

An Optical Mark Recognition and Evaluation System Based On Image Processing

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Abstract— In this study, a rapid, reliable, and low-cost approach for recognizing and evaluating multiple-choice test marks by placing the OMR sheet in front of the camera. This technology is known as optical mark recognition, and it is the process of capturing data on multiple-choice forms. The image processing library OpenCV was used to create the recognition application, which was written in the Python programming language. When the answer sheet is imported into the application, erroneous answers are highlighted in red, while correct answers are highlighted in green, and the result is written on the optical form image after the calculation of the correct/incorrect answers and blanks. This is a low-cost, quick, and efficient method. The success rate of recognition was calculated to be 99.76 percent. In terms of accuracy, reliability, and performance, empirical experiments have revealed that the proposed system outperforms traditional optical mark recognition systems.

IndexTerms—OMR(Optical Mark Recognition),Open CV, Otsu thresholding, Binary Image, Grey Scale Image, Canny Algorithm, Contours.

I. INTRODUCTION

Numerous applications in our daily lives are related to computer-based image processing and computerized recognition in today's technology. Examples include cockpit automation, mobile robot applications, agricultural implementations, surveillance of friends and foes in military zones, biomedical and medicine, geographical data systems, security systems, and applications in design and manufacturing processes. Researchers have been focused on obtaining data about objects on images and drawing conclusions from them. Image processing can be defined as the process of a machine seeing and evaluating an image despite not being as good as the human eye and brain. Image processing applications in educational technologies are extremely limited. As a result, image processing techniques are now being used for a variety of purposes in education. Many tests and questionnaires are used in many fields, including education. Multiple choice questions are asked in many examinations administered by the Assessment Selection and Placement Center or the Ministry of Education. When a national examination is held, the cost of printing question papers and answer sheets in color, transporting them to exam centers, recalling the optical forms, and recognizing and evaluating these forms with special devices is prohibitively expensive. The use of expensive optical form scanners appears to be the most expensive. Each of the preceding operations is a process, and the technique for recognizing answers from optical forms is optical mark recognition. OMR is a technique for capturing data marked on multiple-choice documents such as questionnaires and tests. The OMR technology detects the presence or absence of a mark on a document by sending light through it and measuring the density of the light reflected by circles. However, it is unable to recognize the shape of the mark. Even though there are numerous and diverse OMR systems, the high cost of purchasing and maintaining these devices makes them difficult to use in developing countries. Schools are known to be the most common locations for the use of this technology. With the limited financial resources of the schools, it is extremely difficult to purchase and use these devices. However, using a standard scanner and software, it is possible to implement and evaluate examinations with optical forms more quickly and cheaply. The authors created a mobile application that allowed them to evaluate students' answer sheets without using an optical device and instead of using their mobile phone or tablet PC. Such operations as the justification of the form, revealing its attributions, recognition, and evaluation were carried out in a multiple-choice exam with 100 student participants. Each optical form was recognized in less than 20 seconds. These optical forms were recognized by four devices with at least 90% success and up to 99.7% success. We created an optical mark recognition system using the OpenCV library. A 50-item multiple-choice test is subjected to the recognition process. However, no operation concerning the process's success and confirmation was carried out. We compared a blank form to an image form using the template matching technique in the OMR process. They indicated that the answers were correctly recognized. An OMR application was created with the help of a camera and Python programming languages. The optical forms were recognized using this application by justifying them using four pre-determined reference points on the form. We were able to demonstrate that success rates were high on undamaged forms but low on damaged ones. In optical form, images were recognized by determining key points in the optical form and justifying the image in relation to these points. We created OMR software by combining image processing techniques with OpenCV and Python.

