Short Paper*

Development of an Online Inventory System for the Engineering and Sciences Laboratory Office of Asia Pacific College through a Mobile Application with Equipment Serial Number Detection using OCR

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Abstract

Purpose – The Asia Pacific College's School of Engineering (APC-SoE) strongly establishes theories to its students and integrating all their theoretical knowledge through projects. Since the students need both software applications and hardware components, the Engineering and Sciences Laboratory Office (ESLO) supports them their needs and at the same time – is responsible for the maintenance of the said necessities. The ESLO, though capable of its duties, still does not have an inventory system to easily track each equipment. The developed application called SoE Keep is created for the ESLO to keep track of equipment that needs recalibration, create, edit, and delete equipment from the database, view reports that shows damaged, borrowed, approved, and returned items that students used.

Methodology – The SoE Keep application was developed using Android Studio to work on devices using Android API 7.1.1 and newer version. SoE Keep's database is directly tied up to the database used by the ESLO Web Services to update the inventory and generate charts pertaining to the statistics of each item. Furthermore, the application uses Android OpenCV to perform the Optical Character Recognition (OCR) function. The OCR includes preprocessing tools such as masking and grayscale transformation for feature extraction.

Result – The developed application was evaluated using its accuracy, reliability and its user-friendliness. The application got a 91.67% accuracy rating that is interpreted as a "Good" result. In terms of reliability, the application had a rating of 94.07% that is also interpreted as "Good". The user-friendliness result was grouped into the set of possible users of the application: ESLO Head/Professors and Student Assistants. Furthermore, it had two sub-categories: Overall Experience and Overall Design. The overall experience of the student assistants was rated 3.78 and the overall design is 3.43. For the ESLO Head and Professors, the overall experience rated 4.8 and the overall design is 4.6.

Conclusion – The application developed resulted to the following conclusions that: it was able to have a good accuracy in capturing the serial numbers through an OCR, it also has a good reliability covering the precision of obtaining the correct serial numbers, good overall design and overall experience using the application for the Student Assistants, good overall design and overall experience using the application for the ESLO Head/Professors.

Recommendation – The following are the recommendations that must be taken into consideration: collecting more sample data in testing can further increase the precision of the Accuracy and Reliability ratings, improving the overall User Interface and User Experience of the application, improving the usability of the bounding box for capturing the image, improving the graphical visualizations and provide other options for viewing the data such as lists.

Practical Implications – SoE Keep, in compliance with ISO 2600 standard, provides practical assistance in implementing social obligations while considering cultural, sociological, environmental, and legal variations as well as economic development situations.

Keywords – inventory system, OCR, image processing, grayscale, masking, OpenCV, MySQL, PHP, serial number

INTRODUCTION

Inventory systems, in the simplest sense, are created for organizing, and taking account of resources. It is built on the features of it being accessible, reliable, easy to edit and change values, and the convenience of pulling the data easily in a graphical or tabular form that can be read. It helps keep track of everything that is accounted for in the database, and it can help maintain the minimum and the maximum number of stocks per tool or item. Most inventory system users are companies that buy and sell goods. An example of this is the clothing company, Zara. There are also different kinds of inventory

systems available online – NetSuite.ERP, monday.com, GEP NEXXE, and many more (Epstein, 2021).

The Asia Pacific College – School of Engineering (APC-SoE) teaches students by passing down theories and knowledge and applying them by creating projects that are all based on the lessons they've learned in a certain subject. Because of this, engineering students need not just software applications, but also hardware components that can be used for the creation of projects (Aguirre et al., 2013). The Engineering and Sciences Laboratory Office (ESLO) provides hardware components and maintains the inventory of laboratory apparatus and equipment. There is no inventory system before the pandemic and even if there is, it is not yet implemented due to the incompleteness of the system. The authors decided to complete and improve the inventory system with the use of a camera to detect the serial number of certain equipment.

General Objectives

To develop an inventory system that will monitor the quantity and conditions of the common laboratory apparatus and equipment in a database.

Specific Objectives

- To implement an accurate serial Optical Character Recognition (OCR) scanner with the use of the android application's camera that can identify uppercase and lowercase letters, and the numbers 0 to 9 to read the serial numbers of equipment.
- To determine the reliability of the android application's OCR.
- To develop a user-friendly android application for the ESLO Head in scanning serial numbers, adding, deleting, editing equipment on the inventory, and viewing reports

Scope and Delimitation

The project is designed to record and keep track of the inventory of the common laboratory apparatuses in the ESLO through the use of a mobile application. The items covered by the inventory system are inclusive of all borrowable items that require recalibration – consumables and software are not included. For the students and professors, the Android Smartphone will be used to borrow and return items by integrating a module where they will be redirected to the ESLO Web Services Web Application. However, the application is solely for ESLO use only. It also does not provide a module to view the contents of the inventory system through a mobile app. The application will not work if the phone is not connected to the internet and its JDK package is not compatible with the phone used.

