351	0	187	24
133025351	1	187	24
.....	...		
133025429	1	175	41
133025429	0	175	41
133037867	0	197	89

### 3. ANALYSIS OF STUDENT'S NOTETAKING

In this section, we propose a time series analysis method of student's notetaking by using DP matching.

#### 3.1 Division to Note Duration and Non-note Duration

Students sometimes take non-writing state momentarily to watch contents of the blackboard while they transcribe the contents on the blackboard. In this case, it is possible to think that this state is the part of the movement for writing. So, in our study, the case when the mode takes '0' successively during more than 5 seconds is judged as non-writing duration. As a result, each mode is corrected to '1' from '0' in the section of less than for 5 seconds. Moreover, to analyze visually using a graph, the duration of each continuous mode is rounded up by the second unit. Hence, each mode is changed to data of the second unit from the millisecond unit.

TABLE II: THE CHANGED AND ROUNDED DATA FROM TABLE I.

Time (Second)	Mode
1	1
2	1
3	1
4	1
5	0
6	0
...	...
15	0
16	0

In the following, the procedure that changes the modes from the millisecond unit to the second unit is described.

1. A mode is changed to '1' when the mode of '0' doesn't continue for more than 5 seconds.
2. Each durations of writing state where the mode takes '1' successively and each duration of non-writing state where the mode takes '0' successively are rounded up by one second unit.

For example, we obtain Table II from Table I. It's written on the paper [4] about this transformation in detail.

#### 3.2. Comparison of Two Notetaking Data

To compare notetaking movements of two people, the degree of similarity defined by DP matching method is available. The notetaking data which divided to writing duration and non-writing duration is used as the comparison data. Let's the notetaking sequences of two people as  $A = \{a_i\}$  and  $B = \{b_j\}$ . Here, these sequences take 0 or 1 at each second.

Then, we define a degree of similarity of two notetaking sequences as follows:

$$D(A, B) = \frac{1}{I+J} \min_{i,j} [\sum_{k=1}^K w(k) \cdot |a_{i(k)} - b_{j(k)}|]. \quad (1)$$

Here,  $I$  and  $J$  are the total seconds of noting data of A and B, respectively. Also, the  $K$  means a path of the best route determined by DP matching method. Also,  $w(k)$  means a weight for the path. Specifically, the best path and similarity are obtained as the following DP matching.

$$D(A, B) = \frac{d(a_i, b_j)}{I+J}, \quad (2)$$

$$\begin{cases} d(a_1, b_1) = P1 * |a_1 - b_1| \\ d(a_i, b_j) = \min \begin{cases} d(a_{i-1}, b_{j-1}) + P1 * |a_i - b_j| \\ d(a_{i-1}, b_j) + P1 * |a_i - b_j| + P2 \\ d(a_i, b_{j-1}) + P1 * |a_i - b_j| + P2 \end{cases} \end{cases} \quad (3)$$

Here,  $P1$  means a weight of the penalty when the notetaking values  $a_i$  and  $b_j$  of two people are different.  $P2$  means a weight of the penalty for the difference on the time axis. The similarity when the notetaking states of two people are difference will be bigger if we set the penalty  $P1$  to be bigger. On the other hand, if the penalty  $P2$  is set as a big value, the influence of the temporal difference for two data becomes big. In other words, similarity value also will be big. The similarity value approaches 0 when the notetaking sequences of two people are close and it will be 0 when the two data is just equal.

### 4. EXPERIMENTAL RESULTS

In this section, we report some experimental results obtained by our proposed method.

### 4.1. Experimental Conditions

Students attended a lecture by watching a lecture video respectively and took notes by a digital notebook during the lecture. In the following, experimental conditions are shown.

- Content of the Lecture: A proof of the Pythagorean theorem
- Lecture Time: 5 minutes 13 seconds (313 seconds)
- Number of Students: 8 people
- Notes Size: A4 size paper
- Digital Notebook: ACECAD DigiMemo A402

A lecture video is prepared beforehand as a teaching material to make students' digital notebooks. In this experiment, we didn't use a real lecture in the lecture room but a lecture video. One reason is that it is possible to make the experiment for each student independently with a lecture video. Another reason is that it is possible to collect many students' data even if there are not many experimental tools.

