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An Image Processing Based Optical Mark Recognition with the Help of Scanner

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Abstract **– The Optical Mark Recognition (OMR) is very popular with schools and universities for the reading of multiple choice questions. In this article, we presented an automatic system used for correction the Multiple Choice Questions (MCQ) based on digital image processing. This is a new and fast method that allows hundreds or thousands of OMR answers sheets to be processed. The method used is based on creation of template answer sheet and key points detection algorithm. The proposed method automatically computes the number of correct answers using vertical and horizontal projections and thresholds techniques. The proposed method is able to detect more than one or no selected choice. In this study we have tested more than 100 exam papers. As a result of the study; 100% accuracy was achieved on five different formats of MCQ papers and process time for each test is less than one second. In addition, the performance of the proposed system will be compared with various academic studies.**

Keywords **– Image Processing, Key Points Detection, Optical Mark Reader and Multiple Choice Questions.**

I. INTRODUCTION

The Optical Mark Recognition (OMR) or optical mark reading, is an automated data input process used to find out if there are marked data (crosses, ticks and filled regions) on printed papers such as the Multiple Choice Questions (MCQ) and surveys [1]. This technology has changed much in recent years. Now a day in schools, colleges and classes OMR technology is used. Exams are conducted using OMR answer sheet checking system because by using this technology the conduction of exam is getting much easier, powerful, and cheap [2]. We use OMR technology in school and colleges to judge the student's academic performance. The students refer to the answers on the test by filling the useful such as student ID, student name and multiple choice answers on an OMR sheet using a pencil to darken bubbles marked on sheet. But some students sometimes filled marks on bubble too light or filled less than half of bubble or filled more than bubble in each question. The proposed method is able to detect more than one or no selected choice. After input OMR answer sheets and answer sheet template to computer by scanner. All images will be given as input to the software system. The system begins with four steps. In the first step, we will create the template by selecting coordinates of the template and store them in a file. Next step we apply a algorithm on all images to find center of the starting point and center of end point to accordingly rotate all images to make it perfectly vertical. The third step is for segmenting regions. The regions are automatically cropped and calculate black pixel each bubble in column and row using projection profile and thresholds techniques. In the final step, automatically will check all exam papers with answer key and store the results in file.

This article will be further organized as follows. In the next section we review some related works. In section 3 we explain proposed methodology. In section 4 we show some experimental results in case study. In section 5 presented comparisons with other works and finally in section 6 we conclude our study.

II. RELATED WORKS

In this subsection provide a survey of the literature related to Optical Mark Reader. The OMR scanning evaluation technology started to be used in the 1950s, with a machine consisting of a series of sensing brushes in detecting graphite particles on the document [3].

Chinnasarn et al. presented PC-type microcomputer and image scanner. The system operation could be distinguished into two modes: learning mode and recognition mode. Data extraction from each area can be performed based on the horizontal and vertical projections. For the purpose of checking answer, the number of black pixels in each answer block is counted, and the difference between those numbers in the input and its corresponding model is used as decision criterion. This was a transition between punch Cards and barcodes [4].

Hussmann S. et al. presented his paper "A high speed optical mark reader hardware implementation at low cost using programmable logic". It has described the development of a low-cost and high speed OMR system prototype for marking multiple choice questions. The novelty of this approach is the implementation of the complete system into a single low-cost Field Programmable Gate Array (FPGA) to achieve the high processing speed [5].

Rusul Hussein Hasan et al. (2015) presented OMR based on Modify Multi-Connect Architecture (MMCA). This study focused on the development of an OMR for multiple choice tests via using a new technique, "associative memory with modify multi-connect architecture". The average processing speed is more than 60 pages per minute [6].

A. AL-Marakeby (2013) presented a low cost and fast solution for optical mark recognition system working in multi-core processor system. The answer sheet is captured using a digital camera and the image is processed. Initially the borders of the sheet are located then the bubbles are

detected. Fast techniques are used to detect the bubbles without a rotation correction [7].

