E-assessment using image processing in $\infty\mathbb{E}xams$

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***Abstract*—This paper features a software system called $\infty\mathbb{E}xams$ (InfinityExams) which supports (primarily in higher education) paper-based examination and makes it easier, more comfortable and speeds up the whole process while keeping every single positive attribute of it but also reducing the number of negative aspects.**

The approach significantly differs from the ones used in the previous 10+ years which were implemented in such a way that they could not reproduce and replace the traditional paper-based examination model.

The heart of the article relies on the most important element of the software which is the image processing flow.

***Index Terms*—E-assessment, computer-based assessment, computer-assisted assessment, computer-aided assessment, examination, exam, image processing**

I. Introduction

There is a growing need for storing paper-based information digitalized nowadays. This problem concerns education as well but it does not always get enough attention, however using our technology accordingly many aspects of the educational process could be made a lot simpler, easier, faster, more comfortable and (partially) automatable.

Most of the educational institutions are using traditional teaching and examination methods in most of their subjects still. Though the digitalization of teaching got a little bit of attention in the previous years and began its growth since then. Alongside it there are also computer-based examination methods but it is not the main functionality of the e-learning systems. So mostly the traditional examination models are used concerning those subjects which require such a way to be examined accordingly. From now on the paper-based examination method will be discussed, since it is the main concern of this paper. The keyword "e-assessment" refers to electronic assessment as a software is used to mark the exam papers filled by the students after the exam is completed.

II. Related Works

A. Classifications of related systems

The primary classification is based on the main functionalities of the given system as follows:

1. Computer-based examination and assessment systems
2. Computer-based assessment systems

It is trivial that the former group of systems give a wider solution and it even seems better and easier to do the whole process this way but it is not in every case for certain, moreover usually it is not even worth it. Though it implies that most of the related work in the previous 10+ years discusses these kinds of systems since these should be the real future of computer-based education but not yet. Nowadays the examination part of these systems is too futile and only in special cases (e.g. multiple-choice tests) can it fully reproduce the way of its paper-based equivalent. For example, in the USA they wanted to have these kinds of systems in every school and they wanted to make it obligatory to take exams this way but the plan have not gone accordingly because many states reported malfunctioning systems and other problems concerning these software systems, so they had to cancel this whole plan [1].

Both categories of the previously stated systems can also be viewed from another aspect since both are also assessment systems which have a so-called intelligence of evaluation. According to the intelligence of evaluation the classification is as follows [2; 3]:

- Manual evaluation,
  the evaluation of the solutions is done manually, by human resources.
- Quasi-automatic evaluation,
  the system is able to evaluate the major part of the solutions automatically, still a smaller part of them are evaluated by the teacher.
- Automatic evaluation,
  the system is able to evaluate all answers automatically.

B. Computer-based examination and assessment systems

As it was mentioned earlier most of the related work consists of this class of approach to the problem but below only one of these is highlighted. The reason and the summarization of the highlighted system lie below.

The so-called eMax [2; 3; 4; 5] system which was also made under the roof of Obuda University, John von Neumann Faculty of Informatics, provides quasi-automatic evaluation for short text answer questions and special maths tasks. The text can be any input from a keyboard but at the maths tasks there is a required syntax which must be followed to

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ensure the maximum efficiency of the evaluation algorithms. Because of this restriction many students were not able to adapt well enough to the ways of the system and also the system only proved useful enough in a few cases so the envisioned functionality of the software was not realized. Today the system is still used but sadly not the way it was meant to be...

The problems of similar solutions are discussed in [6].

C. Computer-based assessment systems

There are some works concerning this class of assessment systems as well but not all of them are completed ones [7] or just simply solve a specific problem this way [8]. As previously only one of these is highlighted below but this time there is no personal connection to it. It is just one of the better ones found during the research.

The paper which will be mentioned already states its approach in its title: "Blended e-assessment: Migrating classical exams to the digital world." [9]. It makes the reader sure about what is the aim of the work, it simply is almost the same as mine. It has a strong argument about the usefulness and importance of such a software and even presents the completed software, moreover summarizes some years of experience with the system with the experiences of the students and the teachers. It also features some key solutions in the software itself which mostly only make it more user-friendly but because of this some of my early thoughts of such a software got verified.

