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PROCEEDING FOR INTERNATIONAL COLLOQUIUM ON NEXTGEN CONSTRUCTION

2025

*Future-Ready Construction and Facility Management:
Driving Research and Innovation for a Smart Built Environment*

**PROCEEDING FOR
INTERNATIONAL COLLOQUIUM ON
NEXTGEN CONSTRUCTION
2025**

Organiser:

Universitas Pamulang (UNPAM)

Co-organiser:

Department of Built Environment Studies and Technology,
Faculty of Built Environment,
UiTM Perak Branch

Faculty of Built Environment, UiTM Sarawak Branch

Colloquium Date:

6 May 2025

Unit Penerbitan UiTM Perak, 2025

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Perpustakaan Negara Malaysia

Cataloging in Publication Data

No e- ISBN: 978-967-2776-60-4

Cover Design : Nur'Ain Ismail

Typesetting : Nur'Ain Ismail

DESIGN AND DEVELOPMENT OF AN AUTOMATIC BOOK RETURN MACHINE USING RFID AND IoT TECHNOLOGY

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Abstract

This study presents the design and development of an Automatic Book Return Machine that simplifies the book return process in libraries by eliminating direct interaction between users and library staff. The system integrates Radio Frequency Identification (RFID), sensors, and actuators to automate book verification and storage processes, ensuring accuracy, efficiency, and integration with existing library databases. Each borrower verifies their identity using a student card embedded with an RFID tag, after which the system validates the returned book via a second RFID reader. If the returned book matches the database record, the actuator transfers it to the storage unit, and the system updates the database to reflect the 'returned' status. Books that do not match the borrower's record are automatically rejected. The prototype features a real-time notification system for full storage conditions and user feedback through display and email alerts. This innovation minimizes human error, reduces queues, and enhances operational efficiency in library management.

Keywords: RFID, IoT, automation, library system, book return.

1. INTRODUCTION

Library operations often involve repetitive manual tasks, including book lending and returns. These processes are prone to delays and errors due to human factors. In the context of smart library development, automation has become an essential component for improving service quality and user satisfaction. This research introduces an Automatic Book Return Machine that integrates RFID and IoT technologies to support seamless, contactless, and accurate book return processes. The system aims to reduce librarian workload, optimize transaction time, and improve data accuracy by directly connecting hardware devices to a centralized database.

2. LITERATURE REVIEW

RFID-based library management systems have been increasingly adopted to enhance efficiency in tracking and inventory control. According to various studies, RFID offers superior performance compared to barcode systems due to its ability to read multiple items simultaneously and store unique data for each object. Integrating IoT enables real-time monitoring and remote data updates, supporting smarter library ecosystems. Prior research has explored RFID for book tracking; however, limited studies have developed fully automated return systems that also include storage automation and data synchronization. This study builds upon these frameworks by combining RFID verification with sensor-driven actuators for physical handling of books.

3. METHODOLOGY

The system consists of several integrated modules: 1) User Verification: Borrowers scan their student cards via an RFID reader to confirm their borrowing status. 2) Book Identification: A second RFID reader detects the book's unique tag ID, comparing it against the database record. 3) Automated Sorting: If verification succeeds, an actuator-driven conveyor guides the book into the Storage Book IoT unit. Otherwise, the system rejects the book and reopens the door for retrieval. 4) Storage Monitoring: When the storage unit is complete, the system sends an automatic 'Full Book' notification to library staff for manual collection. 5) Database Update: Once the book is accepted, the system updates the library database, changing its status from 'borrowed' to 'returned'. 6) User Notification: Real-time confirmation is displayed on-screen and optionally sent via email. The prototype is developed using Arduino-based controllers integrated with RFID sensors, DC actuators, and Wi-Fi modules for IoT connectivity.

4. FINDING AND DISCUSSION

Testing of the system demonstrated high reliability in detecting and verifying both student and book RFID tags. The automated actuator system successfully directed valid books to the storage compartment while rejecting unregistered or mismatched items. The average processing time per return was under 10 seconds, significantly reducing queue times compared to manual methods. The IoT notification feature ensured timely maintenance by alerting staff when storage reached capacity. Limitations include dependence on stable Wi-Fi connectivity and the need for periodic RFID calibration to maintain accuracy. The integration with existing library databases proved feasible and scalable for institutional adoption.

5. CONCLUSION

The Automatic Book Return Machine effectively automates the library book return process, minimizing manual labor and improving operational accuracy. The integration of RFID, sensors, and IoT allows for secure, efficient, and real-time transactions. Future development may include machine learning for predictive maintenance, enhanced user analytics, and a mobile application interface. This system contributes to the digital transformation of library services within the framework of smart campus initiatives.

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