A Proposed Computer Vision-Based System for Managing the Self-borrowing and Returning Process in Libraries

Prepared by
Dr. Soha Besher Ahmed Abdelal
Department of Library and Information Science,
Faculty of Arts,
Benha University, Cairo, Egypt,
soha.abdelal@fart.bu.edu.eg

Abstract:

Information services represent the basis on which libraries and information centers are built, and it is the ultimate goal that they seek and work for. Therefore, libraries have sought throughout their long history to develop their services in line with the needs of their beneficiaries, and among these services is the borrowing service. This is developed due to the rapid and massive progress in the field of information and communication technologies from traditional loans to self-lending, where each beneficiary completes the loan procedures himself. The self-lending saves time and contributes to the speedy completion of the loan process. The process of involving the beneficiaries in the self-lending process is one factor that attracts them because of their sense of responsibility, which will be reflected in the increase in frequentness and borrowing rates.

This paper presents the detailed implementation of computer vision, image processing, and barcode decoding techniques used in libraries for more efficient tracking of borrowed books. The main idea of the system relies on implementing image processing, machine learning, and a database that contributes to the system's ability to identify the barcodes of the books and log in their titles, editions, authors, borrower IDs, dates, and times. The study relied on an experimental approach to determine the extent of the ability of the proposed system to decode and detect the barcode of books and carry out the borrowing and self-return process efficiently and accurately without problems and without adhering to certain specifications for the books used.

The experimental results show that the proposed system is accurate, fast, reliable, and capable of recording borrowed books, where the accuracy of the system when capturing the barcode and performing the process of self-borrowing and/or self-returning for one book, or two books or three books reached 100%. The accuracy of capturing the barcode and performing the process of self-borrowing and/or self-returning a book in upright or horizontal positions was 100%. The accuracy of capturing the barcode and performing the process of self-borrowing and/or self-returning books in highlight, or medium light was 100%. The system was unable to capture the barcode and carry out the process of self-borrowing and/or self-returning books in low light without flashing the mobile phone at a rate of 100%. The accuracy of capturing the barcode and performing the process of self-borrowing /self-returning books in low light using the mobile flash was 100%. The accuracy of capturing colored barcodes in the dark by

relying on the mobile flash and performing a self-borrowing and/or self-returning process was 100%. The accuracy of capturing a wet barcode with a layer of water on it and performing a self-borrowing/returning process was 100%. The accuracy of capturing a barcode written on it in pencil and performing the self-checkout/return process was 100%. The accuracy of capturing a barcode written on it with a pen and performing a self-borrowing/returning process was 100%. The accuracy of capturing a color-crossed-out barcode and performing a self-borrowing/returning process was 100%. The accuracy of capturing a crossed-out barcode with a pen and a layer of water and performing a self-borrowing/returning process was 100%. The accuracy of capturing a crossed-out barcode with a pen and colors together and performing a self-borrowing/returning process was 100%. The accuracy of capturing the one-dimensional barcode was 100% while the accuracy of capturing the 2D barcode was 100%. The accuracy of capturing the barcode printed on the covers of the book was 100%. The accuracy of capturing the barcode printed on an outer sheet with transparent adhesive tape was 100%. The proposed system is characterized by high accuracy, speed, and reliability in recording the materials in the library, which saves the staff time and effort. The alert system can also notify employees of any delays at exit stations, helping them to intervene quickly. The system's modular design allows for easy integration with existing library systems, without the need for additional hardware.

Keywords:

self-borrowing/returning, libraries, computer vision, barcode detection, barcode decoding, image processing, and machine learning.

1. Introduction:

Technological progress has forced libraries to change their traditional services and procedures by relying on modern technologies in response to the changing informational needs of their users who are more inclined to technology and prefer to access information and obtain services through technology and its tools **(Hamed, et al., 2022 b).**

One of the main roles of any library is to provide its customers with valuable information services. This role can be achieved quickly and efficiently only through modern technologies, which will contribute to making academic library services more effective and efficient. Moreover will enhance user satisfaction with the services provided and save time for both library staff and beneficiaries **(Ajani & Buraimo, 2022).**

It was stated in the International Federation of Library Associations and Institutions statement in 2013 about the library and development that the library is the only place that provides access to information to help people improve their education, develop new skills, find jobs, build businesses, and other aspects of benefit, and it must adapt to the changes of the rapid technological environment

To facilitate the evolving needs of users to provide information promptly. Academic libraries around the world derive their message from the message of their parent institution and aim to improve the quality of education and its outputs. It also aims to support scientific research by facilitating access to various sources of information. An educated, informed, and participatory society is the function of the library. Libraries enjoy a stable position as trustworthy information brokers. To maintain this position, libraries must adopt new technology to provide comprehensive access to information efficiently and effectively. The Fourth Scientific Law of Libraries and Information stipulates “save the reader’s time.” This requires libraries to develop services based on modern scientific and technological means **(Hamed, et al., 2022 a).**

In recent decades, the latest self-service technologies have radically transformed the way services are provided and have provided service providers with a variety of benefits such as simplifying operations and reducing operating costs. Self-services have become an integral part of the operations that take place in many libraries, through which library visitors are provided with more opportunities to benefit themselves from library services and encourage them to frequent the library **(Wu & Wu, 2019).**