III. The $\infty\mathbb{E}xams$ Software System

$\infty\mathbb{E}xams$ is a computer-based assessment system using manual evaluation and containing the following features:

- Teacher and student user interfaces, login options.
- Teachers, students, exams can be added and modified.
- Generation of special exam sheets and all of its components including QR codes.
- Upload of scanned images of a given exam, automatic image processing of these files and preparing them to be corrected by the teachers.
- Automatic generation of exams with the help of the given QR codes if an exam is not present in the system and sorting of the processed images by exams and by students.
- Exam correction interface for the teachers.
- The end results of the individual exam papers are automatically generated with the help of the given correction of a teacher. Summarized end results are also calculated and different statistics can be viewed by anyone.

A. The system model

The most important and most frequently used flow of tasks is represented in Fig. 1.

After logging in as a teacher the user can create the exam papers in some easy steps, during this process all essential information regarding the given exam will be recorded and using these the special exam papers will be created for the teacher to print them and handle them to the students. After the exam is completed and the students filled their papers those can be scanned, it is recommended to use a document feeder to do so since it can speed up the process quite a lot. The quality of the scanned images has a minimum requirement which is low and exactly is as follows: 1448×2048 pixel grayscale image. Better quality can also be used but it will unnecessarily slow down the scanning and later the image processing processes as well. The next step is to upload the files which can be easily done by some clicks on the user interface. The uploaded images will be processed right during their upload. Once all the selected images are uploaded and processed the teachers can begin the correction of these exams on the given user interface. When they are done, the results are ready to be published and the students can view and react to these of course.

B. The special exam sheets used by the system

Every paper contains some essential information about the given exam and about the one who took the exam on the given paper. All of this is represented in the header of the paper where a QR code can be found containing all the information about the exam and six cells as well where the students must put their identification codes. Also, if there are different groups of papers it is also represented in the QR code but the teachers are not expected to scan each and every one of these so instead it is represented as a big Latin letter beside the QR code. Each paper contains different number of tasks which are separated by horizontal lines from each other. There is also a vertical line present which makes a margin on the paper and to which the number and letter of the given task is stuck. Each paper has a footer which contains essential information about how to use the paper accordingly during an exam. A sample exam paper is represented in Fig. 2. There are also extra papers because it is not alright to limit the size of a given answer. These extra papers are looking almost the same as the one we have seen, but it does not contain any task numbers and letters those must be filled out by the students and the QR code is universal, so the extra papers are not bound to a specific exam, these papers can be used at any time and then the system will sort out to which exam the extra answers belong to.

C. Necessary image processing algorithms and methods

After selecting the images, the user is able to upload these to the system and with it the image processing begins and it loops until each and every one of the selected pictures is processed and are ready to be corrected. The main steps of the image processing flow are represented in Fig. 3.

At first the orientation of the picture must be set to the reference orientation which is when the paper is in standing position and the header of it is on top. First the deskew will take place since it is easier. It is done using Hough transformation [10] which gives an angle which describes the orientation of the given picture and using this information the orientation can be corrected easily with a rotation. The paper might not be in reference orientation yet but since the QR code should be in the top left corner of it if it is the algorithms try