Gokhan Bayar presented a new perspective to the automatic grading systems used for the multiple choice exams. Adapting the Hough transform technique to develop an automatic grading system is the main focus of his work. Hough transform consists of a method that can enable to count the number of points placed on a possible line in a data set or in an image. This method focuses on representing the lines in a form which is constructed based on slope intercept information. In his study was tested more than 1000 exam papers. The average time which is required to complete one of the students' papers is 10.583 sec. [8].

Zampirolli et al. proposed an automatic correction system for multiple choice exams. The system uses an image processing technique for detecting the answer options. Each answer sheet is scanned and transformed to binary format. Then simple morphological operations are used for segmentation [9].

Nutchanat Sattayakawee's (2013) proposed algorithm for test scoring using non-optical traditional grid answer sheets of Thailand. The algorithm is based on projection profile and thresholding methods. [10].

III. Outline of Methodology

This paper proposes a methodology is based on creation of template answer sheet and for key point detection (start point and end point). General steps of the methodology are presented in Fig. 1.

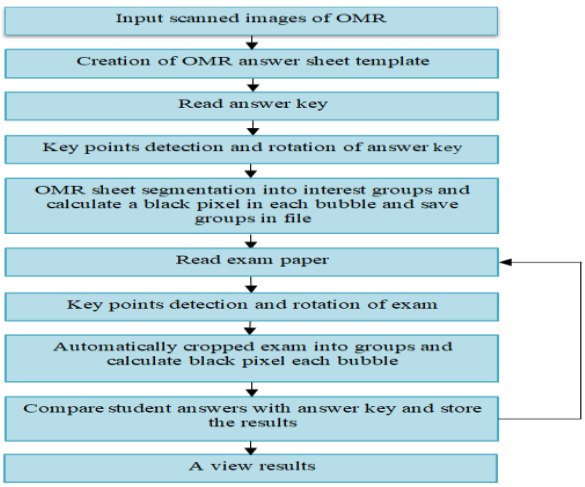


Fig. 1. Flowchart of the main steps of the methodology

In particular, the steps of this methodology are described in detail in the following subsections.

Step 1: Creation of the Template

We have created the template by selecting coordinates (search field of the starting point and end point, length and width of the starting point and end point, the size of bubble and groups regions). All coordinates are stored in file.

Step 2: Key Points Detection

This step is divided into two parts. The first part is to apply the detection algorithm to the starting point. The second part is to apply the detection algorithm to the end point.

The Starting Point Detection:

The first step to is conversion pixels inside the field of research to gray pixels using correcting for the human eye sometimes called luminance method [11], [12] as in (1). In the next step, applying threshold value to convert gray pixels to black pixels. The threshold value of 128 has been used. The pixel less than the threshold are turned to white and the remainder to black pixel. In the final step, from the field of research the algorithm will detect for first black horizontal line which is close to the length of start point for template and find the first black vertical line which is close to the width of the starting point of the template and then calculate center of start point (c1, c2).

$$Color = (\mathrm{Re}d * 0.3 + Green * 0.59 + Blue * 0.11) \quad (1)$$

The End Point Detection:

The first step to detect end point is conversion pixels to gray pixels using luminance method and applying threshold value to convert gray pixels to black pixels. In the next step, from the field of research the algorithm will detect the first black horizontal line which is close to the length of the end point for template and find the first black vertical line which is close to the width of the end point of template. In the final step, calculate center of end point (c3, c4). These cconversions are illustrated in Fig. 2.

Fig. 2. (a) Original key point (b) Key point after grayscale using luminance method (c) Key point after applying the threshold technique

Step 3: Calculate Correct Angle

After having detected the starting point and end point. The algortihm will calculate correct angle (θ) from center of start point and end point by equation (2). The goal of this step is rotate image at a calculated angle to restore it to its normal rectangle.

$$\Theta = (c3\text{-}c1)/(c4\text{-}c2)$$
$$Rotation = \Theta * 180/\pi \quad (2)$$

Step 4: OMR Sheet Segmentation

The answer key will be divided into three regions (student ID, student name and student answers), then apply projection profile and thresholds methods. The projection profile and thresholds are used to identify all information on the answer sheet. For answers the horizontal projection profile is used to identify for each bubble boundary and counting of black values for bubbles in each row. For student ID and student name apply the vertical projection profile identify for each bubble boundary and counting of black values for bubbles in each column. These processor are illustrated shown in Fig. 3.

