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Cost-Effective Small-Scale Mark Recognition Technique in Evaluation of OMR Sheet

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Abstract

In developing countries like Bangladesh, most records are still captured and maintained using paper forms. In every sphere of our life to digitize data, it can be challenging to aggregate, share and analyze the data collected from plain paper. In this research project, an automated system based on digital image processing is intended to develop so that student answer scripts of multiple choices can be evaluated instantly by an instructor. Main target of the paper is to create a program with such perfection that it can perform negative marking, providing grace in case the correct answer is not present in the answer sheet. If answer script contains multiple answer to a question then the system will be able to justify that pattern as well. The system has been developed successfully in MATLAB platform by examining more than thousand exam papers during study. The evaluated result shows that the program possesses the competence of accurately capturing and digitizing data from paper forms.

Keywords: Optical Mark Recognition, gray scale intensity, Standard Script, 2D matrix, RGB format

1. Introduction

The Optical Mark Recognition (OMR) is an automated information capturing process which is used to find out whether there are marked on printed papers such as the Multiple-Choice Questions (MCQ) and surveys [1]. The OMR technology is very popular with schools and universities for the reading of multiple-choice questions. Now these institutions are switching from manual evaluation using pen, paper or device to automated exam evaluation system because of laborious and error prone manual transcription. Day by day using OMR technology Answer Sheet Checking System for the conduction of exam is getting much easier, powerful, popular and cost effective. The aim of this paper is to build such a system that provides acquired marks of a student in assessment in OMR from scanned copies of the student's answer script.

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The system can load scanned copy of standard and student's answer script. Then it compares both the scripts to find obtained marks of the student. It also decreases marks based on negative marking for each wrong answer fixed by the instructor. Then student is also given grace on obtained marks in case of question paper's printing mistake. Designed software for this purpose has the privileges to support multiple answers as well. And finally, after giving all the outcome privileges the acquired mark is evaluated.

MATLAB has been used to implement the software which stands for Matrix Laboratory. It is such a tool for numerical computation and visualization which provides advantages to implement the code in an easier and compact mode. It provides several functions which can intake large amount of structural result in just one line of function. The basic data element is matrix which is easier to implement array-based data which is generally fast to write and run in MATLAB. The existing software for OMR checking is highly efficient but very expensive. On the contrary from the work perspective special attention and efforts have been provided to minimize the problem of evaluating the OMR sheet without any special hardware and making the entire process economical.

The rest of the paper is organized as section 2 provides related works of Optical Mark Recognition technology; section 3 gives methodology of proposed system showing the detail of student script processing, standard script processing and evaluation. Section 4 provides results based on the analysis of section 3 and section 5 concludes the entire analysis.

2. Related Works

A software which provides a solution for reading and processing large number of OMR forms are developed in paper [1] based on Visual Basic language. In our paper we intend to develop a software in MATLAB platform that will recognize the optical mark of a scanned image. The scanned image is captured by a scanner or Webcam. With the advent of information technology, it is desirable to have that the quiz conducted in a class or exam hall can be taken by the instructor using OMR form named answer script. The answer scripts are then evaluated by our

developed software. The evaluation process can be done in a short duration which reduces the huge effort by the instructor in manual process. This also gives the quick delivery of quiz result. The objective is to compare the standard script to student's answer script to provide proper marking to that student's answer script. It is a more confidential, convenient and secures way to implement the required task using modern technology that gives us the privileges to have desired result using simpler functional techniques giving us the proper success criteria.

General approach used by Educational institutions, social welfare and health-based organizations are multiple-choice or bubble forms, where the user needs to fill in a number of circles or bubbles to document a response. Research suggests that these bubble forms are easier to understand and use than forms that require large amounts of writing, especially by people with little education or low literacy [2]. This Optical Mark Recognition technology in terms of bubble forms is a machine-readable device-based technique. Traditionally a special scanning device is used which shines a beam of light onto the form. The device has the capability to detect marked areas on the scanned form owing to reflection of less light than the blank areas. However, for most organizations in developing countries high cost of the specialized scanner is a big issue. In spite of the fact that a few open source OMR systems are still available, all of them require special customization based on different design pattern and requirements of different organizations. As a result, the trial of developing a digitize system to replicate the task of automating the OMR system through software is still on spree. In [3] the authors initially implement mScan which digitizes paper forms used to document vaccine statistics in rural health centers in Mozambique.