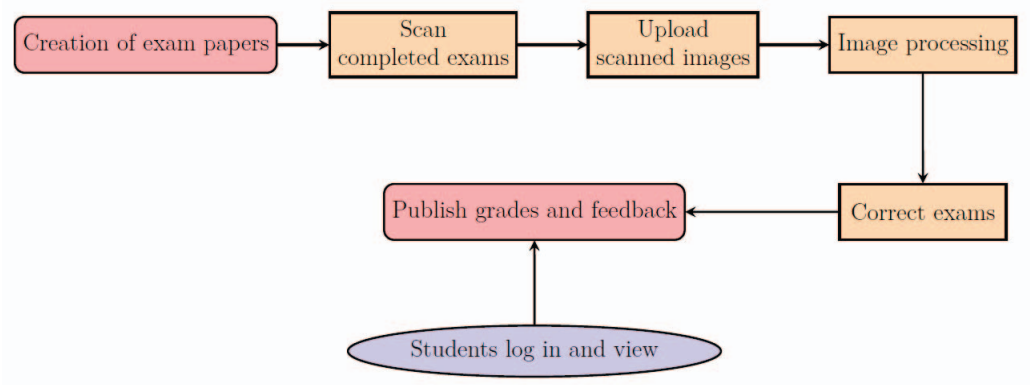

Figure 1: Users functional model image

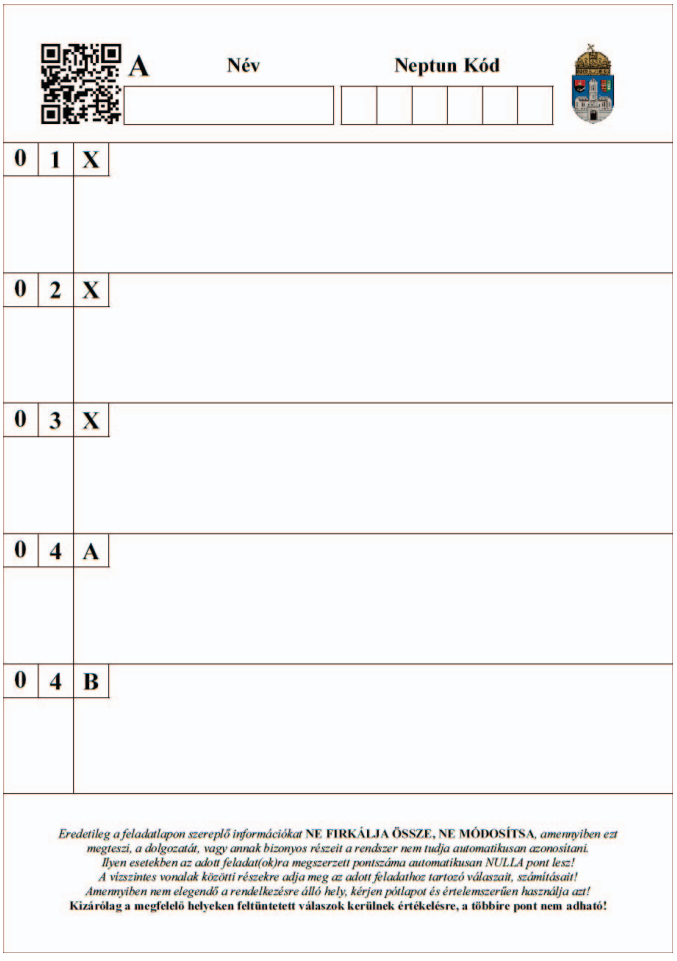

Figure 2: General special exam sheet

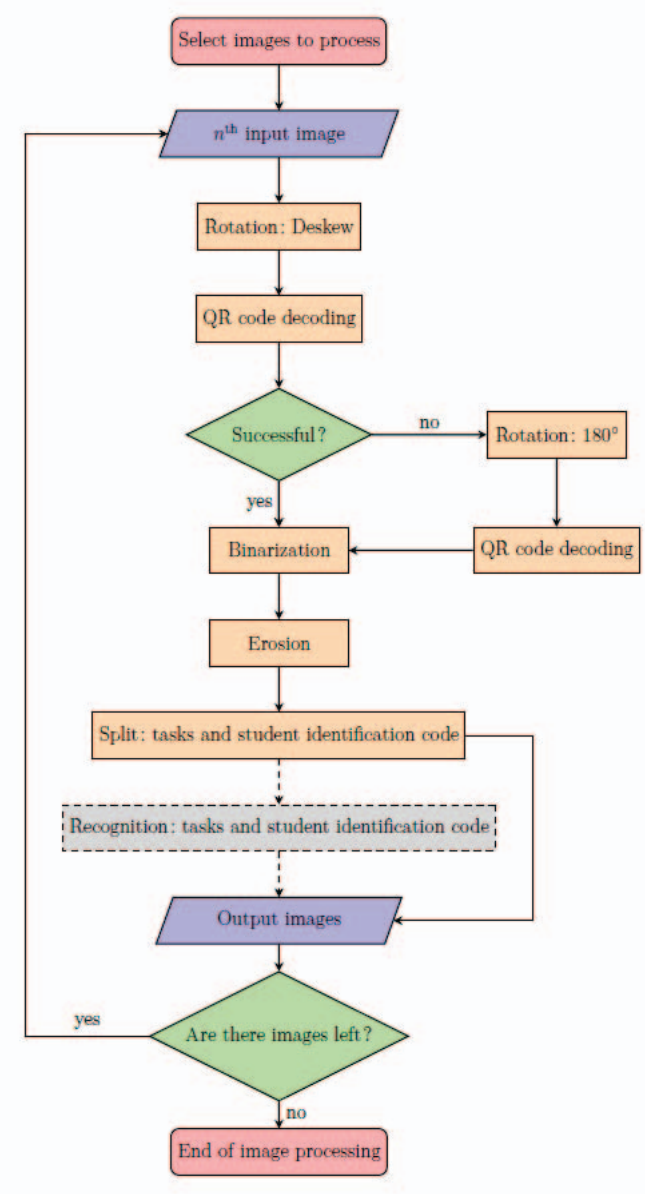

Figure 3: The main steps of the image processing flow

to decode it there. The decoding can only fail when the paper is not in reference orientation, so it should be rotated again, but this time by 180 degrees. After this the QR code should be in place and will be decoded accordingly, thus the information of the given exam will be collected and used. Now to spare storage space and to increase the visibility of the handwriting on the paper the picture will be binarized. The binarization uses Otsu's algorithm [11]. Getting ready for the splitting a pseudo step will take place, it is the erosion of the image [12]. It really is a dilatation but since on the test images the white background was meant as the white foreground by the algorithm, erosion had to be done not dilatation. Anyway, the reason to do this is to make the horizontal lines on the picture thicker and more recognizable by the splitting algorithms in the next step. As mentioned it is only a pseudo step so it will not affect the output images in any way. After this the splitting begins, the horizontal lines get detected and even the vertical line, so the numbers and letters of the tasks can also be located just as the tasks itself are. The pictures get split into as many parts as it is necessary according to the hierarchy of the exam sheet. After this using the information of the split images the recognition part should take place, but it is not yet implemented since it requires some handwriting OCR [13; 14] which is not that easy to do and because of it this part of the process is skipped and is substituted by manually doing this. After all this is said and done the output images are ready to be corrected of the given picture but if there are other files still to be processed the loop continues until there is none left and only then can the correction of the exams be started.

The testing of the image processing was done on 66 pieces of exams which had 2 sides each and was filled out by students according to the instructions and this way they did not sabotage the capability of the algorithms. The error rate of the algorithms was (in every case) 0%, which means that every picture got split into the pieces it was meant to be and thus no information was lost during the processing. For the results see Table I. below.

