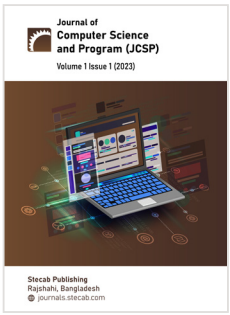

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Research Article

An Automated Entrance Examination Checker Using Optical Mark Recognition

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About Article

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ABSTRACT

Optical Mark Recognition (OMR) serves as a valuable data entry tool, especially in education and testing, by capturing human-marked data from document forms like surveys and tests. This paper presented an automated system for expeditiously and accurately checking the entrance examinations of new students, streamlining the transaction process for university freshmen enrollees. This transition from manual to automated assessment or grading expedites the checking of a 250-item multiple choice exam. The system comprises two main components: hardware and software. The hardware component integrates a microcontroller, LCD, and camera, while the software component is represented by the proposed system. Through the system, the answer sheets can be scanned, the results stored in the database, and the student's score displayed on the device's LCD screen, while also generating report of the entrance exam results in an Excel file. This study utilized Rapid Application Development methodology. The system underwent beta testing and university admission staff and first year students served as the participants. Based on the testing results, they experienced using the system and validated the intended system's features. This proves that the proposed system efficiently scans marks for all valid answers and accurately processes score results from a large number of answer sheets.

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1. INTRODUCTION

Innovation plays a crucial role in enhancing production processes across various sectors. By introducing changes in techniques, adopting new equipment, and leveraging technology, organizations can streamline their operations, boost productivity, reduce manual effort, expedite processes, and enhance service quality. Technological innovations, in particular, follow a systematic process where needs or problems are identified, followed by rigorous research to devise solutions, and eventually commercialized into marketable products or services. This continuous cycle of innovation not only drives progress but also ensures that businesses and organizations remain competitive in dynamic market environments. Institutions continually strive to enhance their operational efficiency, including improving services like enrollment and grading systems. Optical mark recognition (OMR) is a valuable tool for data entry, particularly in education and testing. Wynn (1984) and Deng (2008) both highlight its potential for processing large volumes of questionnaires and answer sheets. Saengtongsrikamon (2009) and Rakesh (2013) further emphasize the cost-effectiveness and accuracy of OMR systems. Optical Mark Recognition (OMR) technology plays a vital role in this endeavor. By allowing machines to identify marks on paper forms, such as ticks, bubbles, or checkmarks, OMR facilitates rapid and accurate data collection from high-volume sources. The process involves scanning or capturing an image of the form, analyzing it to recognize marks, and then transferring the data to a computer system for processing and analysis.

Many colleges and universities using web-based entrance examinations, which not only optimize the assessment process but also offer convenience to both guidance counselor/ admission assistants and applicants or new enrollees. These advancements in technology not only improve efficiency but also contribute to a more seamless and user-friendly experience for all stakeholders involved.

Over the past years, Mindoro State University (MinSU) has witnessed a significant increase in the number of freshmen enrollees across its campuses, including Bongabong, Main, and Calapan. With an estimated 2000 new students at MinSU Bongabong Campus alone, coupled with visible percentage growth of incoming freshmen at the other campuses, there has been a notable rise or increase in workload and time consumption during entrance examinations across all campuses. Based on personal interviews with the guidance counselor and first year students, the university's entrance examination papers are manually checked. This examination serves as an entrance requirement upon enrollment of new students per college. A 250-item test is taken by a new enrollee to be qualified student of MinSU. Every year, more than 1000 new students take this entrance examination and the Guidance Counselor per campus who acted as the examiner, takes time and effort to check all the test papers. Consequently, this process slows down the enrollment phase for new students, often extending the time it takes for enrollees to receive their test results to several hours or days. Recognizing the slow-paced process of checking and releasing results for the entrance examination as a constraint during enrollment, the researchers devised a solution: an integrated system featuring a test paper evaluation device or checker, designed to automate the assessment/checking of test papers for freshmen. Instead of proposing web-based entrance examinations, the researchers opted for a different approach due to concerns regarding internet connection issues. Freshmen applicants continue to prefer taking the entrance exam in person rather than online. As a result, the focus shifted towards developing a device specifically designed for checking the entrance examinations.

