AN IMAGE PROCESSING ALGORITHM FOR AUTOMATIC MCQ GRADING - VISIOGRADER

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ABSTRACT

This paper investigates the idea of creating and using helpful technology for school purposes. It talks about the problems students and teachers face, like making tests for classes and spending a lot of time grading papers. The main point of this research is to suggest a new system called the Visio Grader, which is an interactive tool for school use. This system finds the best ways to make course assessments and grade papers faster using image processing. Compared to other systems like Scantron, the Visio Grader is more efficient and costs less. It can grade multiple images at the same time. Also, it can organize exam questions for teachers in a database. This paper discusses what VisioGrader can do and provides technical details for the image processing algorithm used.

1. INTRODUCTION

Scantron is a technology used in educational institutions all around the world to make the staff's life easier and grading tests faster. It is a test scoring machine that scores multiple choice tests automatically and provides the staff with the results. The problem with scantron is that it only scans a specific and expensive type of paper as well as the machine itself is expensive. Our project VisioGrader is like the scantron, but it is designed to eliminate the problems that all educational institutions face when using the scantron which is the cost. VisioGrader will also include additional functionalities that are not present in a scantron such as a database that will allow the instructor to store and use MCQ questions. In addition, it can generate tests based on parameters selected by teachers. VisioGrader purpose is the same as the scantron and that is to make the life of the faculty easier by scanning MCQ papers and provides them with the results. The way it works is that it generates a test and its answer key. After that teachers scan the students answer sheets and the program is going to compare the answer sheet to the answer key which will produce results.

Project Objectives:
The objective of the project is to create a platform with tools that can help faculty members to:
1. Generate multiple choice questions
2. Generate a bubble answer sheet and key.
3. Upload and grade multiple answer sheets at once
4. Allowing ink and pencil for filling in the answer sheets
5. Processing each image and comparing the answer sheets with the key.

Manually generating multiple choice questions, answers and manually scoring tests is undeniably tedious and time consuming. The proposed online test scoring empowers users to increase efficiencies at minimal cost. This solution minimizes the time spent when grading test questions in the platform with the aid of an accessible and sleek software interface which ensures instructors have the automation tools they need.

2. SIGNIFICANCE OF THE PROJECT

Using multiple-choice questions in written exams is common in international tests like TOEFL because they're fast to grade and don't let students write more than needed. In MCQ, a special machine is used to grade MCQ exams, but it's expensive and needs someone trained to use it. Manually creating multiple choice questions, answers and manually scoring tests is undeniably tedious and time consuming. This solution minimizes the time spent when grading test questions in the platform with the aid of an accessible GUI.

3. RELATED LITERATURE

There are many aspects of image processing that are needed in various industries. Studies on image processing have been getting substantial investments recently.

- Automatic correction of free format MCQ tests (Habeek et al., 2020).
    - Project abstract: Although the technology for the automatic grading of multiple-choice exams exists, it is neither efficient nor as automatic as it claims to be. All proposed methods have a predefined answer sheet format that looks like a crosswords table or a chessboard. Because of this format, all questions must have the same number of choices. Such an answer sheet is not clear, and candidates taking the exam can and will accidentally mark the wrong cell in the table. Most of them assume that there is only one possible answer for every question. This article proposes an algorithm that does not require any special format, works with all scanning resolutions and is fast.
    - The authors propose a model that uses text similarity measures and machine learning techniques to evaluate the similarity between the student's answer and the correct answer. The model is trained using a dataset of MCQs with free format answers and is tested on a separate dataset. The results show that the proposed model outperforms other traditional methods in terms of accuracy. The technicality of the work includes the use of natural language processing techniques to pre-process the answers, and machine learning algorithms to train and test the model.
- Practical Machine Learning and Image Processing (Singh, 2019).
    - An in-depth exploration of using Python for various computer vision tasks, including facial recognition, object detection, and pattern recognition. The book covers both the theoretical concepts and the implementation details, providing clear explanations and code examples to help readers understand the technicality of the work. The book also includes real-world case studies to demonstrate the application of the techniques discussed in the book.
- An Automatic System to Grade Multiple Choice Questions paper-based exams (Abbas, 2009)
    - The use of Multiple-Choice Question (MCQ) in paper-based exams is a very popular choice in the international certificate exams (like TOEFL) because it is very fast to grad, and it does not let the student write any unnecessary information. In international tests, a specialized machine is used for grading MCQ paper-based exams, this machine is very expensive, and it needs a special trained operator to operate the machine correctly and efficiently. This project suggests a method to use a personal computer plus a scanner and a program written in MATLAB programming language to grade a specially designed MCQ exam test paper with 15 questions with four choices for each question which the student can choose only one answer per question. The program has been tested to detect the correct answers by comparing each paper with a pre scanned test paper that contains the correct answers, many forms of test papers are used to answer different sets real questions for a real exam that has been conducted in the computer center in the Baghdad University and shown to produce results that matches the results gained from grading the same papers manually. The program is written in such a way that it can tolerate rotating the papers in the scanning operation using the process of image registration, any kind of pencil can be used to make the correct answer no matter its color. The program can detect question with multiple choices and eliminate them from calculations.