A complete OCR system has been developed in paper [4] for images/graphics captured by camera are embedded textual documents for handheld devices and achieved a maximum recognition accuracy of 74%-92% where in paper [5] the author proposed an automated process of capturing the information, usually in the form of bubble or squares which is color and brightness independent. It is often necessary to take photographs of plants in the field and record the photographs, sample

number, biological replicate number and categories. In paper [6] the authors have presented a tool named as SpotCard that can be used to document human- and machine-readable data on a reusable card. It automatically can read the annotations from the image and stores them in a CSV file including picture date, time and GPS coordinates.

Authors in [7] have proposed a low cost and fast solution for optical mark recognition system which will work in multi-core processor system. A digital camera is used to capture the answer sheet and then the image is processed. Locating the border lines of the answer sheet is executed followed by detecting the bubbles. They have applied fast techniques for bubbles detection without incorporation of rotation correction. To overcome the lighting effects of the images an adaptive binarization has also been applied. There has been a proposal in [8] in which the proposed system consists of an ordinary printer, scanner with a computer to execute computation being assisted by a graphical user interface. Users have the privileges to delineate forms of their particular choice to use it for assessment and other similar activities. After that the filled forms need to be scanned where the scanned images are given as input to a computer. Then after the computation, the result is stored in a user understandable format in spreadsheet. The system in proposal is unrestrained of hardware with system platform, consequently making it independent of platform.

Also, in [9] the authors have proposed Optical Mark Recognition sheet scanning system based on Image processing. They have proposed to find the correct answer starting with scanning the answer sheet and then by finding the region of interest through the application of template matching algorithm. Their final output is only limited to summing up the total marks and displaying of that marks. They have not considered any real-life situations like printing mistake, providing grace, multiple answer consideration etc. which comprises the foundation of our proposal.

3. Methodology

The general working structure of the proposed system is shown in figure 1.

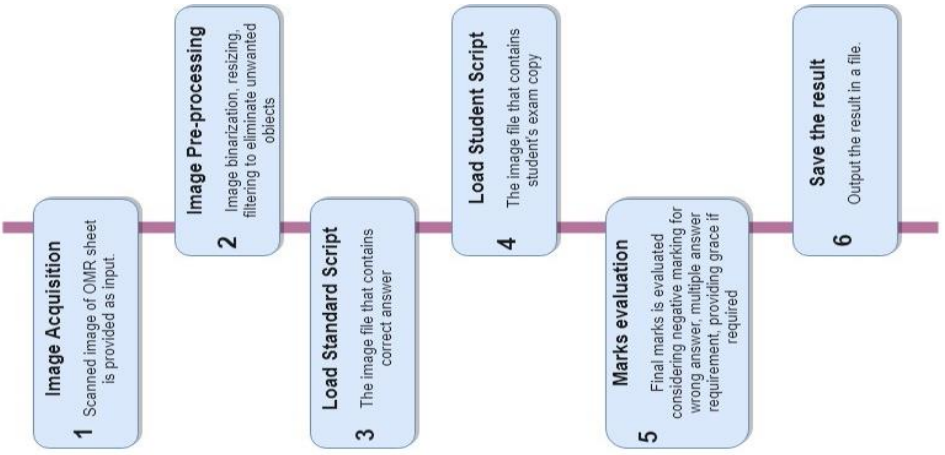


Figure 1: Proposed System Workflow

In this paper, the image of the OMR form (RGB format) is at first converted to gray scale image and then binary image. It could have directly converted to the binary image from RGB, but that would result in more data loss. RGB is one of the formats used by MATLAB in order to store colored images. In this format the color information of the image is stored in a 3D matrix. For a given pixel, the color of the pixel can be decomposed in terms of the fundamental colors, namely the red, green and blue colors. The first floor stores the red intensities (ranging from 0 to 255) with respect to the pixel position in a 2D matrix. Similarly, the second and the third floors store the green and the blue intensities respectively. Gray scale is the format for storing the intensity image (no colors). In this format 0 represents black and 255 represents white. MATLAB uses all the 256 numbers in between 0 and 255 to represent the darkness (or whiteness) of a given pixel. Binary, as the name implies is the format used for storing black and white image. Therefore, only two numbers namely 0 and 1 are used to represent the intensity level. '0' means black pixel (i.e. background in terms of MATLAB) and 1 means white pixel (i.e. object).