It can also be said that the spared storage space was more than 80% using the binarization and other sparing techniques.

TABLE I.
TESTING OF THE IMAGE PROCESSING ON 132 PICTURES AT ONCE

Type of test	Full runtime	Error rate
Best case scenario[1]	00h 02m 22s	0%
Average case scenario[2]	00h 11m 11s	0%
Worst case scenario[3]	00h 19m 00s	0%

[1]Every input image is very close to the reference orientation
[2]Half of the input images are very close to the reference orientation and the other half is upside down
[3]Every input image is upside down

The image processing is the key to the well working of the system and it got sharpened quite a lot during the times but it is far from being the best. A lot of new features could be implemented into it to make it even better and faster and more precise, although it did not fail a single time as it was mentioned earlier, but it is not ready to not fail in special cases when the students try to sabotage its effectiveness, so in the future this will be the main focus of the further development of the image processing part of the system.

IV. CONCLUSIONS

The featured so-called $\infty\mathbb{E}xams$ software system is in alpha version which means that the previously envisioned functionalities have been partially implemented and can be used. The software has a desktop application in which the users can generate exam sheets, browse and edit the database, upload images and correct the exams. The already implemented framework gives a nice look at how the whole system will be assembled. At this very moment, the software can only be used in offline mode.

The functionalities of the system have already been tested with more than a 100 exam sheets filled out by students solely for this purpose. The image processing part of the system has given satisfactory results as it seemed fast enough to process even a massive number of images at once without a single error.

It is beyond doubt that the further development potential of the $\infty\mathbb{E}xams$ software system is great and by seizing this opportunity, when it will be completed and released, it could play a considerable role in the future of the revolution of the digitalization of education.

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