4. ISSUES WITH PRIOR PROJECTS

There are many limitations and issues with prior projects that are like our project. Scantron uses expensive proprietary hardware and software to function. In addition, that introduces many issues and limitations with accessibility and expandability. Scantron requires expensive proprietary papers with specific sizes and layouts for grading. In addition, a specific type of pencil is needed for Scantron to function. Otherwise, it would not read the answers properly. Furthermore, the Scantron answer sheet is cluttered with unnecessary small text and instructions that makes it complicated and overwhelming for students, especially first-time users. In prior projects, scribbles and noise on the paper could potentially make reading the paper or image and grading it impossible. However, our project aims to deal with and eliminate unwanted information on the paper.

Figure 1: Scantron standard paper

Scantron Cost Analysis:
- Hardware and software:
    - The cost of the hardware and software can range from a few hundred dollars to thousands depending on the size of the system.
- Proprietary papers:
    - Scantron proprietary papers are more expensive than standard A4 papers used by VisioGrader. Scantron papers cost $850 for 6000 sheets. ("The Story Behind the Scantrons," 2011) This can lead to higher costs over time (Bcomber, 2001).

5. RELATED PROJECTS

The example of a related project is ExamIO.
- ExamIO:
    - ExamIO features:
        - ExamIO develops software solutions for test evaluations. ExamIO was created based on OMR technology (Optical Mark Recognition) created to design, correct and analyze tests exams and polls.
        - ExamIO is a user-friendly software which will allow you define and correct your tests in a short period of time. ExamIO is an automatic multiple choice test corrector.
        - ExamIO presents in a single software the three elements necessary to carry out a test evaluation: The design of the test template, correction of the filled in tests and numerical and statistical analysis of the results.

6. PROPOSED WORK

VisioGrader is an interactive environment system for academic use which is aimed at serving teachers and education institutions by allowing them to create and analyze tests and their answer sheets and evaluate and assess performance in a minute and in an affordable manner. The system works in four steps. First, the user, who is the teacher, can generate a test with its answer key in a few clicks. Second, instructors scan sheets and upload them to VisioGrader which saves time and energy and without a need for internet connection. Third, the user can obtain the results immediately via email. Fourth, the user can view the item analysis, obtain complete insight on class assessment, and quickly identify issues.

The following steps outline the process for accurately and effectively reading and grading answer sheets using VisioGrader. The project begins with the processing of the answer key image to ensure that it is readable without any issues. From there, the image is converted to grayscale, inverted, and reduced to black and white for optimal results. The image is then cleaned up to remove any unwanted noise or borders. The final step involves comparing the centroids of the white circles on the image with the answer key and deducting points for any mismatch.

Additionally, each answer sheet contains two squares in the top left corner and the bottom right corner for the program to use as anchors to normalize and read the image properly.

By following these steps, VisioGrader is able to efficiently and accurately grade answer sheets:
1. Convert the image to grayscale to unify the colors and eliminate unnecessary colors.
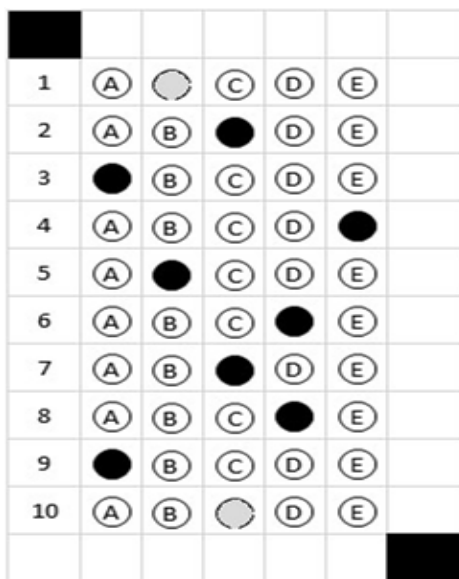