While converting the image from the source format to any other format there is a possibility of data loss and therefore the thresholding for the

conversion should be done to obtain the most optimized conversion. One way for this optimization is trial and error method or the built-in functions for thresholding can also be used. In this paper, the built-in functions are used for this purpose. Before start counting a lot of processing is done in order to get rid of all the letters, lines and all other objects that are not the circles. Then the incorrectly filled (partially filled or over filled) are replaced with unfilled circles, in order to avoid complexity of counting the whole processing has been done through the following steps:

3.1 Student Script Processing

At the initial stage of processing, the loaded script whether student or standard, is read as RGB color image using **imread** function. Then the true color image RGB is converted to the gray scale intensity using **rgb2gray** function. After that the gray scale image is converted into a binary image using a threshold value, and it is done using **im2bw** function. Threshold value is found using **graythresh** function. All pixels in the input image are replaced by the output binary image with **luminance greater than level** with the value 1 (white) and replaces all other pixels with the value 0 (black). To calculate the area of filled up circles since MATLAB considers white pixel as 1 and black pixels as 0 is the main target.

The scanned image might be placed in a wrong way giving it an inclined position. So the next step is to give the image a proper alignment, determining the angle amount to which it was inclined, so that it finds the first object in first position only. Then the image is filtered where leaving only the filled and unfilled circles shown in figure 2, all other objects on the image should be removed. As a first step towards that, from the top and bottom portion of the image where there will not be found any circle, should be **cropped** at a time.

Now from the current image, a new image will be created with those objects having **pixel value greater than or equal to those of unfilled circles**. And the rest of the objects will be eliminated. Again, from this image, another new image will be created with those objects having pixel value **greater than those of empty circles**. And the rest of the objects will be eliminated which is shown in figure 3. Now by comparing the two

images and subtracting concerned filled circles from there having only the unfilled circles and other objects shown in figure 4.

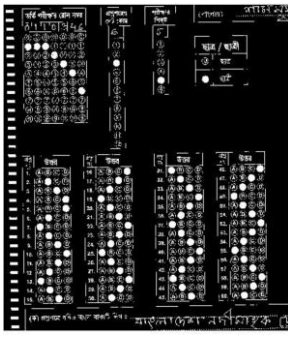


Figure 2: Filtered Image

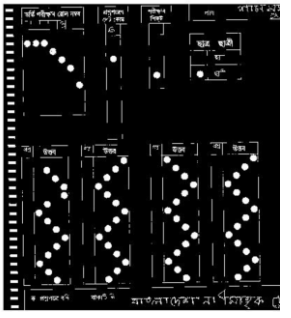


Figure 3: pixel value greater than or equal to those of unfilled circles

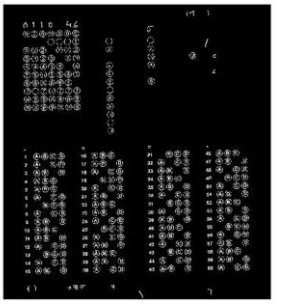


Figure 4: Images after concerned filled circles

Again, comparing the last three images found in figure 2, 3 and 4, an image is found where some unwanted objects is eliminated shown in figure 5.

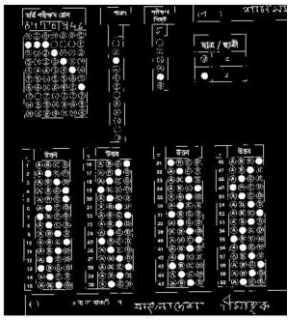


Figure 5: Image after eliminating unwanted objects

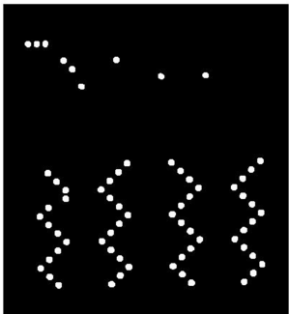


Figure 6: Image after detecting filled circles **imdialete** function

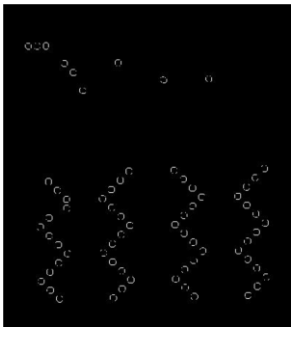


Figure 7: Image with ring type circles

It is identified that radius of each filled circle is about to 10. So with the help of a 10 radius disc, only the filled circles are detected using imerode function, erasing all other objects. Now detected filled circles are transformed into 10 radius circle each using **imdialete** function shown in figure 6.