Significance of the Study

The said study is made significant to the following members: the ESLO Head in organizing the different items easily and doing faster transactions in the ESLO, to the SoE students and faculty in the easier process of borrowing equipment, the APC community for providing paperless transactions, and for future researchers as a basis for improving the other inventory and borrowing systems of APC.

Conceptual Framework

Figure 1 shows the process flow of the whole mechanics of the project. The input reads data from different tools, materials, and items that are, and will be, found in the ESLO. This will consider the item's name, serial number, type, date it was added into the database, the quantity, the condition, and even the name of the student or faculty who has borrowed said item/s.
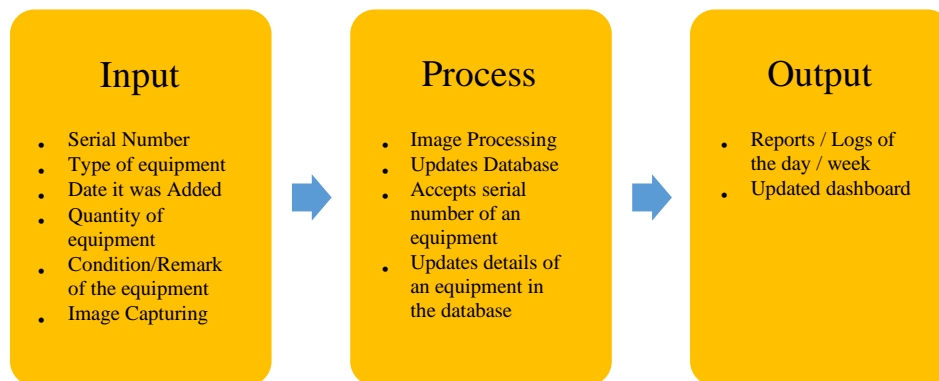
Input
- Serial Number
- Type of equipment
- Date it was Added
- Quantity of equipment
- Condition/Remark of the equipment
- Image Capturing

Process
- Image Processing
- Updates Database
- Accepts serial number of an equipment
- Updates details of an equipment in the database

Output
- Reports / Logs of the day / week
- Updated dashboard

Figure 1. Conceptual Framework of SoE Keep

It moves on to be processed by accepting the data that was read by the camera. The image is processed and updates the database and details according to the action done. This ends with reports that can get pulled from the database per day, week, or even at a custom date range depending on the user as the database keeps getting updated.

LITERATURE REVIEW

Understanding the Importance of Having an Efficient Inventory Management System

From the article, several entrepreneurs think that Inventory management is nothing more than a chore, without realizing that it is a ticket to optimizing business profits (ANSI Information Systems, Inc., 2021). A reliable inventory management system can do more for a business than simply make ordering, storing, and shipping products

that much easier. A more up-to-date, data-driven system can actively drive business cash flow and open new business revenue opportunities. So, if someone runs a physical goods business and is wondering where they can improve, inventory is a good place to start. By having one, it can shear down the cost of one of the biggest operating expenses, help account for stock more accurately, and allows optimization of decision-making for the supply chain. Business opportunities grow exponentially when the owner masters the art of inventory management. When they have better control of the supply chain, it is easier to add new products to the range or establish new sales channels (Baylen, 2020).

Inventory System in Universities: UPM-CAS

Similar to that of the Engineering and Sciences Laboratory Office (ESLO) of APC, other universities have their laboratories as well. These laboratories provide equipment and other tools for the students to use for their experiments, projects, and other laboratory activities, which are vital for the students to gain hands-on learning and experience the actual application of their lecture discussions. Due to the various equipment, an inventory system is used to keep track of the quantity of the products and their statuses.

The University of the Philippines Manila's College of Arts and Sciences (CAS) also has a laboratory that is used for different courses in the college (San Miguel, 2014). The Laboratory attendants oversee the tracking of all equipment's use, as well as that of the disposable items to ensure that these are always in supply. The inventory system that CAS uses comprises tables created through Microsoft Word. This way of storing all the information could cause inconsistencies and errors, adding to the fact that the files are only stored locally on one computer. As the files are not accessible through the cloud, there is a lack of security for important information. With this, the proponents proposed the development of an automated inventory system for the college to use.

The handling of data was made simpler as CAS developed an automated system. To ensure organization, various inventory system components were developed. Depending on their function, laboratories can only access a limited set of information here, which is all under the control of the laboratory faculty coordinator. Less human error was present with such a system, data is safer and more organized, and borrowers may view the equipment's availability.

Introduction to Image Processing (Introduction to Digital Image Processing)

Image processing is a set of steps done to an image to obtain an enhanced version of it or to obtain information from it. The basic steps of image processing include the following:
   a. Taking the image as input
   b. Analyzing and manipulating the image
   c. Obtaining the output which can be an altered image or information obtained from the image

With the technology rapidly changing and evolving, image processing has brought a lot of applications to different fields (da Silva & Mendonça, 2004). Some applications of image processing include the sciences – in medicine, and other branches of sciences such as using image processing in determining different types of plants and animals – entertainment, and multimedia systems. Image processing has also been used in detecting objects – such as vehicles in detecting traffic and in detecting plate numbers in parking lot inventory systems (Bartolome et al., 2012).