Self-service is very popular in all areas of modern life, such as withdrawing money from the cash dispenser in banks, shopping in the supermarket, etc. Everyone has welcomed the concept of self-service because it saves time and reduces costs. Libraries are considered a general cultural service that aims to meet the individual demands of readers. The use of self-service within libraries helps to change the pattern of library services and makes them more effective, which leads to attracting many readers to benefit from library services. Self-service systems put readers in the middle of an open environment and they must face problems and difficulties. This requires librarians to enhance awareness of the beneficiaries of the self-service provided and train them on it first. Self-service has forced librarians to change from helping readers to helping readers to help themselves. This requires librarians to increase their ability to deal with all kinds of difficulties. Therefore, libraries must rely on easy-to-use systems so that readers can benefit from the advantages of self-service easily and smoothly without any problems or obstacles **(Zhong, 2007).**

The “open stack borrowing books” represents the first idea of self-service for the reader to be able to borrow books himself from the open piles. This service began in a library in Italy in the late Middle Ages, and this system continued to be used until it was applied as a global service in the libraries of Europe, America, and other economically developed countries. However, this system was not applied in all libraries, and by the late eighties and early nineties, the concept of open book borrowing service was adopted in some university libraries and some large and medium-sized libraries.

With the rapid technological development, self-services were provided via the Internet, and then the technologies used to provide self-services in the library developed, including artificial intelligence technology **(Zhong, 2007).**

Florence Olabisi Ajani's study confirmed that the use of technology in the process of borrowing and returning books has proven effective in academic libraries and has a major role in facilitating access to information sources, saving time, and reducing error. The study also concluded that technology contributed to improving the performance of academic librarians by more than 70% **(Ajani & Buraimo, 2022).**

Libraries have become smarter with modern emerging smart technologies to improve user experience and increase their satisfaction. Modern technologies in libraries are necessary to bridge the gap between library services and the rapidly and continuously changing user needs **(Hamed, et al., 2022 b).** This required development in library services requires a certain level of proficiency and digital skills from librarians to cooperate with user requests **(Hamed, et al., 2022 a).** In general, libraries are in constant need to search for modern, smart, and sophisticated solutions to improve the quality of the services they provide **(Hamed, et al., 2022 b).**

Definition of barcode and its types:

A barcode is a graphic identifier that arranges black and white bars of different widths according to certain coding rules to express a set of information **(Chuanliang, et al., 2020).** It is also an image that may be in the form of one-dimensional and parallel lines or a two-dimensional array of dots and shapes **(Tu, et al., 2021)**, as shown in **Fig. 1**

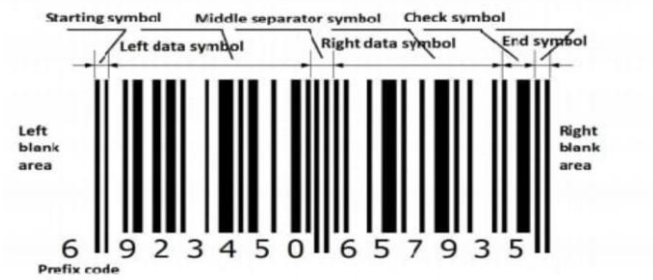


Fig. 1. Barcode (Chuanliang, et al., 2020)

Table 1 shows some examples of barcodes, whether one-dimensional or two-dimensional, as follows:

Table 1: Common barcode types (Tu, et al., 2021)

Name	Type	Stored data	The description
Code 128	1D	It can encode all 128 ASCII characters.	Available worldwide.
Code 39	1D	It can encode all 128 ASCII characters.	It is relied upon by many government agencies.
Channel Code	1D	It can encode from 3 to 8 Numeric characters.	It is used to present numerical data.
MSI Plessey	1D	It can encode Unlimited numerals.	They are used in the binary system - and in inventory labelling.
Planet	1D	It can encode 11/13 numerals.	Applied by the US Postal Service.
Aztec Code	2D	It can encode Up to 3823 alphanumerics.	Mainly used for railway tickets.
Code 16 K	2D	It can encode Up to 154 ASCII.	Applied in France and the USA.
Data Matrix	2D	It can encode numerical characters and Up to 3116 ASCII.	It is used for labelling small-sized electronic components.
Maxicode	2D	It can encode Up to 138 ASCII.	They are in the form of hexagonal and spiral patterns instead of square patterns.
MicroPDF417	2D	It can encode Up to 366 ASCII.	All MicroPDF417 products were created from ISO/IEC 24728 standards.
QR Code	2D	It can encode Up to 7089 ASCII.	It is used in advertising and marketing.
UPC-A	2D	It can encode 11 numerals.	It is applied in retail.

There are many barcode recognition programs on the market, which can be divided into two categories. The first is scanning with an infrared barcode scanner, and the other is using the camera to collect the image and then identifying it through the software programs **(Chuanliang, et al., 2020), (Tu, et al., 2021)**. The one-dimensional barcode scanner cannot read the two-dimensional barcode image, and vice versa, This matter was addressed by the current research, as the proposed system can read all types of barcodes without obstacles, efficiently, accurately, and quickly, which will be clarified in the experimental results of this paper. Among the advantages of barcode technology are ease of use, low cost, and widespread use in different fields **(Elaskari, et al.,**

2021). The difference between one-dimensional code and two-dimensional code is as follows. The one-dimensional code was designed in the form of black rectangular bars called barcodes with limited features, and the two-dimensional code was designed in the form of squares, hexagons, and other geometric shapes with many features **(Elaskari, et al., 2021)**. **Table 2** shows the comparison of both the one- and two-dimensional codes.