Similarly, by creating 2 radius circles and subtracting them from the previous circles in figure 7, there is found ring type circles so that they can be replaced in case any circle is dropped off during filtering. By introducing the concept of label matrix, the position of each object is calculated using **regionprops** function. Now making the position of filled objects null, the image is found containing all those unnecessary objects which should be removed. From the main image, removing the unnecessary objects found from the above image, finally image having only necessary objects i.e. filled and unfilled circles is found:

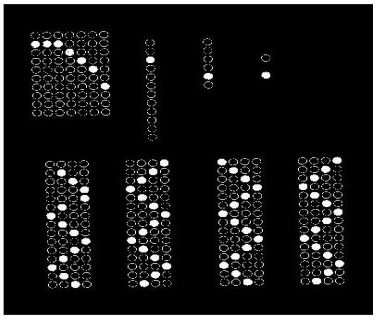


Figure 8: Image without unnecessary object

Now to privilege calculation procedure, the final image is divided into two portions depicting student's roll no, shift info, set code, gender in one portion and student's answer in another portion. In the roll field, objects covering all the rows and columns whether filled or unfilled, their area is calculated. Comparing this calculated areas column wise, with that of filled circles, we need to find out if, in each column there is only one filled circle. If there is any column being empty not having any filled circle, or if there is any column having two or more circles filled, then that roll will be proved invalidated. Otherwise concatenating all the filled objects found horizontally, the original roll number is retrieved. In the set code section, there is only one column. It is needed to find out similarly as depicted above in the previous point, if there is only one filled circle. In case the section is empty the answer script will be cancelled. Similarly even exam shift and in student section whether male or female, concerned information is also collected.

Finally, the total number of objects filled by the student are calculated. Approaching towards that, fill area and perimeter of each filled object is calculated. A threshold value is calculated if the area calculated is less than that value then it is proved that the circle is partially filled and will be treated as a wrong answer. Now taking correctly filled circles as 1 and unfilled circles as 0, the concerned function will return a logical matrix comprising that of student's answer script.

3.2 Standard Script Processing

The processing of standard scrip portion is same as student script processing except that there is no need of roll field calculation.

3.3 Evaluation

After the image processing is done **the 'standard_script' and the 'student_script'** are returned as logical matrices. In the logical matrices '1' represents a correctly filled circle and '0' represents an unfilled or incorrectly filled circle. In order to correlate and to keep track of the question order, the coding is done in such a way that the n^{th} question in the OMR form is represented by the n^{th} row of the processed logical matrix.

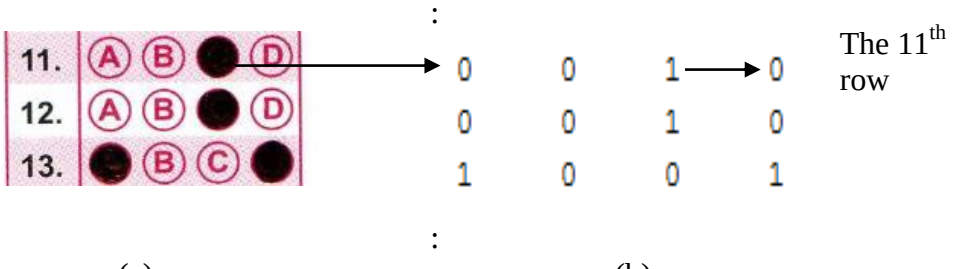


Figure 9: Logical matrix representation of the processed image

That after the logical matrix corresponding to the student's answer script is searched through to find out the questions that have not been answered at all or filled up incorrectly

Two logical matrices 'answered' and 'not_answered' are kept for further calculations. Because in order to give marks (especially for grace marking)

we at first have to know whether that particular question has been answered at all or not.