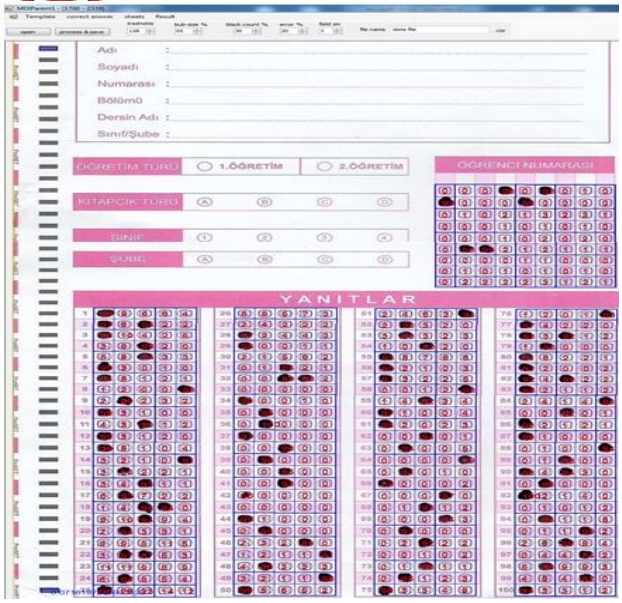


Fig. 3. OMR sheet segmentation and calculate black pixel in each bubble using Projection profile and thresholds.

Step 5: Representation of Answers

The purpose of this step is to represent each question by value. For example, in case two choices answers selected the value of question is -2, in case none choice selected the value of question is -1, in case one answer choice selected the value of question is number of column as shown in Fig. 4. Results are stored in a file as shown in Fig. 5.

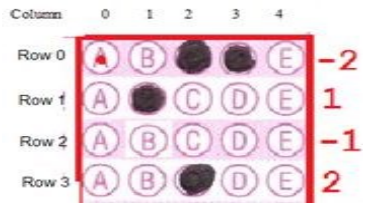


Fig. 4. Representing group answers

Step 6: Comparison Exam Paper with Answer Key

In this step automatically will compare exam paper with already stored file answer key and store the results in file. In Fig. 5, lines 2, 3, 4, 5 refer to groups answers each group has 25 questions, each question represented by value.

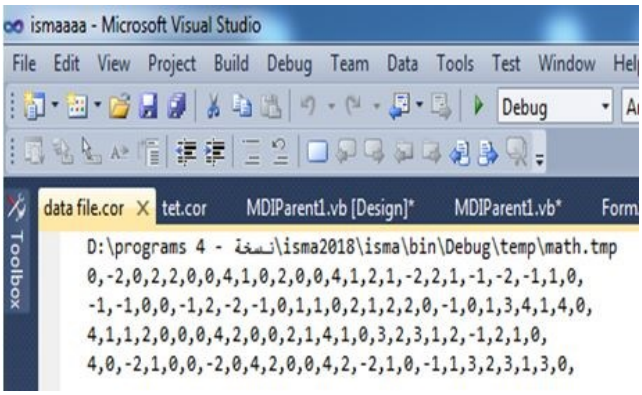


Fig. 5. Result of stored file from OMR sheet Segmentation in Fig. 3.