Figure 2: img2grey

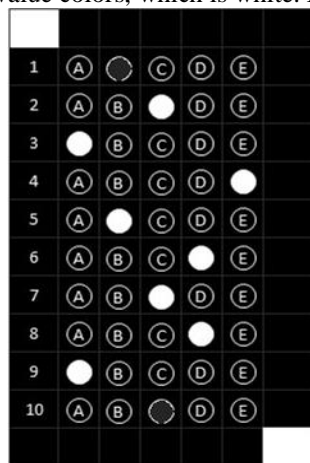2. Invert the colors to obtain high-value colors, which is white. Black is a low-value color.

Figure 3: Imcomplement

3. Change the colors to black and white only, with white being 1 and black being 0.
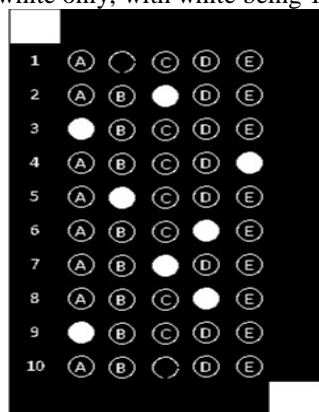
Figure 4: img2bw

4. Clean up the image of any unwanted noise and borders.
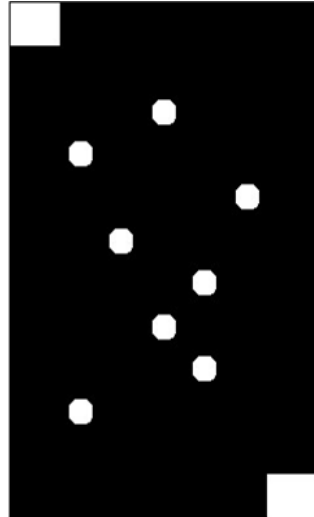
Figure 5: Imerode & Imdilate

5. The fifth step in the VisioGrader process involves identifying and comparing the centroids of the white circles on the submitted answer sheet with the corresponding centroids of the answer key. Points will be deducted for any mismatch between the two. To illustrate this process, refer to the figure below, where the red circles represent the coordinates of the answer key bubbles, and the blue circles represent the coordinates of the bubbles on the submitted answer sheet. The Euclidean distance between these circles is calculated, and if it falls within the designated tolerance, it is counted as a correct answer.
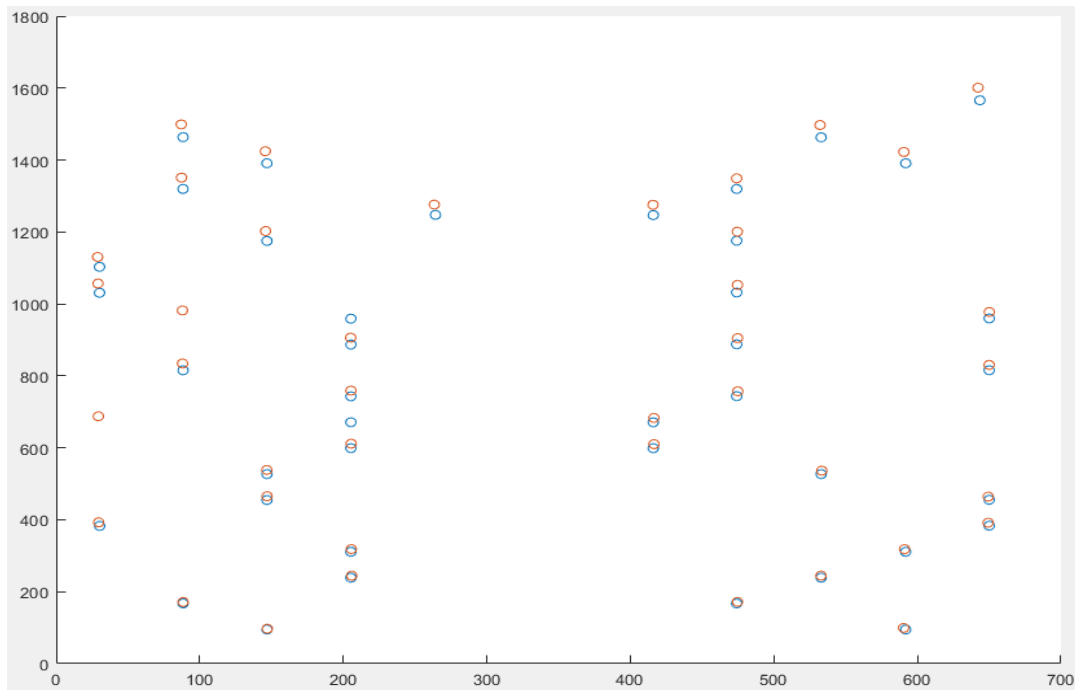
Figure 6: Coordinate comparison graph

