Implementation of a Pen and Paper Based Exam Marking System

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Abstract: Many examinations in school are using paper. Marking of those exams is large burden for teachers. An exam method using a pen and paper device is showed to reduce it. Students can use the device without any teach. The teachers can get the result of exams as digital ink data. They can efficiently mark exams using the system we propose. Moreover, they get new elements to understand the students analyzing their answering process recorded in digital ink. We implemented the system. This paper describes the system and preliminary evaluation.

Introduction

There are various methods to measure student's learning and understanding. Except for physical subjects, mostly, paper exams are employed for measurement. The paper-based testing method is simple and can be used for any subjects. Based on the overall scores of the students, teachers can grasp the understanding of the students and reflect and will be able to reflect it to the follow-up in the classroom. It is an effective and less expensive method, however, marking students’ answer sheets is a burden for teachers. It must be fair, consistent and quick.

Optical mark recognition is one of the solutions. It is a process of capturing human-marked data from document forms such as surveys and tests. Optical mark recognition is only available for selective questions and require a scanner system to read and mark answer sheets. There are many researches has been conducted by using optical mark recognition system (Gorgevik.D 2000). OMR systems can the reduce marking burden for teachers. However, this method can only provide student’s score without any further information. Besides OMR, there is another exam method of using Web form on PC (WBT: Web-Based Test). WBT is a computer-based delivered via the internet. It can be used from remote location in anytime and anyplace. However, it is not free from spoofing because it is not under supervision by any teacher. Moreover, students who are not familiar with PC are under disadvantage for the WBT method.

In this paper, we present another approach that are using pen and paper device. It is not disadvantage for students unaccustomed to PC. Question types are not confined. Teachers can get answering information as digital ink. Marking can be supported by a computer.

In recent years, with advances in IT devices, we have been able to use the user interface besides keyboard and mouse. In particular, many types of pen and/or paper devices have been developed (Anoto Group, KEIREN). For this study, we employ the Anoto pen, which produces time stamps as well as pen-tip coordinates. By using a pen and paper device, handwriting can be recorded and stored as digital ink. Users have no need to understand how to use the device. Indeed, the users just need to write on the paper with the pen in a normal way.
This paper describes a system to reduce the burden of teachers on scoring exams. Students answer questions in an exam by writing on an exam paper with a pen in the same way as usual exams. The only difference is that we employ pen & paper devices from which digital ink (time-sequence data of pen-tip coordinates) is read into a computer. We employ the Anoto Pen and Paper for this implementation. An Anoto pen running on dot patterned paper captures the pattern and identifies the position of the pen-tip in a paper. It is very user friendly for students so that they can concentrate on question answering. Besides that, teachers are free to design any types of questions, not just limited to multiple choice formats as OMR. The examination sheet conducted by the pen and paper device, can accommodate essay writing, word-filling, graph drawing, etc. This system provides teachers with scoring supports.

In addition, teachers can easily get the statistical information through the system, and understand the intelligibility of each student by analyzing the problem solving of each student. For the traditional examination sheet, teachers cannot analyze the thinking of a student during problem solving for exams. For pen and paper device systems, teachers can analyze it through the trace of handwriting. For example, teachers can know in which order and how long a student has spent for each question. Besides that, by using the time-series data from the system, we can group the students through the time-series data information as well.

We made a prototype of a scoring support system as shown in Narcis (L. Narcis 2006). Last year, we resigned the idea with the emphasis on analysis on problem solving by students (Yoshida N 2009). This paper describes the implementation and the evaluation for the pen and paper device system.

**System**

**Overview**

Figure 1 shows the system flow from exam preparation to marking.

![Figure 1. Flow of the exam.](image)

The flow of exam employing our system is similar to the conventional method from preparation of exam to the final step of scoring. To prepare an examination sheet for this system, teachers just need a usual word processor (for example MS Word...etc). However, it must be printed on the Anoto dot pattern.

For students, the way of answering questions is totally same as the conventional examination except that they answer with the Anoto pen on the examination sheet printed with the small Anoto dot pattern. After the students completed the examination, teachers need to collect back the pens and examination sheets.
Scoring Flow

Figure 2 shows scoring on system since collected sheets and pens.