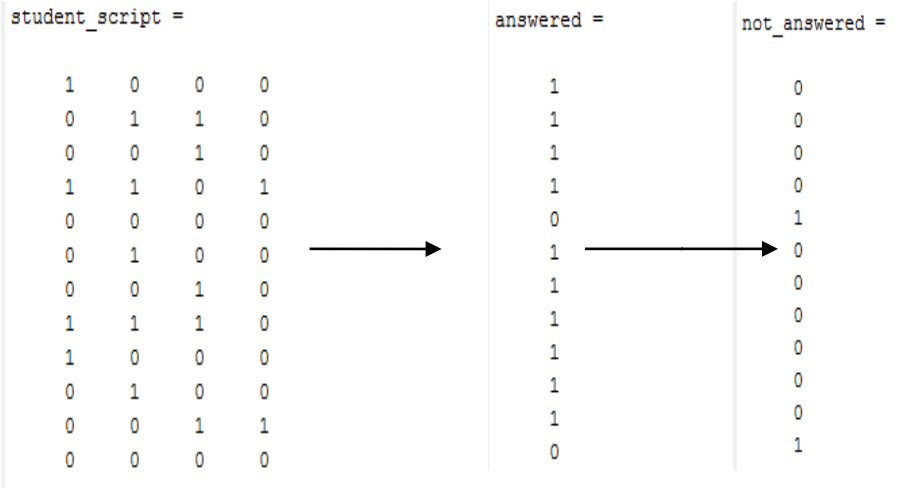
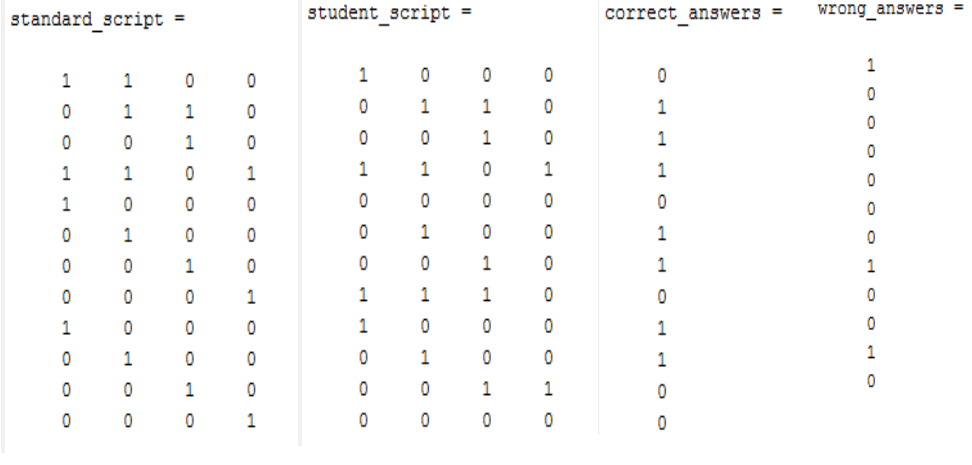


Figure 10: ‘answered’ and ‘not_answered’ logical matrices

Then a thorough compare and search is made through both the ‘standard_script’ and the ‘student_script’ to find out the correct and wrong answers shown in figure 11. The basic idea used for this purpose is, in order for two vectors to be equal the element wise logical AND and OR should be same shown in figure 12.



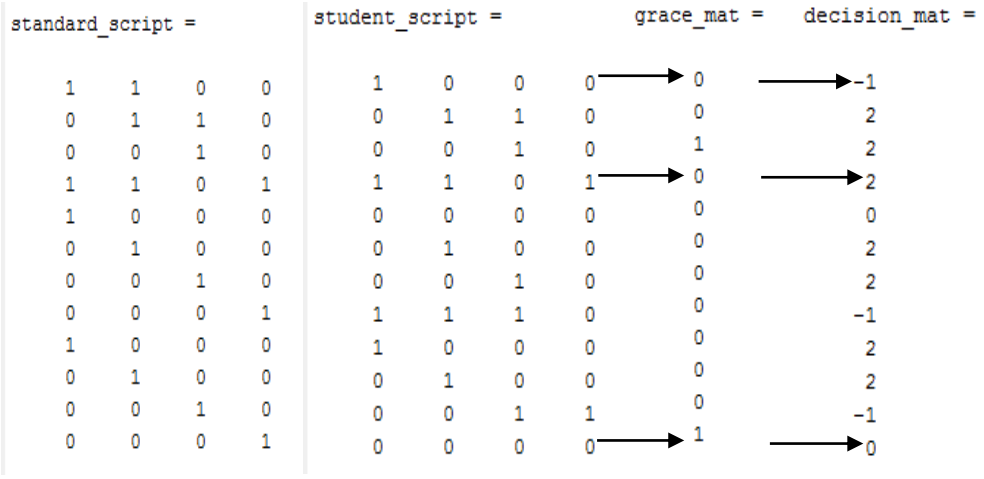
(a) (b) (c) (d)