Table 2: Comparison of one- and two-dimensional barcodes

Comparison Point	Two-dimensional barcode	One-dimensional barcode
Data-Type	It has a high data density, It holds various types of data such as locations, photos, and cost	It cannot carry much information, it holds text and numbers only.
Usage platform	It generally encodes various types of data in patterns of squares, dots, hexagons, and other geometric patterns	It uses a series of variable-width lines and spaces to encode data
Uses of barcodes	It is used for advertisements, payments, and for logging into websites	Used in warehouse, retail, health, and education, Universal Product Codes (UPCs) and the International Standard Book Number (ISBN)

2. The Contribution of this Paper:

The importance of the study is that it seeks to overcome the problems related to the borrowing process within libraries. Most libraries in Egypt rely on the automated system to accomplish the borrowing process, but it consumes time and effort for both the beneficiary and the library specialist, especially with the large numbers of Beneficiaries, which will negatively affect the efficiency of the service provided and the reluctance of the beneficiaries to visit the library and borrow from it. Some libraries also rely on RFID technology to provide self-borrowing and returning services, but its application is very expensive and cannot be generalized in all libraries. Therefore, this paper proposes the application of computer vision technology, machine learning, image processing, and barcode decoding in libraries to track more efficiently borrowed books. The library's automation and simplification of the borrowing process allow for faster and more accurate tracking of borrowed books.

The accuracy of the proposed system when capturing the barcode and performing the process of self-borrowing and/or self-returning for one book, two books or, three books reached 100%. The accuracy of capturing the barcode and performing the process of self-borrowing and/or self-returning a book in upright or horizontal positions was 100%. The accuracy of capturing the barcode and

performing the process of self-borrowing and/or self-returning books in highlight, or medium light was 100%. The system was unable to capture the barcode and carry out the process of self-borrowing and/or self-returning books in low light without flashing the mobile phone at a rate of 100%. The accuracy of capturing the barcode and performing the process of self-borrowing /self-returning books in low light using the mobile flash was 100%. The accuracy of capturing colored barcodes in the dark by relying on the mobile flash and performing a self-borrowing and/or self-returning process was 100%. The accuracy of capturing a wet barcode with a layer of water on it and performing a self-borrowing/returning process was 100%. The accuracy of capturing a barcode written on it in pencil and performing the self-checkout/return process was 100%. The accuracy of capturing a barcode written on it with a pen and performing a self-borrowing/returning process was 100%. The accuracy of capturing a color-crossed-out barcode and performing a self-borrowing/returning process was 100%. The accuracy of capturing a crossed-out barcode with a pen and a layer of water and performing a self-borrowing/returning process was 100%. The accuracy of capturing a crossed-out barcode with a pen and colors together and performing a self-borrowing/returning process was 100%. The accuracy of capturing the one-dimensional barcode was 100% while the accuracy of capturing the 2D barcode was 100%. The accuracy of capturing the barcode printed on the covers of the book was 100%. The accuracy of capturing the barcode printed on an outer sheet with transparent adhesive tape was 100%. The proposed system is characterized by high accuracy, speed, and reliability in recording the materials in the library, which saves the staff time and effort. The alert system can also notify employees of any delays at exit stations, helping them to intervene quickly. The system's modular design allows for easy integration with existing library systems, without the need for additional hardware. The proposed system also helps in tracking books and alerting the library of arrears. It also does not require any specifications in the used books, unlike some of the technologies used in the borrowing service in previous studies, such as RFID technology, which requires large costs for application and requires specific specifications for borrowed books. The proposed system scans any type of barcode, whether single or binary, which makes it superior to other systems presented in previous studies **(Karna, et al., 2019) (Zhou, 2019) (Hamed, et al., 2022) (wang, et al., 2023).**

3- Literature Review:

The Literature review presents the most important methods and techniques that are relied upon to provide borrowing and self-return services in libraries as follows:

(Nyoman Karna) explained through his studies that with the increasing number of students in universities, the automation of library services such as loans and self-return using RFID has become one of the possible solutions to

provide better service to students, but one of the most important problems in the self-service system based on RFID that is not provided by libraries is How to make sure that the identity card of the beneficiary belongs to the person using the service. The researcher tried to evaluate the performance of the borrowing and self-returning device located in the Telkom University open library in terms of the maximum book size that can read its RFID tag and the average time required to process it Books and the optimal weight of the book for the self-return system. It was found that the maximum thickness of the book is 50 millimeters and the cover thickness of 4.8 mm. It was found that the system can read the RFID tag for the thickest book. Faster at a rate of four and three than the manual system, where the self-treatment time was 10 seconds compared to 43 seconds in the self-treatment to the optimal weight of the book so that the self-return system works correctly. The researcher concluded that a book whose weight is less than 150 grams is not processed because it is not heavy enough. Sufficient for slipping, while a book weighing more than 2400 grams cannot be read because it slips very quickly. The optimal weight range for the book to be processed ranges from 200 grams to 2300 grams **(Karna, et al., 2019). (Donghua Zhou)** also explained through his study that some libraries rely on self-service loan and return devices and RFID readers. Despite the advantages of these modern technologies, their application requires large financial expenditures to purchase the required devices and tools **(Zhou, 2019). (Xueling Liang's)** the study showed that some libraries rely on the Internet of Things to borrow and return books with the help of RFID technology **(Liang & Chen, 2020).**