Step 7: *Read All Exam Papers*

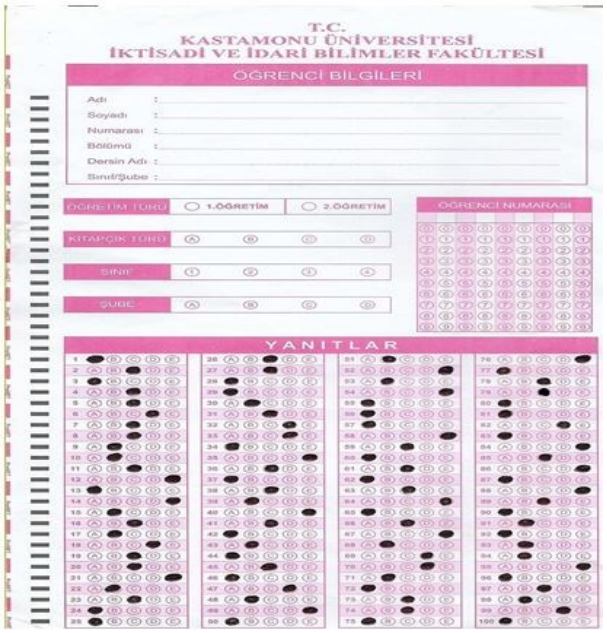
In this step, we apply step 2 to step 6 for each exam paper instead of the answer key until read all exam papers.

Step 8: View Result

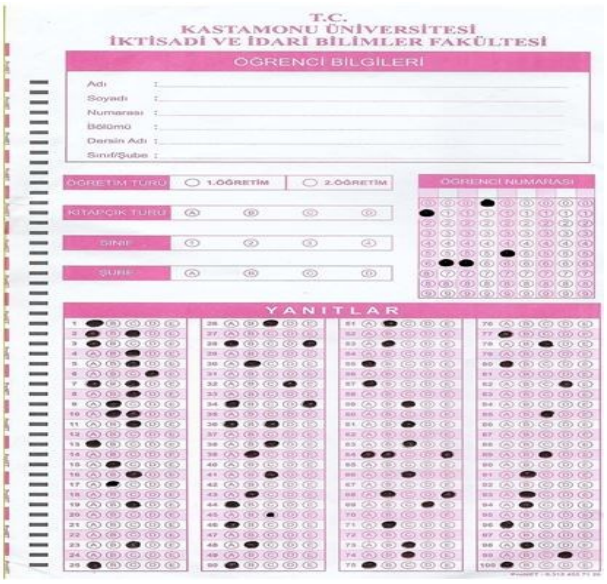
The results will be presented in the next section.

IV. Case Study and Experiments

In the experimentation, the proposed algorithm is tested with 5 different formats of papers. In this paper we have been used three types of answer sheets with samples answer students as illustrated in Fig. 6, Fig. 8 and Fig. 10, Type I contains 100 answers, 25 answers in each column.



(a)



(b)

Fig. 6. Tested of Type I with (a) answer key containing 100 answers (b) Student test containing 53 correct answers and student ID "16605"