This paper aimed to developed a specialized automated entrance examination checker solely for Mindoro State University (MinSU) to reduce the admission personnel workload and time associated with checking the papers and disseminating results for new enrollees. The MinSU Automated Entrance Examination Checker offers a printable result, a report containing crucial details such as the student's name, examination date and number of correctly answered items

2. LITERATURE REVIEW

Optical mark recognition (OMR) technology, which detects human-marked data on documents, has become an essential tool for efficiently capturing and processing data from paper-based forms. The roots of OMR technology can be traced back to the mid-20th century when the need for automated data collection methods emerged (Cunningham & Holan, 2019). Early OMR systems utilized optical scanners to detect and interpret marks made on paper forms. Over time, advancements in imaging technology and software algorithms have greatly enhanced the accuracy and efficiency of OMR systems (Kurdi *et al.*, 2020). OMR technology relies on the detection and interpretation of human-made marks on paper documents (Alnajjar & Saeed, 2018). These marks, typically in the form of checkboxes or bubbles, are analyzed by OMR software, which translates them into digital data for further processing (Raza *et al.*, 2021). OMR technology finds widespread applications in education, surveys, elections, and data collection (Wu *et al.*, 2019). In education, OMR is used for grading exams, processing evaluations, and analyzing survey responses (Zhang *et al.*, 2020). Similarly, OMR systems are employed in elections to tabulate votes from paper ballots quickly and accurately (Lee *et al.*, 2018). A range of studies have explored the application of Optical Mark Recognition (OMR) in different contexts. Atasoy (2015) developed a real-time OMR system using a webcam and a small OMR form, demonstrating its robustness and reliability. Ha (2020) presented a software system for processing surveys at a university, based on digital image processing, which accurately detected valid answers and multiple marks.

The utilization of Optical Mark Recognition (OMR) technology for entrance examination checking has gained prominence due to its efficiency and accuracy in processing large volumes of paper-based exams. OMR technology has been widely implemented in entrance examinations across various educational institutions and organizations. Studies have shown that OMR systems offer advantages such as rapid processing, reduced manual effort, and increased accuracy in grading exams (Ali & Ghani, 2020). By automating the checking process, OMR helps streamline the evaluation of entrance exams, thereby saving time and resources for administrators and examiners. Research indicates that OMR-based entrance examination

checking systems yield reliable results and minimize errors compared to manual grading methods (Khan *et al.*, 2019). These systems are capable of accurately detecting and interpreting marks made by applicants or examinees on answer sheets, ensuring fair and consistent evaluation. Furthermore, OMR technology facilitates the generation of detailed reports and statistical analysis of exam results, providing valuable insights for educational institutions and exam authorities (Nugroho *et al.*, 2021). Despite its benefits, the implementation of OMR systems for entrance examination checking may encounter challenges such as initial setup costs, technical issues, and the need for staff training (Thakur & Singh, 2018). as well as poor document quality and variations in mark detection (Rahman *et al.*, 2020). Future research in this area may focus on addressing these challenges, improving OMR software algorithms, and integrating advanced features such as artificial intelligence for enhanced performance and reliability.

3. METHODOLOGY

The development of the proposed entrance examination checker adheres to the Rapid Application Development (RAD) methodology, as outlined by Lomio & Mejidana, (2023). This methodology involves distinct phases, including requirements planning, user design (prototype, test, and refine), construction, and cutover. RAD fosters an iterative development process and sequential progression through these phases, depicted in Figure 1. This approach enables the continuous addition and enhancement of features.

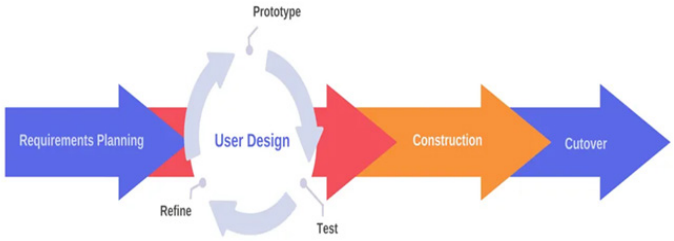


Figure 1. Rapid Application Development Cycle

3.1. System Architecture

The system architecture, illustrated in Figure 2 through a block diagram, visually portrays the components and interactions within the proposed system, facilitating a quick understanding of its structure and functionality. This diagram offers a clearer representation of the system flow, highlighting the key processing steps involved in capturing, processing, and analyzing the answer sheet data.