Some studies suggested a system for the digital library, such as the study of **(Chuanjie Xu and Wen Bo),** which suggested a system that the researchers called the reader service system using computer technology, communication technology, and network technology, through which the user can manage, borrow books, return them, reserve books, and other functions. The researchers concluded that the system implements the borrowing service efficiently, and this system contributed to making the readers feel enjoyment as a result of obtaining information sources easily and quickly **(Xu & Bo, 2020).**

As suggested by **(Pratibha S. Yalagi; and Prachi V. Mane),** a system for automating smart libraries using face recognition technology, where the proposed system uses face recognition technology to enter user data to carry out the borrowing and return process, and the accuracy of the system reached 99.38%, as the system was able to efficiently identify users at the time of issuing the book and returning it **(Yalagi & Mane, 2021).**

(Faten Hamad) also confirmed that the borrowing service can be provided in libraries through the use of borrowing and self-return machines to facilitate services for the beneficiary, or through kiosks located in train or subway stations to borrow books and return them, but this study confirmed that good planning must be done to provide smart services and She pointed out that one of the most

important problems that libraries face in applying modern technologies in providing library services is financial issues and poor infrastructure, in addition to training employees, all of which represent the main challenges that librarians face in developing services, and their absence negatively affects the level of services provided **(Hamed, et al., 2022 a). (Qi Kang a, Zhiqiang Song)** also explained through their studies that some libraries allow the borrowing of printed books through mobile applications or through the library's website, where the beneficiaries select the books to be borrowed, and the library delivers the books to homes, and the return process takes place Through self-service machines. Some libraries rely on Borrowing and self-returning machines. Some libraries also provide scanning services for book chapters or articles to be reviewed and sent to beneficiaries by e-mail **(Kang, et al., 2022).**

Among the studies that dealt with the use of RFID technology in the process of lending and self-return in libraries is the study of both **(Siguo Bi and Cong Wang)**, but the researchers noted in this study that there are some negatives to this technology, as an error occurs in reading some RFID tags on books **(wang, et al., 2022).**

We note from the previous presentation that the most widely used and common technology in providing self-borrowing services is RFID technology. Despite its advantages, it has many disadvantages, as we have shown in most of the previous studies, such as the material cost, which hinders libraries from applying it due to the lack of available budgets. And a need for certain specifications in the books used in terms of size and weight, and the occurrence of some errors when reading the RFID tags.

These defects are not found in the current proposed system, which does not require high expenditures for application and does not require specific specifications in the books used, whether in terms of size or weight.

4- The Problem Statement and Objectives:

Libraries face great challenges in managing the process of borrowing and returning, especially in the case of large numbers of Beneficiaries, because it will cause crowding in front of the library specialist. This requires the necessity of a new technology that contributes to overcoming this problem and enables the beneficiaries to borrow the books they need themselves without referring to the library specialist. This paper proposes a system to manage the process of self-borrowing, self-return, tracking arrears, and issuing based on machine learning and image processing easily and does not require prior training for the beneficiaries of the library and does not require large costs compared to the expensive self-examination machines that rely on RFID technology as was clarified in previous studies **(Karna, et al., 2019) (Zhou, 2019) (Hamed, et al., 2022) (wang, et al., 2023).**

The main objective of this study is to determine the extent of the ability of the proposed system, based on computer vision technology, to manage the process of self-borrowing and returning. The sub-objectives are:

- Shedding light on the features of the proposed system and its components.
- Clarifying the requirements for designing the proposed system for managing the self-borrowing and returning process in libraries.
- Explaining the stages of implementing the proposed system, its modules and their functions.

5- Design/methodology/approach:

The main idea of the system relies on implementing image processing, machine learning, and a database that contributes to the system's ability to identify the barcodes of the books and log in their titles, editions, authors, borrower IDs, dates, and times. The study relied on an experimental approach to determine the extent of the ability of the proposed system to decode and detect the barcode of books and carry out the borrowing and self-return process efficiently and accurately without problems and without adhering to certain specifications for the books used.

6- Existing check-in system:

The traditional checkout process in libraries often involves manual scanning and data entry, which can lead to errors and inefficiencies. With the help of computer vision and barcode decoding technologies, libraries can automate and streamline the checkout process, allowing for faster and more accurate tracking of borrowed books.

6.1 Proposed automated check-in system:

We propose an automated checkout system that minimizes required human input. The key features of the proposed system are:

- Barcode detection - The system automatically detects and decodes the book's barcode.
- Automated logging - The checkout date and time are logged automatically.
- Minimal user input - The system only requires the user to manually enter name, ID number, and state, As shown in **Fig. 2.**

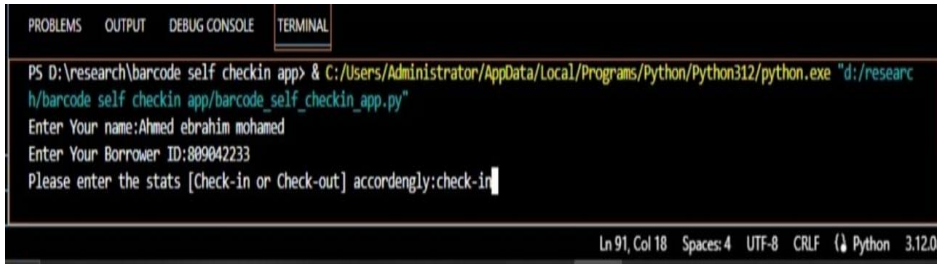


Fig. 2. The data required to perform the self-borrowing process

- Centralized database - All data is saved to a shared CSV database for easy tracking, management, and reporting.
- Delay alerts - A complementary system alerts staff of any delays at checkout.
- 6.1.1 The system is designed to be:
  - Fully automated - Minimal human intervention is required during normal operation.
  - Scalable - The modular design and reliance on robust barcode and vision libraries enable it to scale independently to support large volumes.