Fig. 2 shows the lecture's contents on the whiteboard. The theorem is proved using a figure. Fig. 3 shows a scene of experiments.

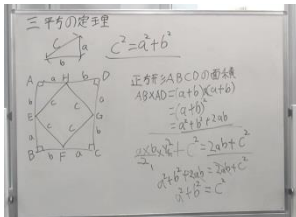


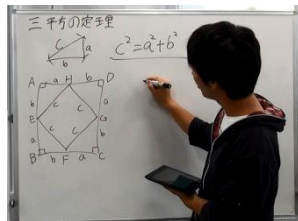
Fig. 2: Contents of a Whiteboard. Fig. 3: A Scene of Experiments.

### 4.2. Graphs and their Characteristics of Students

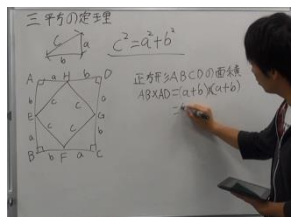
Fig. 4 shows the change in writing on the whiteboard.



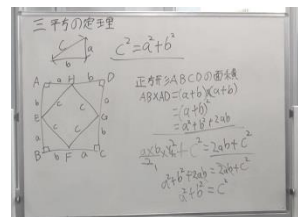
60 seconds later.



120 seconds later.



180 seconds later.



313 seconds later.

Fig 4: The Change in Writing on the Whiteboard.

The theorem is introduced in the first 60 seconds. In the next 60 seconds, the figure for the proof has been drawn. The proof using numerical formulas starts 180 seconds later. After 313 seconds, the explanation ends.

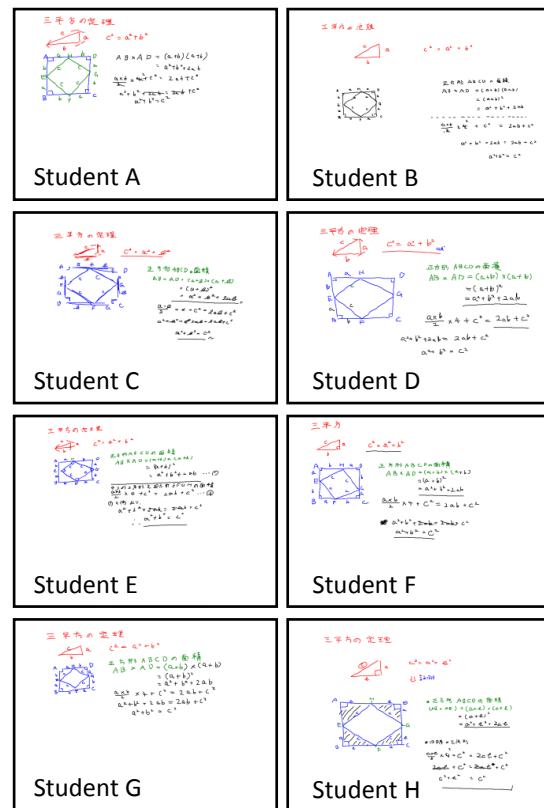


Fig. 5: Notes of Eight Students.

Fig. 5 shows notes of 8 students. Red strokes, blue strokes and green strokes were written within 60 seconds, 120 seconds and 180 seconds, respectively.

Fig. 6 shows the graph of the state of teacher's writing on the whiteboard. We made the graph by manual watching at the lecture video. Here, the red arrow in the graph means the period of the lecture video.

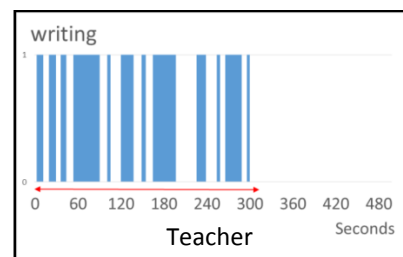


Fig. 6: Graphs of a Teacher.