After collecting back the pens from the students, the teachers need to connect the pens to the PC (Figure 2 - 1). The system reads ink data written while exam from each pen. The system outputs ink data by the form of PCG files. They are read together with the examination sheet as an image file (Figure 2 - 2). Then, teachers specify the area of student’s name and those of questions (Figure 2 - 3). At the same time, teacher inputs point and correct answer for each question. The digital ink from each input area is cut out as an answer (Figure 2 - 4). Handwritten characters are translated into text by a character recognize engine. By this process, the answers by the students are automatically compared with the true answers which are input at the step 3 (Figure 2 - 5). For the recognition errors or non text answers, the teachers need to manually score them using the interface (Figure 2 - 6). The marked examination can be printed out or saved as an Excel file for analysis purpose as well (Figure 2 - 7).

Marking Function

Conventionally, teachers mark all the answers for some question by turning the answer sheets one by one and mark those for another question again by turning them one by one. This is to keep the consistency of marking. The system helps teachers to mark in this way. The system groups together all the answers for each question (Figure 3). By using this system, the teachers can stay focus on each question and its answers. Therefore, teachers can mark the questions more efficiency. In previous studies, we have confirmed that this function allow teachers to mark questions 40% faster than the normal method (L. Narcis 2006).
Automatic marking can reduce the marking time of the teachers. Optical mark recognition is such a system but the type of questions is restricted. Our system extends OMR. A character recognition engine converts digital ink of handwritten answers into text. Our system automatically marks the students’ answers by comparing recognized answers to the correct answers and cluster answers according to the recognition (Figure 4). For selection type questions, the automatic marking function is robust. For phrase filling or essay writing questions, however, it is error prone. Due to this nature, the system just clusters the answers and the teachers can verify the result and correct misrecognitions.

For correcting the misrecognition and mis-clustering, we made a user friendly interface. Figure 5-A shows the interface. The teachers only have to drag and drop the incorrectly clustered answers to correct clusters. For example, if the correct answer is clustered into incorrect group, the teachers only have to drag the answer to the correct cluster. If the incorrect answer is clustered into correct group, they just need to drag it to the incorrect group.
Next, we will describe the interface for marking graph expected questions (Figure 5-B). For questions where the answers are given as graphs, the system overlaps the graphs through the use of different shades and thicknesses in the lines. The teachers pick up the correct answer, and the system will automatically set true to all the answers similar to the selected correct answer. This enables the teachers to mark the graph expected questions easily.

**Output of Exam Result**

The system enables the teachers to analyze the problem solving of the students as well. By using this system, the teachers not only get the scores of the students, they can analyze the history of problem solving of the students as well. Figure 6 shows a student’s answer order, answering time for each question and whether the question is revisited or not. The system will emphasize the stroke over long interval. It apprises the teachers where the student hung up and guides the teachers to explain the points more concisely. Besides that, the system plots score and answering time of all the students, which enables the teachers to understand the overall trend of the students.

**Evaluation Plan**

We have prepared the evaluation plan of the pen and paper-based marking system employing the Cross-Validation method. This system is aimed at reducing the working load on teachers. The main criterion of the evaluation is the time for marking exams. The students and the exams will be evaluated this time.
College-level questions (e.g. Math, Japanese language, English) are prepared in two sheets (A and B). We ask 10 college students. We will employ two methods for marking exams. One of them is marking the exam sheets as usual. The other is marking by the proposed marking system. The teachers are divided into two groups which is G1 and G2. G1 marks the sheet A exam by hand and the sheet B exam using the system. G2 marks the sheet A exam using the marking system and the sheet B exam by hand (Table 1). We measure the time for marking the exams. The time for marking the exams will be tested by t-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>G 1</td>
<td>Normal</td>
</tr>
<tr>
<td>G 2</td>
<td>System</td>
</tr>
</tbody>
</table>

Table 1. Evaluation plan.

If the time of G1 for the sheet B and that of G2 for A is shorter than G1 for A and G2 for B, respectively, it will show the efficiency of the proposed system regardless of the teachers and questions in the exams.

Conclusion

This paper described a system of using a pen and paper-based device to reduce teacher’s burden for marking exams. The system provides teachers to mark exams efficiently and effectively. They can also employ the new element of time series to analyzing the problem solving of each student. We have implemented the system and presented our evaluation plan. In future, we will follow the evaluation plan.

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