6.1.2 Key system components:

- Barcode detection module
- Time logging module
- User input module
- Database saving module
- Alert handling module
- Report generation module

The key features and system components work together to create an automated checkout system that minimizes required human input while reliably checking out books at scale. The modular design also enables flexibility and ease of integration.

6.2 System Requirements:

Each platform necessitates specific requirements to run applications based on Barcode Detection as follows:

6.2.1 Hardware requirement:

- Processor: 7th generation
- RAM: Minimum 4 GB

- Hard Disk: Minimum 500 GB
- GB. Camera: High quality

6.1.2 Software specification:

- Platform: Windows 10
- Linux language used: Python
- Frontend tools: vsCode
- Backend: CSV Comma Separated Values Database

The proposed system can be divided into two main stages. Each stage consists of several modules. The modules and their functions are defined in this section.

6.3 Stage One:

6.3.1 Books database setup:

Building the central database that contains all the Barcodes and the book information such as book title, book author, edition, publication date..etc

6.3.2 Stage Two of the project:

At this stage, we build the main program that utilizes the computer vision library OpenCV and the main barcode detecting and decoding library PyZbar to detect and decode the barcodes on each book. The system works as follows:

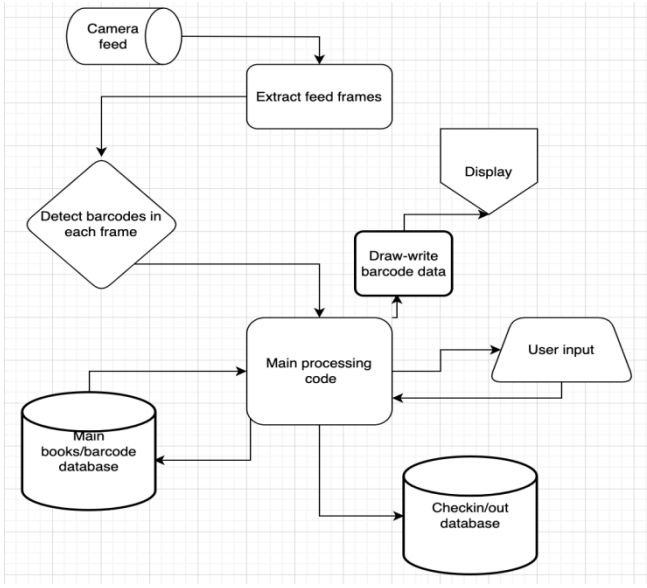


Fig. 3. System Diagram

First, the users run the request. Then the application's simple interface asks about the user name, borrower ID, and the request type which is checkout or check-in. Then the camera access modules run to detect the barcodes and decode them. When the user is done. The program automatically compares the data detected with the main books database pulls the book information and logs it in the separate logging database alongside the user name, borrower ID, and the time and date.

Experimental Results:

The author tested the accuracy of the system of self-borrowing and self-returning on a group of books at the Faculty of Law, Mansoura University. They numbered 20 books. The test results can be seen in Table 3.

Table 3: Results of testing the proposed borrowing and self-returning system

No	Condition	Total Number of Detections	Number of Accurate Detections	Number of Inaccurate Detections	Percentage of Accuracy
	Self-borrowing/returning process for one book only	30	30	-	100%
	Self-borrowing/returning two books together	30	30	-	100%
	Self-borrowing/returning three books at the same time	30	30	-	100%
	Self-borrowing/returning a book in an upright position	30	30	-	100%
	Self-borrowing/returning books in the highlight	30	30	-	100%
	Self-borrowing/returning books in medium lighting	30	30	-	100%
	Self-borrowing/returning books in low light without the flash of the mobile phone	30	-	30	-

No	Condition	Total Number of Detections	Number of Accurate Detections	Number of Inaccurate Detections	Percentage of Accuracy
	Self-borrowing/returning process for books in the dark using the mobile flash	30	30	-	100%
	Capturing colored barcodes in the dark by relying on the mobile flash	30	30	-	100%
	Recognizing a wet barcode with a layer of water on it	30	30	-	100%
	Recognize a crossed-out barcode with a pencil	30	30	-	100%
	Recognizing a crossed-out barcode with a pen	30	30	-	100%
	Recognize a color crossed-out barcode	30	30	-	100%
	Identifying a crossed-out barcode with a pen and a layer of water on it	30	30	-	100%
	Recognize a crossed-out barcode with a dry pen and colors together	30	30	-	100%
	One-dimensional barcode recognition	30	30	-	100%
	Recognition of two-dimensional barcodes	30	30	-	100%
	Identify the barcode printed on the book's skins	30	30	-	100%
	Recognize the barcode printed on an outer sheet of paper with transparent adhesive tape on it	30	30	-	100%