Image processing plays a significant role in the technology and innovations present today (Great Learning Team, 2022). According to the article, image processing is a way of communicating between a human viewing system and digital imaging devices as information is translated between the two.

Introduction to Neural Networks

Just like how the human brain can perform tasks and recognize different information, a neural network can determine the relationship between a large amount of data with each other – as it is rooted in artificial intelligence (Chen, 2022). It uses different algorithms and formulas to handle information. Neural networks contain multiple layers of nodes, namely the input layer, hidden layers, and output layers (IBM, n.d.). Neural networks also have different types, perceptron, feedforward, convolutional, and recurrent.

Neural networks are mostly seen in finance and business applications. This plays a big role in predicting different factors such as prices and stocks. With neural networks, business owners can use predictions to make significant decisions for their businesses based on the data they hold and analyze.

Review Paper on Real-Time Image Processing: Methods, Techniques, Applications

This paper states how challenging image processing is when it is implemented in various applications and systems. This may be complicated, but real-time image processing is one of the most important factors needed today. The percentage of error or failures of image processing are high, and this paper helps in showing the current state of image processing, techniques, and methods on how image processing is made. The methods and techniques are the focus of the proponents of this project since the project will also be based on this paper.

The two different methods of image processing are also discussed – Analog and Digital Image Processing. Image Enhancement, Image Recognition, and Image Compression are the methods that the proponents showed for the image to be processed easier and more accurately.

Image Enhancement removes other obstacles that hinder image processing and has higher accuracy in analyzing a certain image. This helps to maintain the original content of the image which are the pixels that hold the information needed for Image Processing. There are 6 methods under Image Enhancement – Interpolation, Contrast Enhancement, Density Slicing, Edge Enhancement, Noise Removal, and OTSU's Method (Masri, 2019)

Image Processing: Research Opportunities and Challenges

The paper contains different ways where image processing is used such as improvement of pictorial information for human interpretation, processing of image data for storage, and many more. The study mainly focuses on defining its meaning and scope for its uses to establish its versatility towards its usage.

Image processing has so much to offer in terms of different fields, such as in the medical field wherein it was used for Lung disease and Heart disease identification, and in the military wherein they used it for defense surveillance to monitor if any intruders are approaching their land based on its usage shown from the paper. Due to its nature to adapt from different fields as an identifier it opens a lot of opportunities for its usage making it usable for all kinds of things, which the proponents could take advantage of for creating an efficient inventory system (Hegadi, 2010).

Standardization of Image Quality Analysis

Several image quality analysis programs are available (Wüller & Kejser, 2016). For the world of archiving, which is based on many test charts and methods for data analysis In 2012, ISO established a working group to reconcile these techniques and provide a standard mode of operation picture quality analysis for archiving systems This has resulted in the creation of three documents that have been or will be published soon to be published The International Organization for Standardization (ISO) 19262 defines the terminologies used in the field of To unify the language, an image was captured. ISO 19263 outlines the process issues and provides specific instructions on how to perform the measurements.

Finally, ISO 19264 gives a detailed description of the measurements as well as goals and tolerance levels for several areas. The new ISO 19264 technical specification for analyzing image quality based on a single capture of a multi-pattern test chart will be presented in this article, as well as the reasons behind its current design. ISO 19264 is a standard that specifies a method for determining the overall quality of digital photographs created by two-dimensional originals scanned or photographed on a copy stand. ISO 19264 provides the main image quality parameters, such as resolution and color depth of the technique, as well as the metrics used to evaluate these quality characteristics for image quality analysis, and how the individual results. The results of the

measurements should be reported. It also includes a multipattern test chart as well as suggestions for defining objectives and the image quality metrics' tolerances.

Google OCR for Android vs. Android Tesseract

Optical Character Recognition (OCR) is the process of identifying and reading characters and symbols from an image (Izertis, 2016). Recognizing text from images is now made possible with all the online sources and libraries and through phones nowadays with high-quality cameras. OCR processing can be done either offline or online depending on the user's preference and application requirements and specifications (Iakovlev, 2020).

Two popular OCR tools are the Tesseract OCR and the Google Cloud's Vision API. In a general view, the two tools can work with different modes to fit specific types of documents with the following as the most common modes:
For Tesseract:
- Single block
- Sparse text
- Single column

For Google Vision:
- Text detection model
- Document text detection model

With the use of image pre-processing, results for Google Vision improved significantly, detecting only the necessary parts of the document. Tesseract, on the other hand, did not show much different results from the previous scenario as watermarks in the background were not scanned. The detecting of the text from the two OCR tools showed good results. In recognizing the text, Google Vision's performance was close to perfect while Tesseract did not do a good job.