II. MATERIAL AND METHOD

The OMR system in this work was created with the Python software language and the OpenCV library. Python is a programming language created by Guido Van Rossum, a Dutch programmer. Python is a high-level programming language that is platform-independent, interpretable, and interactive. There is no need for a compiler in this language, as there is in C, C++, and Java. Intel

introduced OpenCV (Open Source Computer Vision) as an open-source library for image and video analysis. The following operations were performed in order on the image obtained with a camera:

- Betterment and crystallization of the image
- Binary conversion with Otsu thresholding
- Morphological operations
- Detecting the edge
- Contour extraction and corner finding
- Geometrical correction
- Bubble finding
- Comparing bubbles
- Printing out the results in a file and on the image

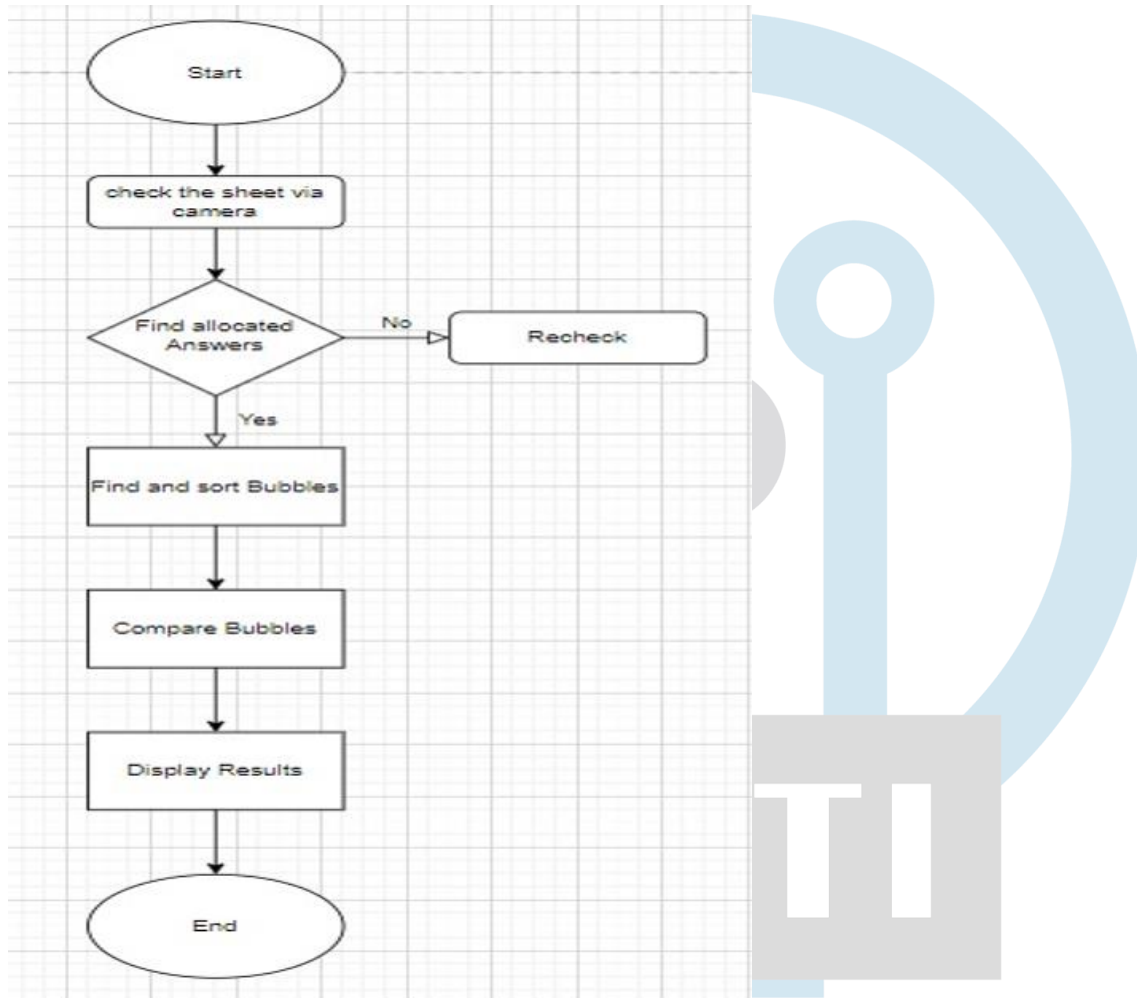


Figure -1

Figure 1 depicts the proposed OMR System's flowchart. An image is recognized as a two-dimensional vector series and defined as a two-dimensional function such as $f(x,y)$. A pixel is a coordinate on an image that is indicated by an area $f(x,y)$ function. The pixel is the smallest element of a digital image. The image is investigated under three headings in digital image processing methods. It is divided into three types: binary images, grayscale images, and color images. The optical answer sheet image is converted from RGB to Grayscale. When converting to grayscale, the average method is used, which involves multiplying RGB channels by predetermined factors. The formula in Equation 1 is used to calculate this method.