The proposed system for self-borrowing was able to recognize the barcode of only one book and two books together at the same time and performs the borrowing process accurately, efficiently, quickly, and without any problem, and above the barcode appears the process that will take place, whether a borrowing or return process, which the user specified at the beginning of using the system as shown **Figs. 4 and 5.**

Fig 4. The process of borrowing two books together

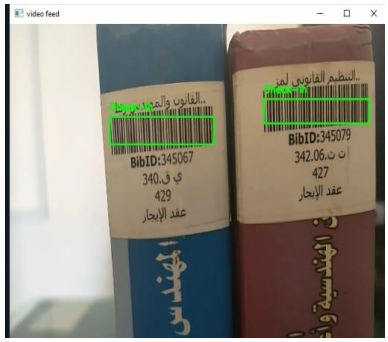


Fig. 5. The process of borrowing one book

The proposed system also allows the process of borrowing/self-returning three books simultaneously without any problem or errors occurring, with the utmost accuracy, speed, and efficiency, which will reflect positively on the efficiency of the borrowing service provided as it will contribute to saving the time of the reader and the library specialist as shown in **Fig. 6.**

Fig. 6 The process of borrowing three books together at the same time

The proposed system can recognize the barcode and perform the borrowing/returning process, whether the book is in a vertical or horizontal position, quickly, accurately, and efficiently, as shown in **Figs. 7 and 8.**

Fig. 7. Capturing a barcode for a book in an upright position

Fig. 8. Picking up a barcode for a book in a horizontal position

The proposed system can recognize any type of barcode, whether one-dimensional or two-dimensional, as it can recognize each type separately or together at the same time efficiently, accurately, and without any errors, as shown in **Fig. 9.**

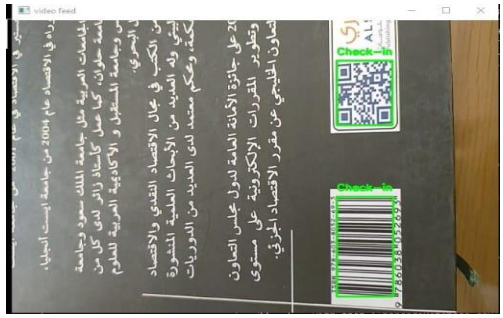


Fig. 9. Capturing one- and two-dimensional barcodes

The system can also capture more than one or two barcodes to perform the self-borrowing process efficiently and accurately at the same time, as shown in **Fig. 10.**

Fig. 10. Capture more than one and two-dimensional barcodes

Through experience, the ability of the system to capture the barcode and perform the self-borrowing process was shown, whether in high or medium lighting and the dark, but by relying on the flash of the mobile phone, as shown in **Figs. 11, 12 and 13.**

Fig. 11. Capture the barcode in the dark using the mobile flash

Fig. 12. Capture the barcode in medium light

Fig. 13. Capture the barcode in high light

The ability of the proposed system to recognize the barcode crossed out or written on it was tested, and it showed its ability to read the barcode with high accuracy and speed, whether it was written on it in pencil, pen, or colors, and this makes the proposed system more accurate and more capable of dealing with any barcode, even if it is written It is as shown in **Fig. 14, 15 and 16.**

Fig. 14. A barcode is written on it in color

Fig. 15. Barcode written on it in pencil

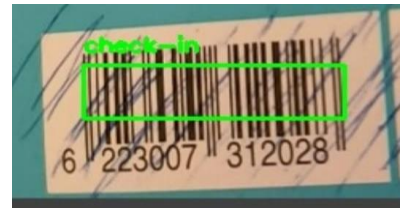


Fig. 16. A barcode written on it with a pen

Through experience, the accuracy and efficiency of the system were also shown in capturing the one-dimensional and two-dimensional barcodes and performing the self-borrowing process in dim light or the dark, but by relying on the mobile flash, even if the barcode was distorted by the pen, colors, or both, as these writings did not affect the ability of the system to read Capturing the barcode and performing the borrowing process, and this indicates the accuracy of the system used as shown in the following **Fig. 17.**

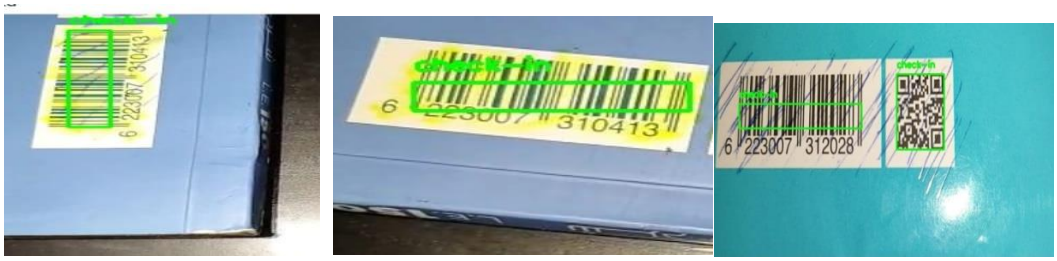


Fig. 17. Capturing a distorted one-dimensional and two-dimensional barcode in the dark with a pen and colors using the mobile flash

The proposed system was able to recognize the barcode while it was wet quickly and efficiently, and this indicates the accuracy of the proposed system and its ability to read the barcode even if it has a layer of water on it, as shown in the following **Fig. 18 and 19.**