PUP-ECE's Automated Laboratory (AutoLab) System

The Polytechnic University of the Philippines's Electronics and Communications Engineering Department provides laboratory services to its students being that the university's College of Engineering holds their specialty courses. The ECE Laboratory makes use of a manual inventory and logging system, everything making use of borrower's slips and logbooks. This process proves to be inefficient as each process has its paperwork, everything being in a different place. According to the paper, in a test conducted, there were inefficiencies in 9.39% of the 2300 ECE Room Utilization Logbook transactions, 41.38% of the 742 Borrower's Slip transactions, and 45.94% of the 603 ECE Transactions Logbook entries.

The proponents proposed an automated system called AutoLab through the use of bar codes. Through the proposed system, all the different transactions done in the laboratory are compiled and compressed in one place. Here, all transactions are recorded and managed, and all data are stored in a database as compared to the manual transactions recorded in logbooks. To test the proposed system, the proponents gathered two hundred sixty-seven respondents to use the system. The system had results of 4.51 being highly effective in minimizing the time to perform its functions and 4.50 being effective in its reliability. The accuracy of the information displayed in the system was rated as 4.71 being highly effective.

All in all, the system garnered the following results in handling information: recording of borrower's information as 4.72 being highly effective, recording of a key as 4.71 being highly effective, recording of equipment as 4.68 being highly effective, and updating of records as 4.70 being highly effective. (Salvador, 2015)

Development of Engineering and Sciences Laboratory Office Reservation, Borrowing, and Monitoring System

The goal of this research is to create a reservation or borrowing system that can track equipment inventory and generate reports based on the updated inventory, which includes both hardware and software components. With its 15.6" Resistive Touch Screen Panel, the kiosk made use of touch screen technology, which will be used by students to make selections on the kiosk. It also used smart card technology with the ACR122 NFC Contactless Smart Card Reader, which oversees verifying users' identification cards. After the identification card has been verified, the system will take the user to a Visual Basic platform where the transaction can be selected. The information acquired will then be saved and retrieved during report preparation using the Microsoft Office Access database management system. The ESLOB-RBMS project included reliability testing, which highlighted the kiosk and system's limitations and capabilities. With this, the project's goals of building a reservation, borrowing, and monitoring system for the Engineering and Sciences Laboratory Office, as well as reporting production and inventory of laboratory equipment and tools, were met (Peruda et al., 2015).

METHODOLOGY

Figure 2 shows the system block diagram of SoE Keep which illustrates the processes upon input of a serial number. Upon acquiring the serial number image, the image will undergo image processing to obtain the text from the image. The text will be compared to those of which already in the database. The user will then input the necessary item information and will update the database either with new or updated content. After updating the content, the inventory system dashboard of ESLO Web Services will update, and necessary updates for reports will be visible via the mobile

application. Figures 3 to 5 are a sample of the SoE Keep interface and the entire process of its functionality is discussed step-by-step below.
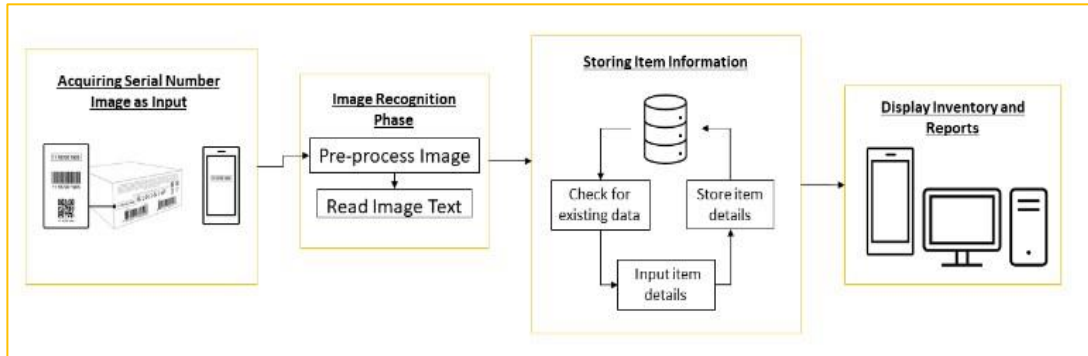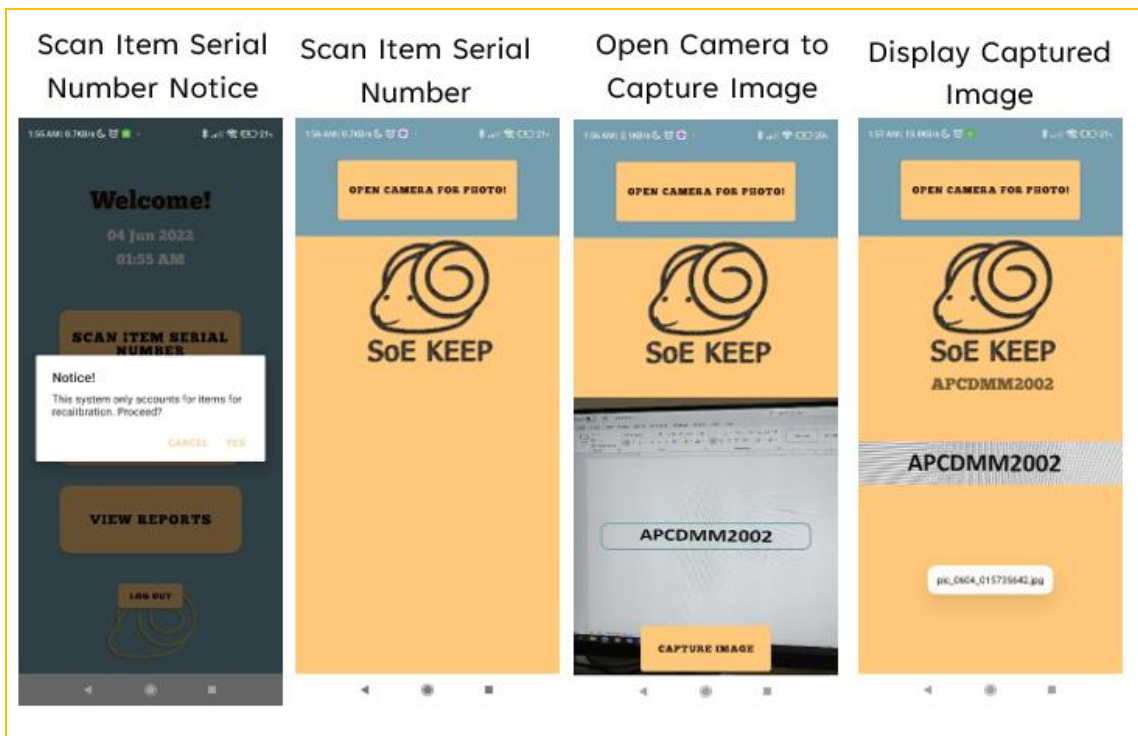