Fig. 7 shows 8 graphs of each student obtained by our method. In the graphs of 3 students A, B and H, there were a long duration of non-writing that is more than 60 seconds. Those durations were 92 seconds, 139 seconds and 69 seconds, respectively. On the other hand, 5 students C, D, E, F and G were almost always writing during the lecture and didn't have so long non-writing state. Also, almost every student except Student B has

stopped writing after 195 seconds in the lecture for a while. This reason is that the teacher hadn't written anything on the whiteboard for the next 30 seconds and used only already drawn figures for the proof.

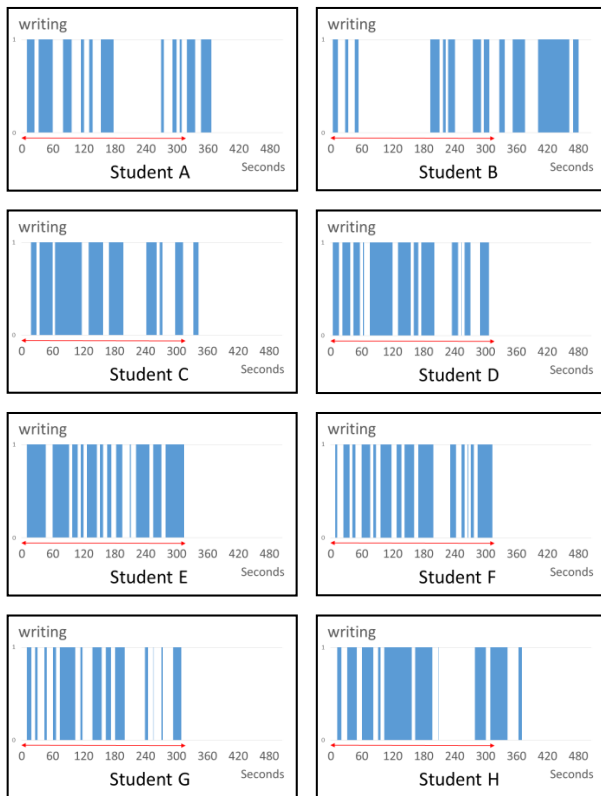


Fig. 7: Graphs of Eight Students.

### 4.3. Classification of Students' Type

Table III shows notetaking times and the degrees of similarity between each student and the teacher. The time in the table III means from starting the lecture video to stop notetaking by each student. In the experiment, we set both penalties  $P1$  and  $P2$  to 1.0. From the table III, the degrees of similarity are less than 0.2 between the teacher and five students C, D, E, F and G. This means that notetakings of these students are similar to teacher's writing on the whiteboard. On the other hands, the similarities of three students A, B and H are bigger than 0.2. One reason of the bad similarity for the student B is the total notetaking time. The notetaking time of the student B was 481 seconds and it was too longer than the total lecture time, that is, 313 seconds. The student was writing after the lecture video. The other reason is that the student B has a long non-writing section in the first half. Student A and H have a similar long non-writing section too. From these results, we classified students to two notetaking types. Students belonging to the first type I have a long non-writing duration and the similarity for the teacher is more than 0.2. Students of the second type II have the similarity of less than 0.2. In the case of Type II, almost every student stopped their notetaking immediately after the lecture ended.

TABLE III: SIMILARITIES AND TYPES OF STUDENTS' NOTETAKINGS.

Student	Notetaking Time (Seconds)	Similarity for the teacher	Type
A	367	0.220913	I
B	481	0.331652	I
C	343	0.181679	II
D	307	0.153473	II
E	315	0.178628	II
F	314	0.169329	II
G	310	0.160772	II
H	371	0.213763	I

## 5. CONCLUSIONS

In this paper, we proposed a method to analyze a student's notetaking in lectures by using an electronic notebook. We defined a degree of similarity between two persons by using DP matching method.

In the experiments, we analyzed notetakings behaviors of 8 students using a lecture video. Then, we classified notetaking types of those students to two types. In this time, we set a threshold of the similarity to 0.2. The first type is a student who has a long non-writing duration. The other type is a student whose notetaking is similar to teacher's writing on the whiteboard. In the future works, we have to verify the effectiveness of our method by applying it to various students and real lectures.

## ACKNOWLEDGMENT

This work has been supported by JSPS KAKENHI Grant Number 16K00499.

## 6. REFERENCES

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