Fig. 18. Capturing a distorted one- and two-dimensional barcode with a pen with a layer of water on it

Fig. 19. Capturing a one- and two-dimensional barcode with a layer of water on it

The proposed system can capture the barcode in all its cases, whether it is printed on the cover of the book or printed on an outer paper with transparent adhesive tape to fix it on the cover of the book. The adhesive tape did not constitute a barrier to capturing the barcode, and this also indicates the efficiency of the proposed system for capturing the barcode and carrying out the borrowing or self-return process. As shown in **Fig. 20 and 21.**

Fig. 20. A barcode printed on an outer sheet and fixed to the book with adhesive tape

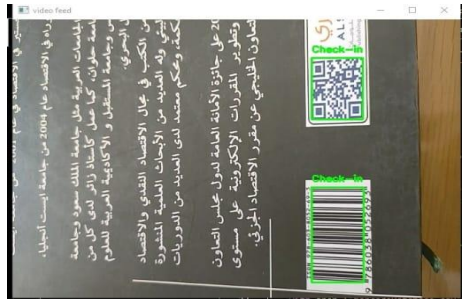
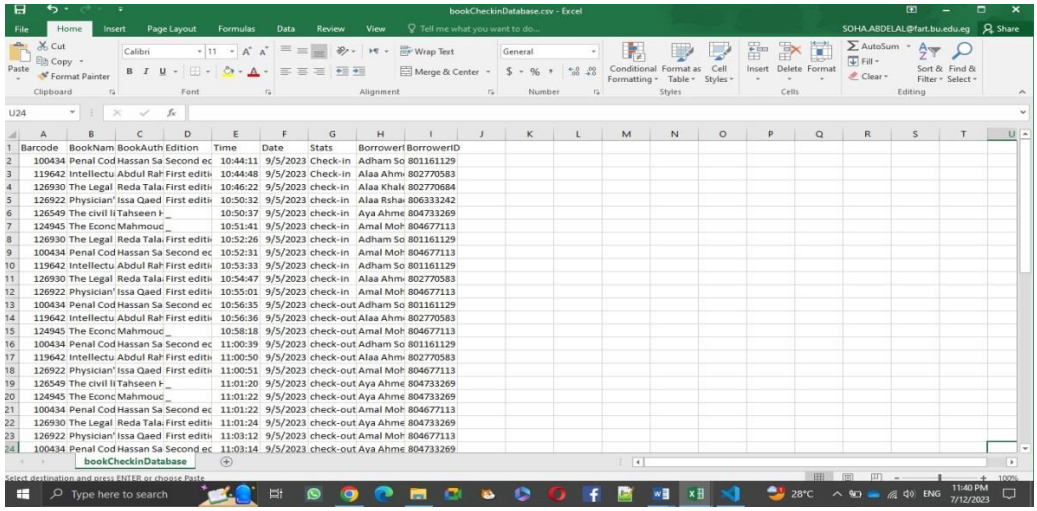


Fig. 21. A barcode printed on the book's cover

The speed of the proposed system was evaluated compared to the automated system used in the library through which the library provides the borrowing service. The borrowing process on the automated system applied in the library took 45 seconds, on the other hand, the borrowing process using the proposed system took 4 seconds, and this reflects the speed of the proposed system, which will greatly contribute to saving time and effort for both the beneficiary and the library specialist.

The process of detecting the barcode and performing the self-borrowing/returning Generates a CSV report for the self-checkout and return process, including the following data: [B-Code] - [Barcode] - [BookName] -

[BookAuthor] - [Edition] - [Time] - [Date] - [Stats] - [BorrowerName] - [BorrowerID] As shown in **Fig. 22.**



Barcode	BookNam	BookAuth	Edition	Time	Date	Stats	BorrowerI	BorrowerID
100434	Penal Cod	Hassan Sa	Second ec	10:44:11	9/5/2023	Check-in	Adham So	801161129
119642	Intellectu	Abdul Rah	First editi	10:44:48	9/5/2023	Check-in	Alaa Ahm	802770583
126930	The Legal	Reda Tala	First editi	10:46:22	9/5/2023	check-in	Alaa Khal	802770684
126922	Physician	Issa Qaed	First editi	10:50:32	9/5/2023	check-in	Alaa Rsha	806333242
126549	The civil li	Tahseen H	_	10:50:37	9/5/2023	check-in	Aya Ahme	804733269
124945	The Econc	Mahmouc	_	10:51:41	9/5/2023	check-in	Amal Moh	804677113
126930	The Legal	Reda Tala	First editi	10:52:26	9/5/2023	check-in	Adham So	801161129
100434	Penal Cod	Hassan Sa	Second ec	10:52:31	9/5/2023	check-in	Amal Moh	804677113
119642	Intellectu	Abdul Rah	First editi	10:53:33	9/5/2023	check-in	Adham So	801161129
126930	The Legal	Reda Tala	First editi	10:54:47	9/5/2023	check-in	Alaa Ahm	802770583
126922	Physician	Issa Qaed	First editi	10:55:01	9/5/2023	check-in	Amal Moh	804677113
100434	Penal Cod	Hassan Sa	Second ec	10:56:35	9/5/2023	check-out	Adham So	801161129
119642	Intellectu	Abdul Rah	First editi	10:56:36	9/5/2023	check-out	Alaa Ahm	802770583
124945	The Econc	Mahmouc	_	10:58:18	9/5/2023	check-out	Amal Moh	804677113
100434	Penal Cod	Hassan Sa	Second ec	11:00:39	9/5/2023	check-out	Adham So	801161129
119642	Intellectu	Abdul Rah	First editi	11:00:50	9/5/2023	check-out	Alaa Ahm	802770583
126922	Physician	Issa Qaed	First editi	11:00:51	9/5/2023	check-out	Amal Moh	804677113
126549	The civil li	Tahseen H	_	11:01:20	9/5/2023	check-out	Aya Ahme	804733269
124945	The Econc	Mahmouc	_	11:01:22	9/5/2023	check-out	Aya Ahme	804733269
100434	Penal Cod	Hassan Sa	Second ec	11:01:22	9/5/2023	check-out	Amal Moh	804677113
126930	The Legal	Reda Tala	First editi	11:01:24	9/5/2023	check-out	Aya Ahme	804733269
126922	Physician	Issa Qaed	First editi	11:03:12	9/5/2023	check-out	Amal Moh	804677113
100434	Penal Cod	Hassan Sa	Second ec	11:03:14	9/5/2023	check-out	Aya Ahme	804733269