Figure 2. System Block Diagram of SoE Keep

Figure 3. Actual Screenshots of Admin's Graphical User Interface of SoE Keep
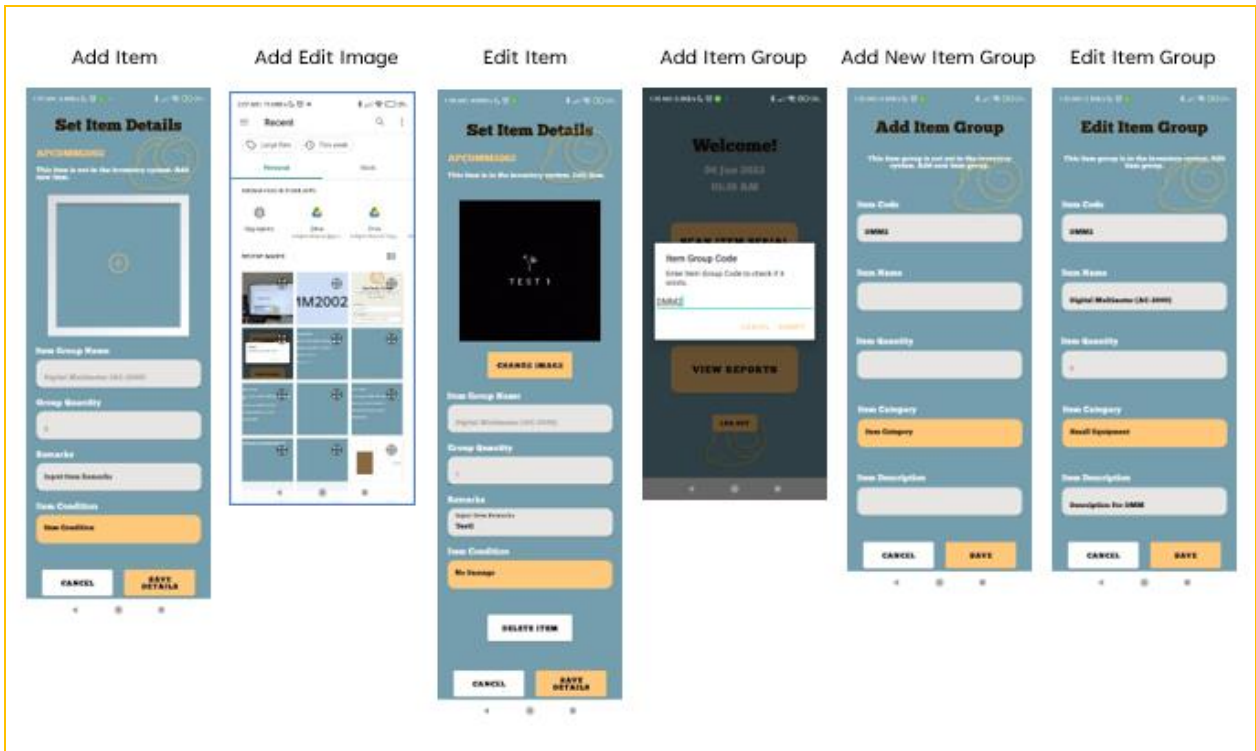
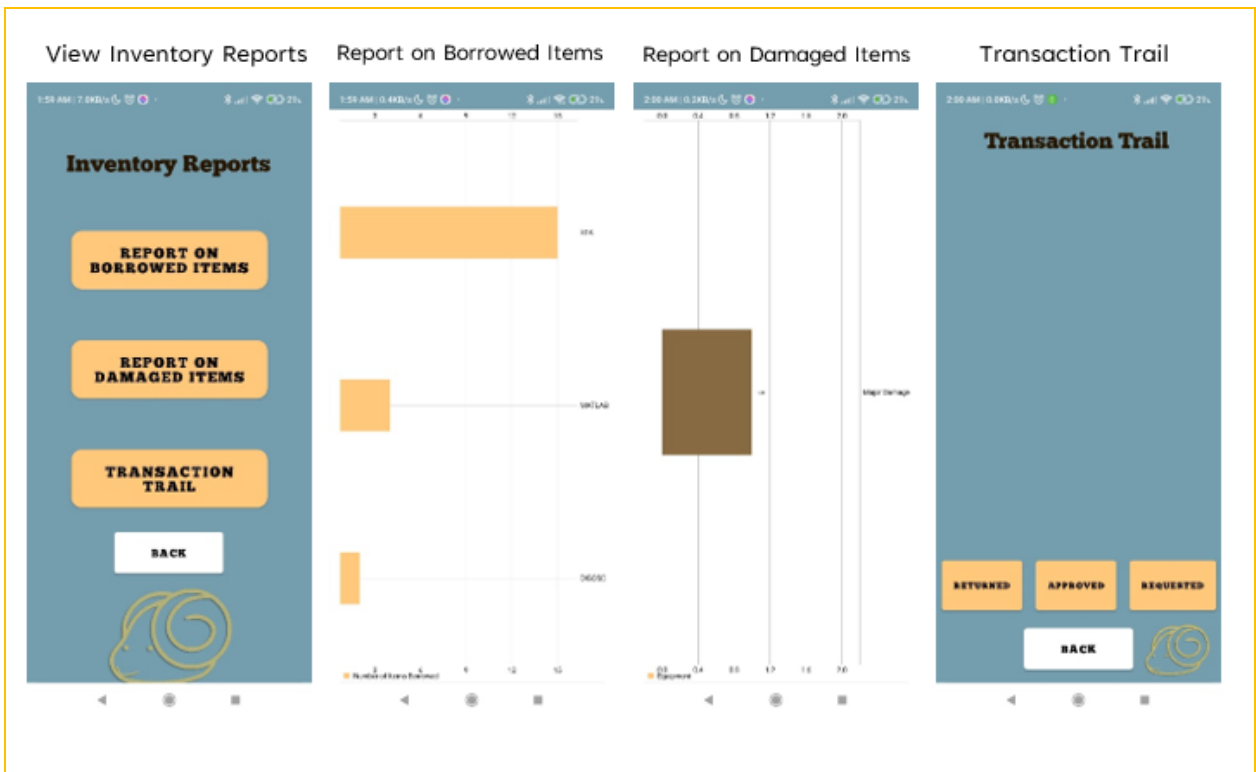*Figure 4.* Actual Screenshots of Admin's Graphical User Interface of SoE Keep

Figure 5. Actual Screenshots of Admin's Graphical User Interface of SoE Keep

Acquiring Serial Number Image

The necessary steps for acquiring the serial number image are done as follows:
Step 1: Get camera permission, Exit the application if the permission was not granted if it is then proceeded to Step 2.
Step 2: If the user clicked the "Capture Image" button then proceed the Step 3 otherwise stay at Step 2.
Step 3: The function "myPictureCallback_JPG" will get the frame data of the captured imaged.
Step 4: The function "myPictureCallback_JPG" will check if the image was in landscape mode since it was often defaulted as landscape.
Step 5: If the function "myPictureCallback_JPG" found that the image was not in landscape then it will call the function "createImageFile" to create an image file for the image to be retrieved within the app otherwise proceed to Step 6.
Step 6: The function "myPictureCallback_JPG" would rotate the data frame image for it to become portrait then call the "createImageFile" function to create an image file to be retrieved withing the app.

The Acquire Serial Number Image Algorithm shows how the SoE Keep be able to acquire the serial number image. This is correlated to the algorithm shown on Masking Algorithm, which is mainly about isolating the serial number. This section mostly discussed how SoE Keep was able to acquire the image that is captured within the application itself.