$$\text{Gray} = (\text{red} * 0.3 + \text{green} * 0.59 + \text{blue} * 0.11) \quad (1)$$

The grey in the formula represents the average pixel value. The image has been converted to grayscale and purified of pixel errors using the Gaussian Blur Filter to clean up pepper-pot appearances. Figure 3 depicts a Colorful Answer Sheet, while Figure 4 depicts a Gray scaled image of an optical form filtered with Median Blur.



Fig. 3. Colorful Optic Form



Fig. 4. Image that has been grayscaled and filtered

A thresholding value is used when converting a grayscale image to a binary image. Each pixel in the grayscaled image is evaluated during processing. In the image processing method, the thresholding value is determined by the user. Pixels below the thresholding value are designated as 0, or black, and those above as 255, or white, throughout the process. The developed application has no pre-determined thresholding value. Because of the angle of the light source, the light on the image will not be delivered even if the images are shot with a mobile phone or tablet PC. As a result, the object and background will blend. It is critical to establish grey-scale thresholding to avoid this. For this operation, several techniques are suggested. A perfect histogram has a deep and distinct valley between the two peaks that represent the background and the objects. The threshold can now be calculated from the valley's bottom. However, most images make it difficult to detect the valley's bottom delicately.

If the valley is wide and flat, there is a lot of noise, or the peaks are not evenly spaced, it is especially difficult to detect. By minimizing intraclass variations, Otsu's method seeks a threshold that yields better results when two peaks of the histogram of the original image belong to the signal or foreground and the other to the background. Otsu's threshold is found by combing through all of the image's pixel value ranges until the intraclass variations are at their smallest. As previously stated, a class with a broad range detects the threshold detected by Otsu's method, whether foreground or background. Thus, when the image's histogram contains more than two peaks or one of the classes has a wide range, Otsu's method produces the smallest results. This operation was carried out because the thresholding values must be determined dynamically using Otsu's method, and the greyscaled image must be converted into a binary system. The binary converted image is shown in Figure 5 using Otsu's thresholding method. Following that, the corner-finding technique is used to define the borders of the binary image's objects.



Fig. 5. Binary image

J. Canny invented this method, known as the Canny Edge Detector, for finding corners in 1986. Canny Edge Detector is a well-known image processing tool that detects edges with pinpoint accuracy. It is widely regarded as the industry standard for edge detection. Canny identified the edge-detecting problem as a signal processing optimization problem and created a solution to optimize an objective function. Although the solution was a hard-exponential function, Canny discovered numerous ways to predict and optimize the edge-detecting problem. The Canny edge detector algorithm is shown in action on a binary image in Figure 6. The Canny algorithm was used to detect the squares surrounding the form's marked areas.

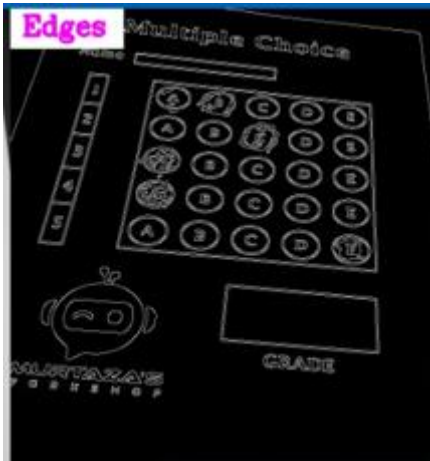


Fig. 6. Image processed with Canny algorithm

Although algorithms like the Canny Edge detector can detect the edge pixels that separate different parts of an image, they can't tell you anything about the entities themselves. In the following step, the edge pixels are combined with the contours. A contour is a collection of points on a graph or image that represent a curve. It is critical to divide an image into pieces when classifying or segmenting it. Contours are defined as a curve made up of all the same color or density constant points (along the border). They can be used to perceive, identify, and analyze figures. Figure 6 shows an example of corner detection and contour extraction in action. This operation determines squares and circles on the image. The rectangles from which the corners and contours were extracted are shown in Figure 7.