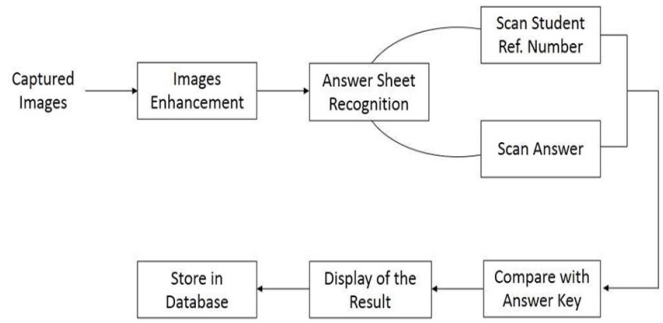


Figure 2. Block Diagram of the Proposed System

a. Camera (Image Acquisition): Captures the image of the answer sheet. This is the input stage where the physical answer sheet is converted into digital data.

b. Image Processing (Enhancement): After capturing the image, it undergoes image enhancement processes. In this step, adjustments such as contrast enhancement may be applied to improve the quality and clarity of the captured image for better recognition.

c. Optical Mark Recognition (Answer Sheet Scanning): Scans the answer sheet, extracting the student reference number and answers. It utilizes optical mark recognition techniques to interpret marked bubbles.

d. Comparison with Answer Key: Once the student number and answers are scanned, the system compares them with the answer key stored in its database. This step involves matching the answers provided by the student with the correct answers stored in the system

e. Digital Display: The test result is displayed digitally in real-time and showing the student's score on the test.

f. Database (Result Storage): Finally, the system stores the test results in a database including the student number, student name, course and corresponding score. The stored results can be accessed and viewed in Excel file format. This allows for easy retrieval and access to the results for future reference.

3.2. System Testing and Evaluation

Beta testing was conducted with a targeted group of users to validate the system's features, functionality, and overall usability, while also gathering valuable feedback for further improvements. The testing group comprised five admission office staff members and ten first-year students from different colleges. Participants were instructed to provide feedback on their experience with the system, including any issues encountered and suggestions for improvement. They were encouraged to report their observations objectively and thoroughly. Also, they were asked to provide remarks for each task performed, indicating whether they considered it a "pass" or "fail" based on their experience.

4. RESULTS AND DISCUSSION

The proposed system has been successfully designed and developed, as depicted in Figure 3. It comprises the following components: The switch of the device acts as the on and off button to start the device. The camera captures the paper inserted inside the device. It has a 15-megapixel camera capture and an image quality resolution of 1080p. The motor and roller help to release the paper out of the device when the user inserts the paper inside the device and the application software finishes scanning the test paper or answer key. The Liquid Crystal Display (LCD) of the device displays the status of the device, the status of the answer key and test paper scanning, and the test score of the examinee.

4.1. Description of User Interface and Processes of the Proposed System

Figure 4 illustrates the login form that initializes the opening of the MinSU Automated Entrance Examination Checker. This

Figure 3. Automated Entrance Examination Checker Device

login form can only be access by the Guidance Counselor of the campus and other registered user assigned by the guidance counselor.