Image Processing: Masking Algorithm

Masking Algorithm displays how the SoE Keep application was able to mask the serial number (Jang et al., 2020) with the help of the user to contain its contents inside the bounding box. The result of this algorithm would be isolating the serial number by removing the noises around it to efficiently extract its content. It is done through the following steps:

Step 1: The function "myPictureCallback_JPG" will get the rotatedBitmap variable which stored the data frame from the acquired serial number image which is called from the saved JPG file in which the function "myPictureCallback_JPG" created.
Step 2: The function "myPictureCallback_JPG" will calculate the ROI (Region of Interest) aspect ratio.
Step 3: The calculated aspect ratio of the function "myPictureCallback_JPG" would then be use as a viewfinder to get the border size and position of the screen to get the position of the ROI from the acquired serial number image.
Step 4: The function "myPictureCallback_JPG" would then prepare the calculation in terms of the ROI's position and the size needed to be cropped.

Step 5: The image acquired would then be passed to an if and else statement within the function "myPictureCallback_JPG" to check the limits of the acquired serial number image and make a crop out of it based on the prepared calculation to isolate the serial number captured within the borders of the rectangle from the capture interface.

Step 6: Save the cropped acquired serial number image as a JPG file by recalling the function "createImageFile" within the "myPictureCallback_JPG" function.

Grayscale Conversion Algorithm

Grayscale Conversion Algorithm presented below shows how it can utilize the OpenCV library in terms of preprocessing the image acquired from the masked serial number image. This also shows the step-by-step process on conversion of each acquired masked images to grayscale to utilize the OCR in scanning the serial number because the image only now contains a value of 0 and 1 for each pixel.

Step 1: The "onFragmentInteraction" function will retrieve the cropped image file.

Step 2: The image retrieve will be stored inside a variable called "tmp" and create a filter variable to be used later inside the function of "onFragmentInteraction".

Step 3: Variable "tmp" will now be converted into grayscale using the function "Imgproc.cvtColor" from the library of OpenCV within the function of "onFragmentInteraction".

Step 4: The converted "tmp" image will then be stored to the "filter" variable using the "Utils.matToBitmap" function from the library of OpenCV within the function of "onFragmentInteraction" then be displayed from the interface of the SoE Keep application.

Reading the Text from the Image

This section is about how the SoE Keep application be able to extract the serial number information from the preprocessed image. The Image Processing section utilizes the Google Vision throughout the process of extracting the information from the pre-processed image. Because of this, the SoE Keep application was able to successfully extract the data and used it throughout the process of acquiring and transmitting data.

Step 1: The pre-processed image will be stored "frameImage" variable to copy its data frame, initialize the "textRecognizer" variable from the Google Vision library, and store the "frameImage" within the parameter of "textRecognizer" function to variable "textBlockSparseArray" to prepare each pixel.

Step 2: The "textBlockSparseArray" variable will be for looped to analyze each pixel to get the corresponding text detected by the function of "textBlock" from the Google Vision library and stack the character detected from the string variable named as "stringImageText".

Step 3: The text stacked on the "stringImageText" variable will be displayed from the Interface of SoE Keep application.

Transmit Data and Acquire Item Information

This section discusses the overall function on how the SoE Keep application is able to transmit and acquire the data information from the database.

Step 1: The author will be presented to the capture interface.

Step 2: If the image is captured the system will then mask the region of interest to get the serial number base from what the user have captured inside the rectangle shown from the interface of the SoE Keep app.

Step 3: The masked image will be converted to grayscale image.

Step 4: The converted image will be passed to an OCR function to extract the text captured from the image.

Step 5: The extracted text from the OCR will then transmitted from the database to compare.

Step 6: If the data/text extracted after comparing match the database it then the system will then proceed on displaying the following information, if not the system will automatically ask for the users input for the info of the new serial code.

Storing Item Information

Considering that the previous section has successfully transmit data and acquire item information, this section will now simply save the data acquired – including the extracted text from the OCR – into the database of SoE Keep.

Displaying Inventory Results

For the last section, the ESLO Web Services inventory dashboard will update and will display the changes made in the previous section. For the mobile application, the reports will be updated according to the changes in the inventory records, and it will be displayed accordingly.

RESULTS

The researchers underwent system testing wherein these testing is done as follows: checked the accuracy of the application by testing its ability to scan numbers and letters using image processing in one (1) day, checked the reliability of the application by monitoring its precision of obtaining the correct numbers and letters in five (5) days, and lastly, its user friendliness by letting a number of SoE professors and students use the application and answer questions using a Likert Scale (Tables 1 to 4).