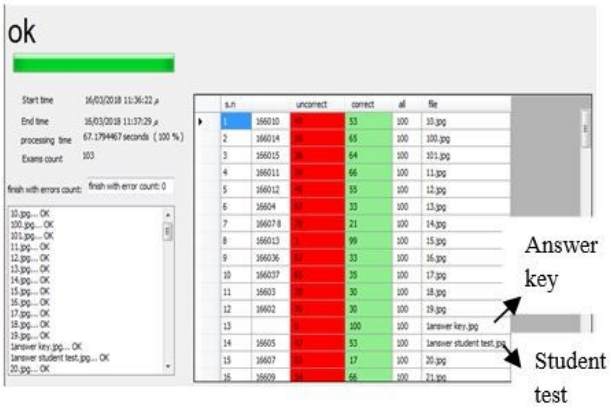


Fig. 7. Sample results of Type I for 100 tests

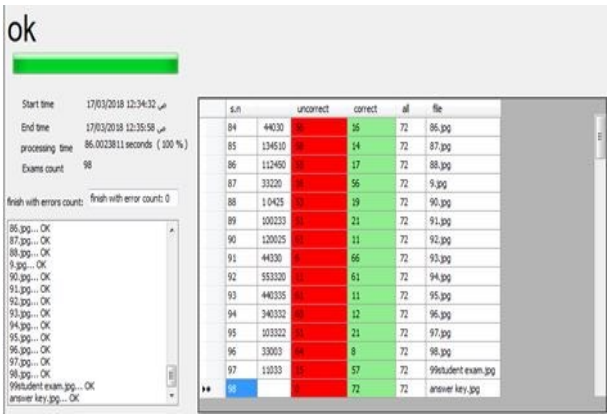
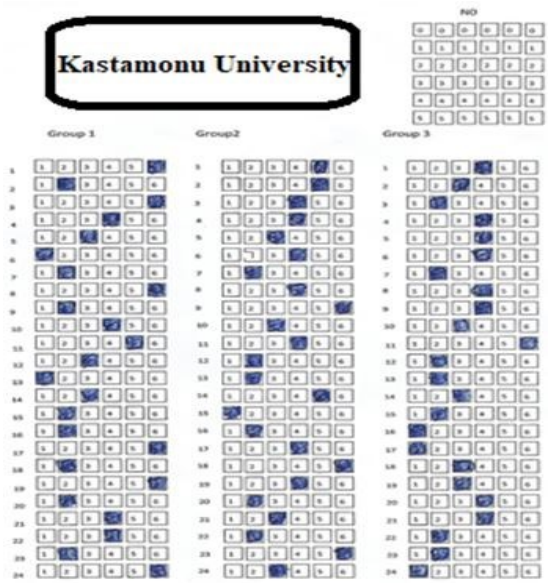
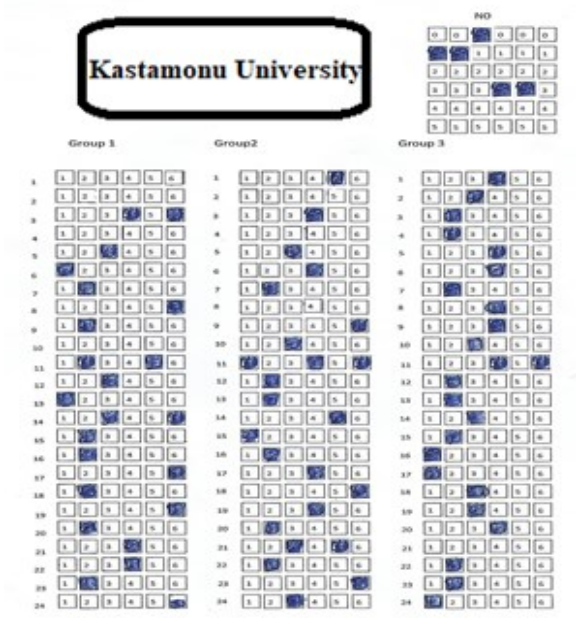


Fig. 9. Sample results of Type II for 100 tests

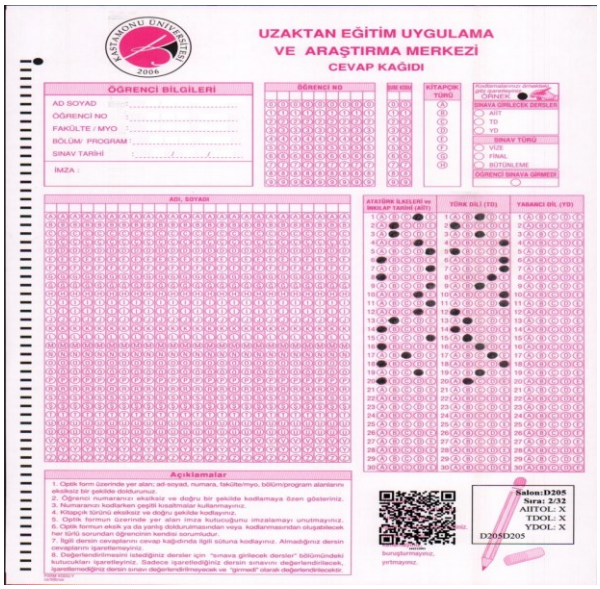


(a)