Figure 11: Finding out correct answered and wrong answers for marking

	Matched				Not matched			
Standard_script	0	1	1	0	0	0	1	0
Student_script	0	1	1	0	0	1	1	0
Vector_AND, v_1	0	1	1	0	0	0	1	0
Vector_OR, v_2	0	1	1	0	0	1	1	0
Decision making	$v_1 = v_2$				$v_1 \neq v_2$			

Figure 12: The answer will only be correct if the vectors v_1 and v_2 are equal

Then comes down to the decision-making part with grace and negative marking shown in figure 13. For the sake of demonstration it has been assumed that the marks allowed per question is '2' and the negative mark allowed per question is '–1 '.



(a) (b) (c) (d)

Figure 13: Finding out grace and negative marking

In order to achieve our goal we have followed the following steps:

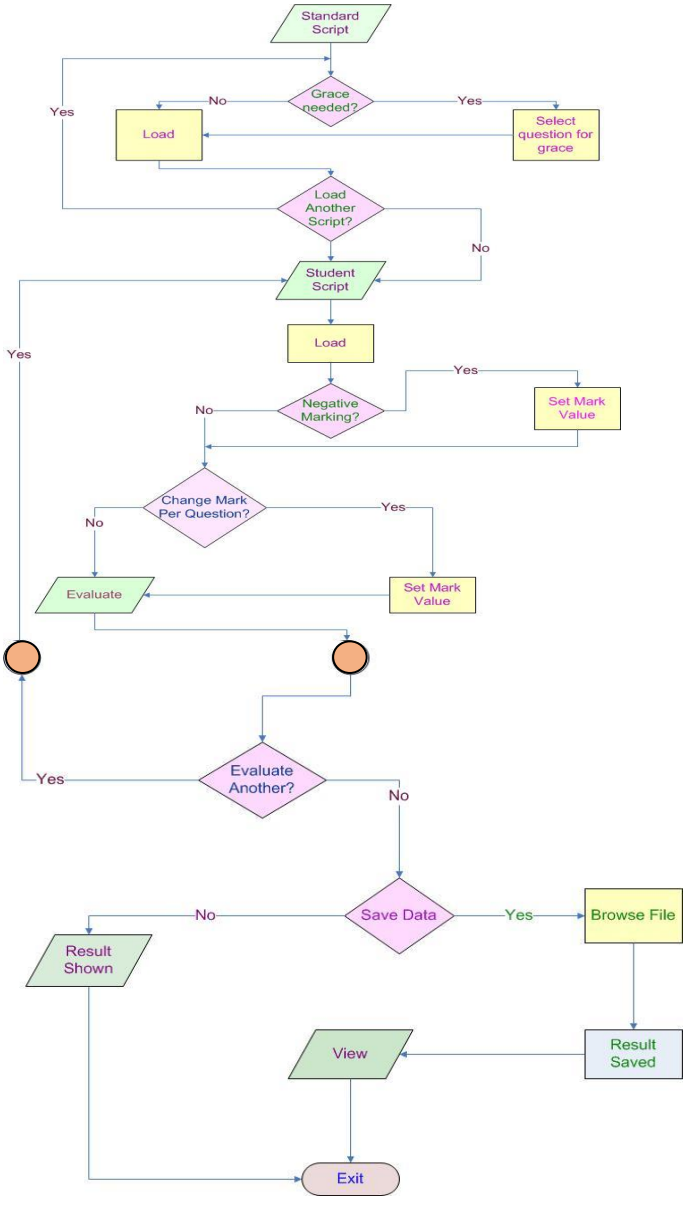


Figure 14: Flow chart of the system

4. Result

Finally following the process discussed above, a Matlab based solution is developed that loads the standard answer scripts with multiple set questions. Then it is to be mentioned the negative marking options in each set. After that, the student answer scripts are loaded and the system evaluate the results and save in the disk for publishing. The snapshots of the system and the sample of Admission Test result generated by the system are shown in figure 15 and 16. More than 1000 sample scanned answer scripts are examined and accurate results were found. Accuracy are measured by randomly evaluating students answer scripts manually and compared with the system results and achieved 100% accuracy. But processing time is not as fast as traditional OMR automated system in case of large inputs. If large number of students answer scripts are loaded at a time then the system may be slow. But in future it may be minimized by upgrading the system time to time.