Fig. 22. The report generated by check-in/check-out

Discussion:

Library services were affected by the emergence of modern technologies, and libraries were forced to adopt these technologies to provide information services to the satisfaction of users, these technologies may be old technology that are used and adapted in a new and innovative way within the library, This applies to what was done within this study of combining barcode detection technology and machine learning. Artificial intelligence and machine learning can effectively improve the services provided in libraries to students and researchers and influence them positively. This is the way that contributes to encouraging user participation as it provides Accuracy and efficiency **(Hamed, et al., 2022 b),** the system proposed in this paper uses image processing and machine learning technology to detect barcodes and perform the borrowing and self-returning process for library collections. In comparison with other related works **(Karna, et al., 2019) (Zhou, 2019) (Hamed, et al., 2022) (wang, et al., 2023)** the proposed system shows better performance characterized by high accuracy in performing the process of borrowing and self-referral as follows. After testing the proposed system, it was found that the accuracy of the proposed system when capturing the barcode and performing the process of self-borrowing and/or self-returning for one book, two books or three books reached 100%. The accuracy of capturing the barcode and performing the process of self-borrowing and/or self-returning a book in upright or horizontal positions was 100%. The accuracy of capturing the barcode and performing the process of self-borrowing and/or self-returning books in highlight, or medium light was 100%. The system was unable to capture the barcode and carry out the process of self-borrowing and/or self-returning books in

low light without flashing the mobile phone at a rate of 100%. The accuracy of capturing the barcode and performing the process of self-borrowing /self-returning books in low light using the mobile flash was 100%. The accuracy of capturing colored barcodes in the dark by relying on the mobile flash and performing a self-borrowing and/or self-returning process was 100%. The accuracy of capturing a wet barcode with a layer of water on it and performing a self-borrowing/returning process was 100%. The accuracy of capturing a barcode written on it in pencil and performing the self-checkout/return process was 100%. The accuracy of capturing a barcode written on it with a pen and performing a self-borrowing/returning process was 100%. The accuracy of capturing a color-crossed-out barcode and performing a self-borrowing/returning process was 100%. The accuracy of capturing a crossed-out barcode with a pen and a layer of water and performing a self-borrowing/returning process was 100%. The accuracy of capturing a crossed-out barcode with a pen and colors together and performing a self-borrowing/returning process was 100%. The accuracy of capturing the one-dimensional barcode was 100% while the accuracy of capturing the 2D barcode was 100%. The accuracy of capturing the barcode printed on the covers of the book was 100%. The accuracy of capturing the barcode printed on an outer sheet with transparent adhesive tape was 100%. The proposed system is characterized by high accuracy, speed, and reliability in recording the materials in the library, which saves the staff time and effort. The alert system can also notify employees of any delays at exit stations, helping them to intervene quickly. The system's modular design allows for easy integration with existing library systems, without the need for additional hardware.

Conclusion and Future Work:

The proposed system aims to provide high accuracy, high speed, and reliability in checking items in and out of the library. It has the potential to automate the checkout process, saving staff time and effort. An alert system could notify staff of any delays, helping them intervene quickly. The modular design allows the system to integrate easily with existing library systems, requiring no additional hardware. It was found after testing the proposed system that the accuracy of the system when capturing the barcode and performing the process of self-borrowing and/or self-returning for one book, two books, or three books reached 100% under different conditions as explained in the discussion section. The proposed system is characterized by high accuracy, speed, and reliability in recording the materials in the library, which saves the staff time and effort. The alert system can also notify employees of any delays at exit stations, helping them to intervene quickly. The system's modular design allows for easy integration with existing library systems, without the need for additional hardware. Although the proposed system of borrowing and self-referencing is acceptable, it still needs development and improvement to be able to detect more accurately in different circumstances. The proposed system has not been tested to borrow

more than 3 books at one time, nor has it been tested under different characteristics of the camera. Future research to improve the efficiency of the proposed system will be investigated as follows. An integration can be made between the proposed system for detecting barcodes and performing the borrowing process, and the automated system in the library, which includes a database of books in the library and borrower data, and also linking them to a login system using face recognition technology so that each student can log in through face recognition to operate Self-lending and self-returning of books through the existing database without manually writing the data, thus reducing the possibility of errors.

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