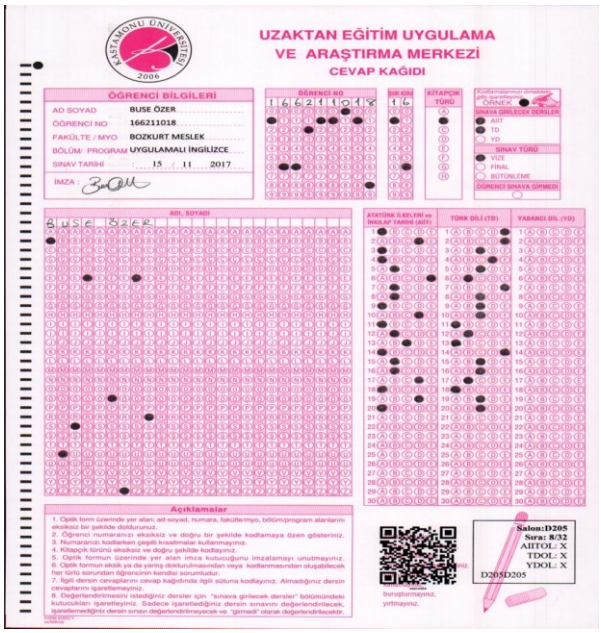


(b)

Fig. 8. Tested of Type II with (a) answer key containing 72 answers (b) Student test containing 57 correct answers and student ID "11033"



(a)



(b)

Fig. 10. Tested of Type III with (a) answer key containing 40 answers. (b) Student test containing 22 correct answers, student name "BUSE" and student ID "166211018".

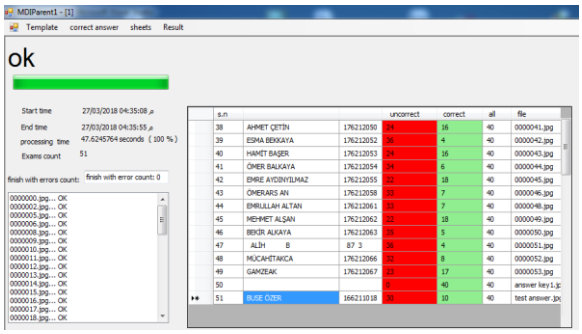


Fig. 11. Sample Results of Type III for 50 tests.

Some of answers contains more than one answers or no selected chooses. The proposed algorithm detected correct answers in both cases, Type II contains 78 answers, 24 answers in each column and Type III contains 90 answers, 20 answers in column are used as illustrated in Fig. 10. The results obtained from processor are shown in Fig. 7, Fig. 9 and Fig. 11.

These results contain all information for each student such as student ID, student name, the number of correct answers. The average accuracy of answer checking tested on 100 images for three different answers sheets was 100% and the process time for each test less than one second.

Table 1, presents the total processing time of each answer sheet type.

Table 1: Processing time for each type

Answer sheet type	Number of tests	Number of question for each test	Total processing time (sec.)
Type I	100	100	67.179
Type II	100	72	86.002
Type III	50	40	47.624

V. Comparison with other Works

In this comparison, we focused on compare with the accuracy result and process time. Table 2 shows accuracy some papers that compare them.

Table 2: Comparison of other works and our working

Process time each test	Previous works	Number of Questions	Accuracy (%)
Less than 2 seconds	N. Karunanayake (2015)	50	97.6%
10.583 sec.	G. Bayar (2016)	25	100%
1.30 and 1.19 seconds	K. Chinnasarn (1999)	100	High accuracy
Less than 1 second	**Our work**	100	100%

VI. Conclusion

In this paper we have presented a system uses Visual Basic (VB) language within the Visual Studio integrated development environment (IE) for evaluation of algorithm which provides a solution for reading and processing large number of forms. The system automatically checks scoring of Multiple Choice Tests and presenting high accuracy in the results. The system can also be applied in other different types of answer sheets. The system is designed with easy user interface.

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