6. Utilize the two squares in the top left corner and the bottom right corner of each answer sheet as anchors to normalize and read the image properly.
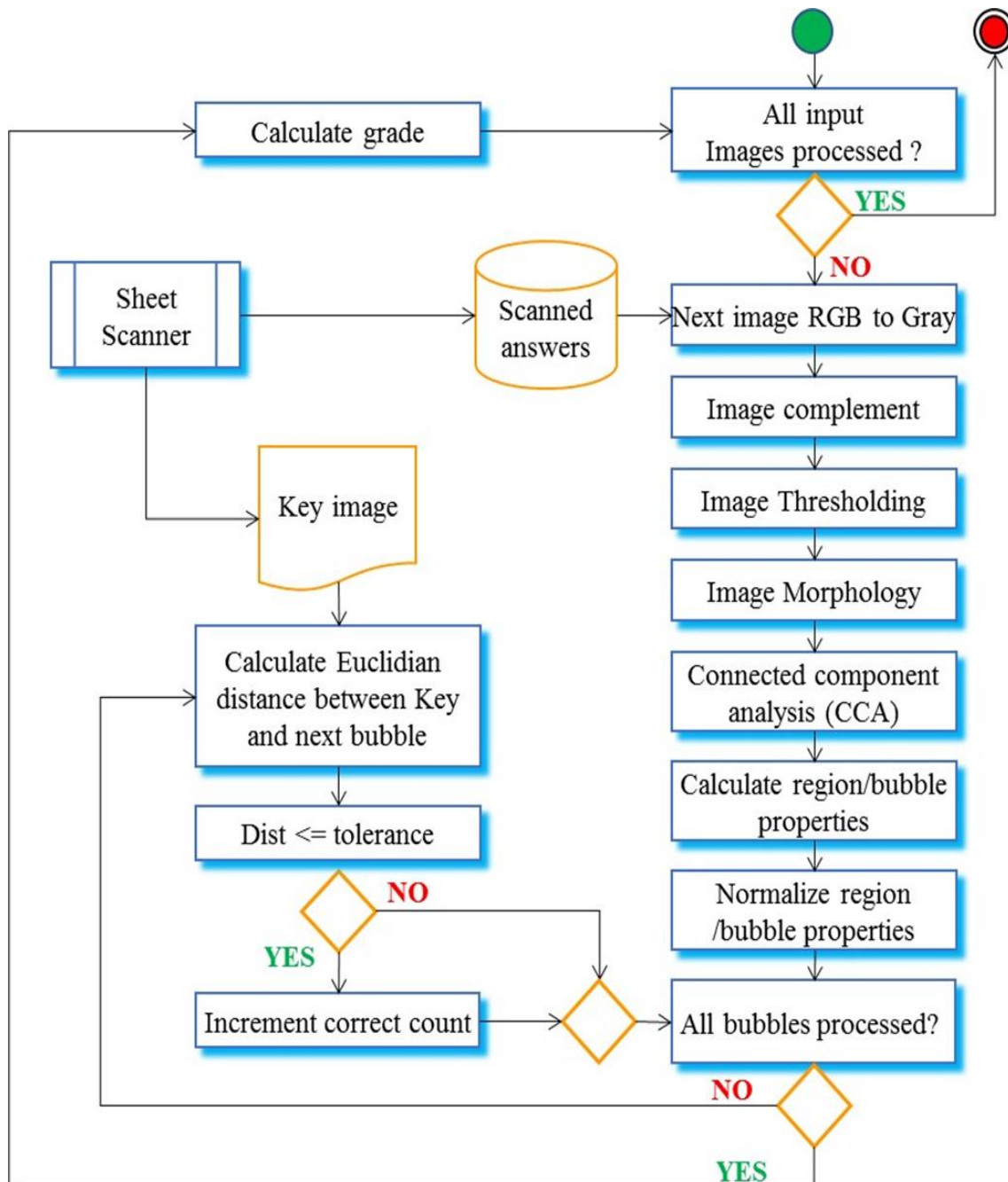
Figure 7: Algorithm Activity Diagram