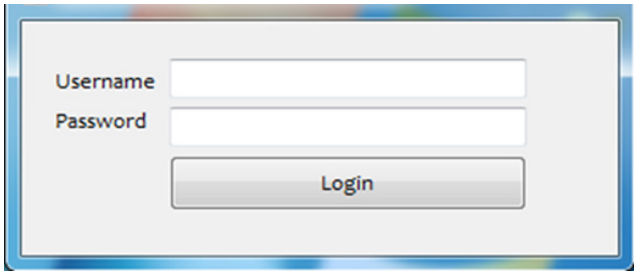


Figure 4. Login Form

Figure 5 displays the Main Menu Form, featuring various tabs and buttons, including Connect/Disconnect, Start/Stop Camera, Scan Answer Key, Scan Test Paper, Device Status Area, Student's Examination Record Area, Scanned Image Area, OMR

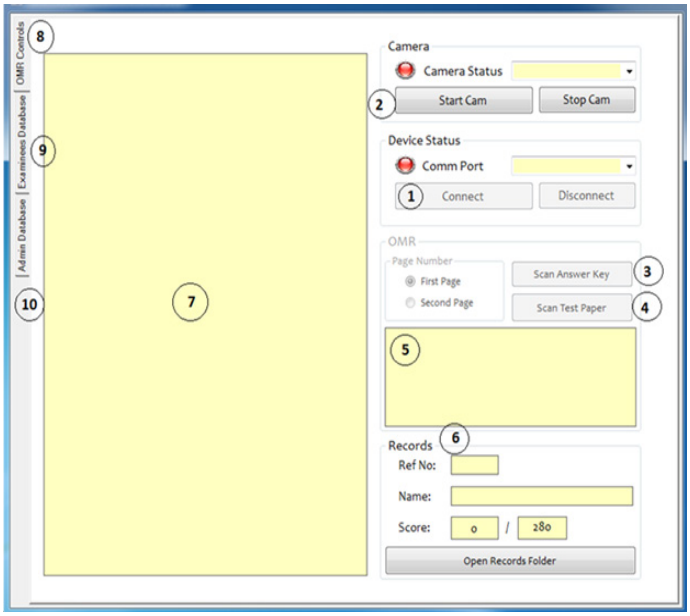


Figure 5. Main Menu

Controls, Examinee Database, Admin Database, and Record Folder. Each button activates its corresponding function upon clicking.

In Figure 6, the Connect and Disconnect buttons facilitate the connection between the device and the application software of the automated checker. Upon switching on the device, the user initiates the connection by clicking the Connect button. Once the device and application software are successfully connected, the user proceeds by clicking the Start Cam button.

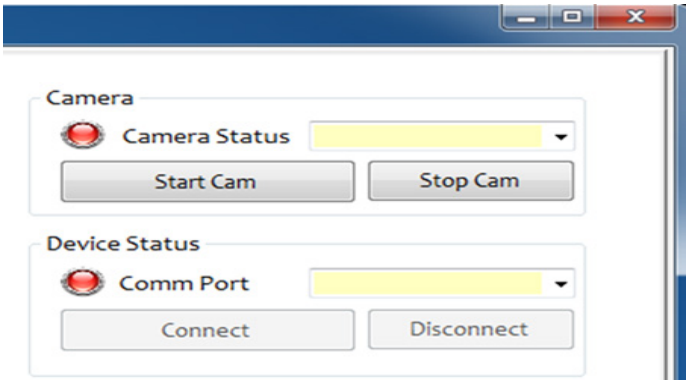


Figure 6. Device Connection and Camera Connection of the System

Examinee Database tab, as depicted in Figure 7. This form includes fields for the Reference Number, First Name, Middle Name, Last Name, and Course of the student. Under the form, buttons are provided for adding, deleting, and updating student information. On the right side of the form, a list of students is displayed. Additionally, a filter/search function is located in the top right pane of the form, facilitating ease of use when searching for specific students or courses.