Table 1. Summary of Accuracy Table Testing

Objective	Serial Number	Trials	Success rate (fraction)	Success rate (percentage)
Ability to scan Letters and Numbers	OSCL	3	3⁄3	100%
	DMM2	2	2⁄2	100%
	DMM6	2	2⁄2	100%
	VAPS	3	2⁄3	66.67%
Overall Success Rate:				91.67%
Equivalent System Rating:				Good

Table 2. Summary of Reliability Table Testing

Objective	Serial Number	Trials	Success rate (fraction)	Success rate (percentage)
Ability to identify all Letters and Numbers	OSCL	15	5 + 5 + 4⁄15	93.33%
	DMM2	15	5 + 4 + 5⁄15	93.33%
	VAPS	20	4 + 3 + 5 + 4⁄20	80%
	AGEN	15	5 + 5 + 5⁄15	100%
	DMM6	15	5 + 5 + 5⁄15	100%
	SGEN	20	5 + 5 + 5 + 5⁄20	100%
	ANPS	15	5 + 5 + 5⁄15	100%
	FCNT	15	4 + 4 + 4⁄15	80%
	DGPS	20	5 + 5 + 5 + 5⁄20	100%
Overall Success Rate:				94.07%
Equivalent System Rating:				Good

Table 3. Summary of User-friendliness Table Testing for ESLO Head

Objective	No. of Users	Response Rate (fraction)	Response Rate (percentage)	System Rating
User-friendliness of the android application	5	$(5\ x\ 4) + (4\ x\ 1)⁄5$	4.8	Very Good
		$(5\ x\ 3) + (4\ x\ 2)⁄5$	4.6	Very Good

Table 4. Summary of User-friendliness Table Testing for Student Assistants

Objective	No. of Users	Response Rate (fraction)	Response Rate (percentage)	System Rating
User-friendliness of the android application	**14**	$\frac{(5 \, x \, 5) + (3 \, x \, 4) + (4 \, x \, 3) + (2 \, x \, 2)}{14}$	3.78	Good
		$\frac{(2 \, x \, 5) + (5 \, x \, 4) + (4 \, x \, 3) + (3 \, x \, 2)}{14}$	3.43	Good

DISCUSSION

Accuracy

The accuracy of the application is based on the percentage of successful scanning attempts and the total number of scan attempts. This is determined by getting the overall success rate in percentage, to be divided by the total number of serial numbers used. Shown in Table 1 that the success rate is 91.67% that translates to a Good rating.

Reliability

The reliability of the application is based on the ratio of correctly predicted characters and numbers of the scanned serial number. This is also determined by getting the overall success rate in percentage, to be divided by the total number of serial numbers used. The difference with the accuracy testing is that this Reliability testing will take the researchers five (5) working days to measure its precision. As seen from the Table 2, the reliability of SoE Keep is 94.07% which equates to a Good system rating.

User-Friendliness

User Friendliness is divided into two – the ESLO Head and the Student Assistant. There is a possibility that the ESLO Head will be hiring Student Assistants, so the researchers decided to open the User-friendliness testing to students. Selected SoE Professors and students will be testing the application and will be answering a survey that consists of a Likert Scale for them to rate the overall experience and the overall design of the application.

As seen from the Table 3 and Table 4, the user-friendliness result from the ESLO Head/Professors resulted to a 4.8 overall experience and a 4.6 overall design. For the student assistants, a 3.78 overall experience and a 3.43 overall design. This translates to Very Good for the ESLO Head/Professors and Good for the Student Assistants.

CONCLUSIONS AND RECOMMENDATIONS

SoE Keep is an application that keeps track of the inventory of the ESLO for ease of use of the ESLO Head. The application can capture and scan the serial numbers of items for recalibration and from there add them to the inventory system, edit, or delete items. The ESLO Head is also able to view reports such as the transaction trail, borrow reports, and damage reports. All functions of SoE Keep were implemented and tested through both functional and system testing—both of which mainly focus on the core function of the application to identify the text on the serial numbers through an OCR, add, and retrieve data from the database relating to the scanned serial number. The application is dependent on the internet connection, thus its speed of retrieving and saving data may vary.

During the testing process, it was seen that the application performs well in capturing and identifying serial numbers—even in low light or dim places—if the stickers are not tampered with, and the serial number is captured within the bounding box included in the application. Scanning serial numbers that are tampered with causes the application to read ghost letters and affects the accuracy of the OCR. Slow internet connection on the other hand causes the unsuccessful uploading of images to the online servers. All points for improvement of the application were noted and stated in the Recommendations of the project. Despite these, the proponents have been successful in delivering the functions of the application such as adding new items to the database, editing existing items, deleting items, and viewing the item reports. Following the specific objectives, the application was able to accurately capture the serial numbers and read its characters, be successful in repeatedly scanning the serial numbers and perform its other functions, and finally, the users were able to use the application easily due to its user-friendliness.

During the completion of testing and evaluating the specific objective of the application, the proponents observed that some features from the designed project needed some improvement in terms of functionality and visual design. The fixes for the minor issues with the features that needed improvement have not been applied due to time constraints and the lack of expertise in creating the specific features of the application.

IMPLICATIONS

The application developed was able to comply in the implementation of an environmental solution by resorting into a paperless process in the ESLO. This makes way for the institution to be more sustainable and efficient as for the present time.

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DECLARATIONS

Conflict of Interest

All authors declare that they have no conflicts of interest.

Informed Consent

The researchers' photos were included in the research paper, which ensures their full consent to have them published in an international journal.

Ethics Approval

The conducted research uses only the researchers' photos and did not include other humans as participants hence it does not violate any ethical issues.

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