7. DETAILS OF THE TECHNOLOGIES TO BE USED

- **Digital camera**: To capture high quality images for the VisioGrader project, a digital camera with at least 24-megapixel resolution and a full-frame sensor would be ideal. Additionally, a lens with a wide aperture such as f/2.8 or lower, and a high ISO range (e.g. ISO 100-51200) is recommended for optimal image quality.
- **MATLAB**: To use MATLAB for image processing and analysis, a computer with a compatible operating system (Windows, Mac, Linux) is required. Additionally, the necessary licenses for the Image Processing Toolbox and Deep Learning Toolbox add-ons should be obtained. MATLAB version R2020b or later is recommended.

- **Modern Computer**. It is important to ensure that the computer meets the system requirements for running MATLAB and any additional add-ons that will be used for the project.
- **Scanner**: A scanner with high resolution (at least 600 dpi) that can handle the paper size of the answer sheets is recommended. It should also have automatic document feeder (ADF) and duplex scanning to save time and increase efficiency. Compatibility with the computer and the operating system should also be considered.

8. TECHNICAL FEASIBILITY

AUK can get the resources (hardware, software, and network) needed for VisioGrader. The software is easy for understand and use, with the code already wrote in MATLAB. All users need to do is upload the student's answer sheet, and it will be compared to the key answer sheet. The hardware, like digital cameras and modern computers, isn't something that nobody has used before.

The good thing about VisioGrader is it have enough capacity for future needs, meaning it can be expanded if needed. Creating prototypes will be need to make sure VisioGrader is working and doing what it should do, but the good thing is prototypes are not a problem in this case because it costs nothing and will make sure the system is working well.

9. COMPATIBILITY CHECKING

VisioGrader is compatible with every computer with MATLAB enabled.
- SOFTWARE:
    - MATLAB Availability
        - MATLAB is available on Windows, Mac, and Linux.
    - Add-Ons:
        - Our project depends on two main MATLAB add-ons to function
            - Image Processing Toolbox
            - Deep Learning Toolbox
- Hardware:
    - Computer:
        - Our project is compatible with any computer hardware that can run MATLAB. However, a modern computer is recommended to process higher quality images for faster and more accurate processing.
    - Digital Camera or scanner:
        - A digital camera or a scanner is needed to scan the images of answer sheets
        - A scanner is a better option as it can scan the papers with ideal alignment

10. RELEVANCE OF THE TECHNOLOGIES

MATLAB is data analysis and algorithm development and programming platform developed by MathWorks. MATLAB has many add-ons and plugins that can provide various functionalities for the users. For our project, we will be using the Image Processing Toolbox and the Deep Learning Toolbox add-ons. MATLAB also provides features for designing a functional user interface for our program.

11. MATLAB IMAGE PROCESSING

This table lists the MATLAB image processing functions that were discussed in the technical section of the project. It provides a clear overview of the specific functions that were used to process and analyze the images in the VisioGrader project.

Table 1: Matlab functions				
Index	Process	Description	input	output
1	rgb2grey	Convert the image from RGB to black and white or greyscale.	colored image	grayscale image
2	Imcomplement	Inverts the image colors	grayscale image	inverted grayscale
3	im2bw	Make the grayscale image to binary colors (black and white) 0 and 1.	inverted grayscale image	black and white only image
4	imerode	Erodes the image and makes thin structures even thinner to clean up the image of unwanted small structures and noise	Black and white image	Cleaned up image
5	imdilate	Dilate the image to compensate for the erosion by adding pixels to the remaining structures	Eroded image	Further cleaned up image
6	bwlable	Give each object region a unique ID pixel value.	black and white image	black and white image with labeled white regions

12. CONCLUSION

In conclusion, VisioGrader is a useful and efficient tool for teachers to grade multiple-choice tests automatically. This system gets rid of the need for manual grading and reduces mistakes made by humans, saving teachers a lot of time and effort. With its easy-to-use interface, teachers can quickly create and make tests from a collection of test banks, choose settings like the number of questions and difficulty levels, and get the tests graded automatically. VisioGrader's ability to work on any system that can run MATLAB, its low cost, and its skill in dealing with answer sheets that have extra marks and noise make it a better choice than traditional grading methods like Scantron. In short, VisioGrader offers a helpful and effective way to grade multiple-choice tests, making things better for both teachers and students.

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