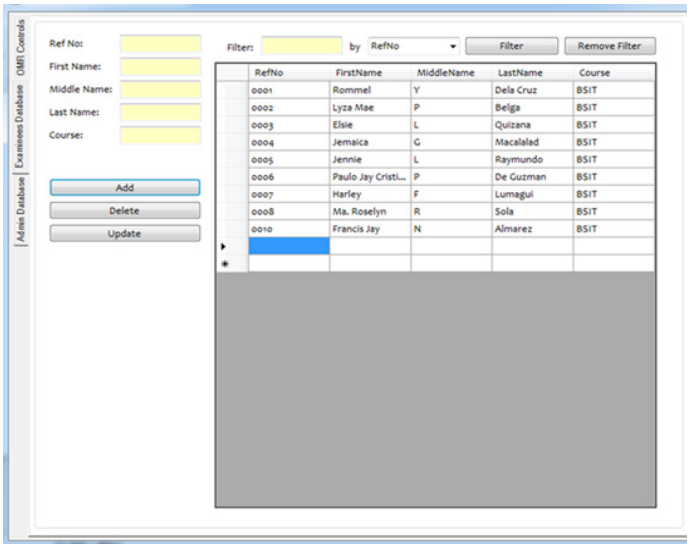


Figure 7. Examinees Database Form

In Figure 8, the OMR controls and Student's examination area of the system are depicted. Once the device is started and the examiners are registered, the user is required to scan the answer key, beginning with the first page followed by the second page. The scanned images of the answer key are temporarily stored. Upon completion of the student's examination, the user scans the first page of the test paper, followed by the second page. The device status is displayed on the screen during scanning. For the test paper, the student's reference number, name, and score are simultaneously displayed.

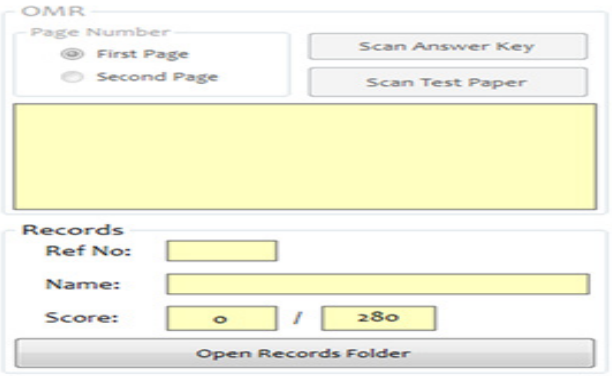
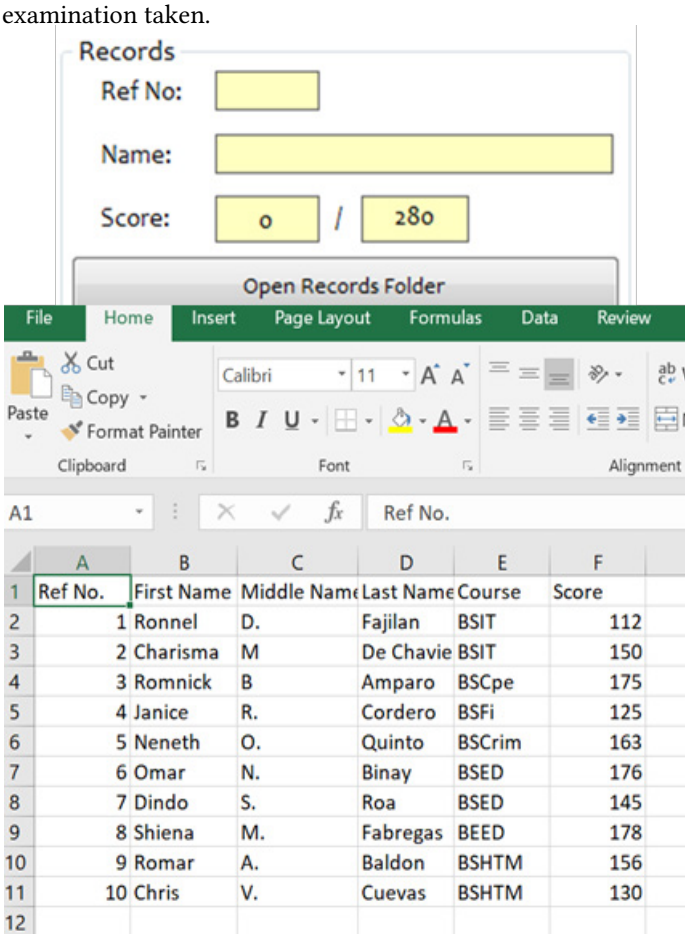


Figure 8. Scan Answer Key and Scan Test Paper Buttons and Student's Examination Area

In Figure 9, the stored test results of students are displayed. By clicking the "Open Records Folder" button, users are redirected to files containing the list of all students who took the examination on that day. These files can be viewed using Microsoft Excel, and include the student's Reference Number, Name, Course, Test Score, and the Total Number of Items of the examination taken.