Fig. 7. Contour extracted

In the image in Figure 7, the allocation of the answer area has been detected. The binary conversion of the answer area allocation and the colored form of the contour operation on the image as shown in Figure 8.

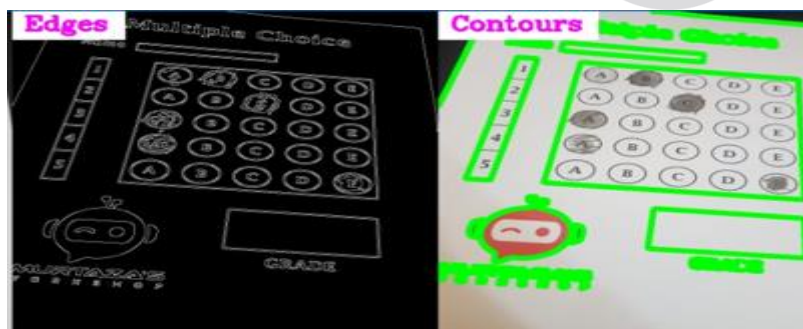


Fig. 8. Binary image (on the left), contour extracted image (on the right)

After the contour operation, the coordinate system ordered the contours in Figure 8 from left to right and top to bottom. After that, the answers on each line were compared to those on the answer sheet. As a result, whether the circular areas were correct, incorrect, or blank was determined. Correct answers were shown in green, while incorrect answers were shown in red. The result was printed on the image. Finally, it was typed into a file and saved. Figure 9 depicts the answer sheet's evaluated form. Figure 10 depicts the written form of the result on the optical answer sheet, including the number of correct, incorrect, and blank answers.



Fig. 9. The comparison and evaluation of grades for the answers

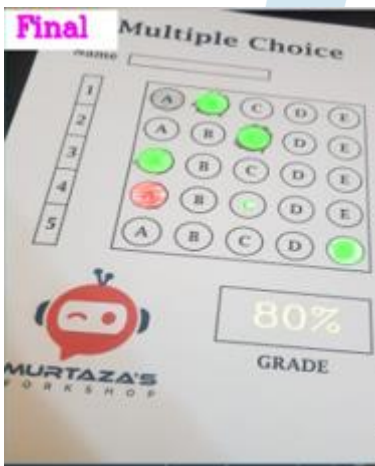


Fig. 10. Final State of Student Optical Answer Sheet

III. RESULT AND DISCUSSION

Python programming language was used to create the system for optical mark recognition. Along with the application's success in terms of accuracy and dependability, the following benefits can be ordered:

- Instead of using special, colored, and expensive optical form paper, a black and white printout of an answer sheet can be used
- the optic forms can be captured by the camera.
- The same operations can be performed without the need for an Optical form reader or scanner.

IV. CONCLUSION

This paper describes an Optical Mark Recognition system created with the Python programming language for multiple-choice tests. As a result, fast, dependable, and effective software like this will not only save personnel time but will also be very inexpensive. Students will also be able to learn the results as soon as possible. When the software is used in a large number of other schools, it will be possible to collect a large amount of data about the students' grades. Users in other cities may be able to use the software in multiple-choice examinations. When success rates are considered, the software has proven to be efficient to use when evaluating the answer sheets of multiple-choice exams. This study yielded some important findings for future research in OMR, OCR, classification methods, and image processing techniques. The developed application has been tested in real-world students' school exams. It has the potential to be developed and used in future applications such as questionnaire reading using similar systems, voting forms, attendance forms, product evaluation, and reading and evaluating university entrance forms. Instead of a computer, the proposed system can be developed and implemented on a mobile phone.

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