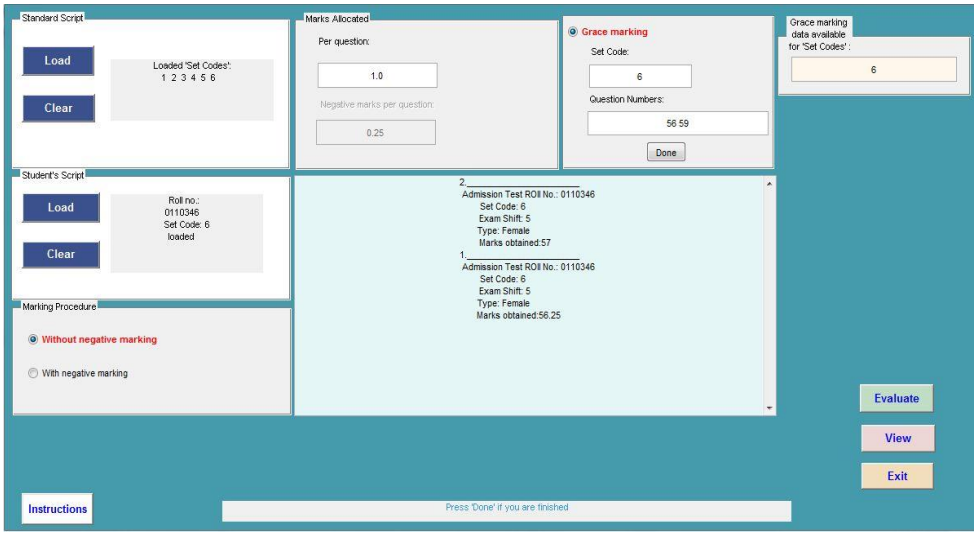
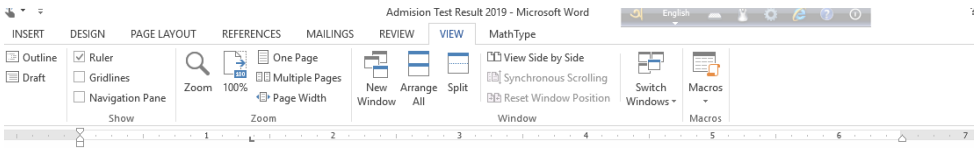


Figure 15: Admission Test Result Evaluation (ATRE) System



Admision Test Result 2018
Institute of Information Technology
Jahangirnagar University, Savar, Dhaka

At 2018/4/15 and At Time 14:26:18

Serial No.	Exam Roll	Set Code	Exam Shift	Gender	Obtained Marks
1	800001	1	1	Female	56.25
2	800002	6	1	Male	57.00
3	800003	4	2	Male	57.50
4	800004	1	1	Female	60.00
5	800005	5	2	Female	59.00
6	800006	4	2	Male	57.50
7	800007	4	2	Male	56.50

Figure 16: Admission Test Result generated by the ATRE system

5. Conclusion

Government, social and health organizations are working to digitize the flow of life. But still now paper forms are heavily used to collect information. So, paper forms should be processed through scanner so that it can automate the capture of digital data from paper. Experimental evaluation and preliminary user feedback show that though this software comparatively slow down process, nevertheless it is an accurate and robust tool that is ready to be extended to develop an *apps* for smart phone so that an instructor can evaluate student scripts instantly. In order that the efficiency and processing capabilities of the software will be increased with faster rate, lower cost, and more accuracy.

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