	A	B	C	D	E	F
1	Ref No.	First Name	Middle Name	Last Name	Course	Score
2	1	Ronnel	D.	Fajilan	BSIT	112
3	2	Charisma	M	De Chavie	BSIT	150
4	3	Romnick	B	Amparo	BSCpe	175
5	4	Janice	R.	Cordero	BSFi	125
6	5	Neneth	O.	Quinto	BSCrim	163
7	6	Omar	N.	Binay	BSED	176
8	7	Dindo	S.	Roa	BSED	145
9	8	Shiena	M.	Fabregas	BEED	178
10	9	Romar	A.	Baldon	BSHTM	156
11	10	Chris	V.	Cuevas	BSHTM	130
12						

Figure 9. Stored test results of students

4.2. Testing and Evaluation Results

Table 1 outlines the distinct features and functionalities of the entrance examination checker device, along with their corresponding validation criteria, issues/problems encountered and result. Validation results are indicated as either" Pass" or "Fail", dependent upon the fulfilment of criteria during testing and validation, based on relevant observations.

Table 1. Validation Matrix

Features/ Functionality	Validation Criteria	Problems/Issues Encountered	Validation Result (Pass/Fail)
Login/ Logout	Users with valid credentials can log in and out of the system	None	Pass
Add New User	Allows administrators (Guidance Officer/ Assistants) to add new users	None	Pass
Image Capture Quality (Answer Sheets)	Captures clear and accurate images of answer sheets for accurate interpretation of markings and text Ensures high resolution for accurate analysis.	None	Pass
Scan Answer Sheets	The system accurately extracts the student reference number and answers from the scanned answer sheet without errors or omissions, while ensuring that OMR techniques correctly interpret marked bubbles and that the scanning process is efficient and completed within an acceptable timeframe, allowing for timely processing of large volumes of answer sheets.	If the paper is crumpled or has folds and has unnecessary marks it is rejected. Using ballpoint pens and pencils are not suitable as their ink reflects and cannot be detected.	Pass
Display results on LCD	Provides reliable results (determine correct answers and scores) consistent with manual grading.	None	Pass
Store results in database and generate report.	The generated reports accurately reflect the stored examination results without any inaccuracies, ensuring that they contain all relevant information, including student details and examination/test scores.	None	Pass
User interface	User-friendly interface for ease of operation and navigation. Clear and intuitive design.	None	Pass
Portable design	The weight and size of the device is lightweight and compact enough for easy transportation and handling by users, allowing them to carry it comfortably without occupying excessive space.	None	Pass

5. CONCLUSIONS

The proposed system was successfully developed and implemented. It automatically computes the test result of the freshmen applicants or new enrollees, displaying it on the screen and the digital display at the same time and can accommodate large amount of test papers each day, increasing the production rate of the admission office. The system

reduces human intervention during the process of checking multiple choice type of examination and speeds up the process of checking the entrance examination test paper of the new enrollees. The system was successfully implemented at MinSU Bongabong Campus and the developed system confirms the functionality of the system. The validation process ensures that the system effectively addresses the university specific needs, enabling admission office to optimize resources, streamline processes, and enhance overall operational efficiency. This research contributes to the practical application of the RAD system design method in the context of checking entrance examination. The system is intended to be used for entrance examination of the college students in Mindoro State University. In addition, it can be used for High School and Senior High School examinations as well. It can also be used for checking any examinations of the faculty if the examination is multiple choice and uses the specified format of answer sheet. The system is beneficial to both examiner and examinees for it speeds up the process of checking the entrance examination and reduces the waiting time of students to know their test score. The system can change the stored answer key, making it possible to use the system for other multiple-choice type of examination aside from entrance examination. However, the system has limitations. It needs a PC or laptop with 8GB memory or higher. The maximum number of items that can be checked is up to 280 only. Students are required to use markers for shading their answers, as light shadings with pencils or ballpoint pens cannot be detected by the system. Additionally, it is important to ensure that the paper remains flat and free of folds or creases, as well as unnecessary marks.

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