# Fabrication of Automatic Library Robot

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**Abstract -** The Library Automation Robot is a device used to automate the process of retrieving and putting books within libraries using inexpensive sensors and electromechanical systems. The robot navigates based on predefined black lines with the help of IR sensors and the linear actuator moves to the necessary shelf height with the help of a NEMA17 stepper motor. A gripper is a servo-controlled device that does the holdings of books according to the input of the user, the reasoning being that a user types a book number into the controller and the robot will move to the respective position and lift the actuator to obtain the book. The system deals with the problem which are encountered by librarians, including mis-shelving, manual labor, and time-consuming handling of books. This project illustrates that it is an economical and semi-autonomous project that can be implemented in small educational institutions.

***Key Words***: Line following, Linear actuator, Stepper motor, Servo gripper, Arduino Uno, Book handling.

## 1. INTRODUCTION

Challenges that libraries experience usually include the loss of books, unnecessary manual work, and the tedious procedure of returning the books. The old system relies on human resources in order to arrange shelves, find books, and transverse through various sections. As the academic institutions grow, there is a rising demand of systematic and automated management of libraries. The Library Automation Robot provides a unique solution that incorporates the mechanical automation and the ease of electronic control. The robot moves on a pre-allocated route with the help of IR sensors and retrieves books with the help of a servo-based gripper that is installed on a vertical linear actuator. The stepper motor used is a NEMA17, which serves a lead-screw function to allow the actuator to control the height.

This project is cheap and manual compared to sophisticated SLAM-based library robots, which are costly and difficult to develop, which is why it can operate in small libraries. The system has the following functionality which operates on the command of the user typed in through the serial communication where each book number has a pre-defined height in the shelf. The purpose of this work is to create a working prototype that will be able to prove effective mechanical movement, autonomous navigation, and automated book retrieval,

## 2. LITERATURE SURVEY

**Suthakorn et.al [1], T**he Comprehensive Access to Printed Materials (CAPM) system, developed to solve library space shortages by storing books in off-site facilities and using autonomous mobile robots to retrieve physical books on demand. The robot fetches books from shelving units and sends them to scanning stations. The long-term goal of this project is to provide remote users real-time digital access to printed content via automated retrieval and scanning systems. The system uses modified commercial robotic platforms along with proprietary software.

**Vivek et.al [2],** This focuses on automating the book return process in libraries to address inefficiencies caused by manually restacking books, especially in multi-floor facilities. Traditionally, books are returned to a common drop-off point and then sorted by staff, which is time-consuming. To solve this, the project proposes an autonomous robot capable of returning books to their original locations without human intervention. The system is controlled using Arduino Mega and RFID technology, supported by a CAD-designed, fabricated robotic model. The result is a reduction in book handling time, increased safety, minimized repetitive movement, and lower material handling costs with reduced manpower.

**Alim et.al [3],** Highlights the integration of automation and information technology in modern libraries, focusing on the development of library robots to enhance the efficiency of book management. A key problem addressed is the misplacement of books by users, which hampers accessibility and increases the librarian's workload. To resolve this, the paper proposes an automated mobile robot system that uses RFID technology to identify book titles and the A-Star algorithm to determine the shortest path for placing books back on shelves. The A-Star algorithm efficiently calculates optimal routes within the library, ensuring quick and accurate book return operations. The study confirms that the A-Star algorithm yields reliable and accurate results, making it a suitable method for autonomous navigation in library environments.

**Asemi et.al [4],** This review paper explains the evolution of intelligent libraries, covering AI-based management systems, expert systems, and robotics. It discusses challenges such as cost, training, and infrastructure and proposes future areas where robotics can enhance user services.

**Alshahrani et.al [5],** Their system employed Simultaneous Localization and Mapping (SLAM) and LiDAR technology, which provided high-resolution environmental mapping and accurate localization of the robot within the dynamic space of a library. This enabled the robot to move seamlessly through complex layouts, avoiding obstacles while retrieving and delivering books with a high degree of precision. The study highlighted the system's robust performance in large academic institutions where space and complexity are significant factors. However, the authors also noted critical limitations—primarily the high cost of SLAM and LiDAR sensors, which rendered the solution impractical for small libraries or institutions with limited budgets. Despite the cost barrier, the research set a benchmark for precision and autonomy in robotic library management systems.

**D Mukherjee et.al [6],** They approached library automation from a cost-effective and educational perspective, focusing on a simple robotic design integrated with infrared (IR) sensors and servo motors. Their project emphasized accessibility and ease of deployment, especially for educational institutions and small libraries with limited technical infrastructure. The robot was designed to navigate through predefined paths and perform basic book handling tasks, such as identifying drop-off points and moving books to specific areas. The coding was simplified using platforms like Arduino, making the system easy to implement and maintain by non-experts. However, the robot had limitations in terms of vertical mobility and lacked the ability to grip or place books accurately on multi-level shelves, thus requiring manual intervention for full functionality. Still, the research contributed significantly to developing affordable solutions for library automation and served as a foundational model for future low-cost robotic systems.

## 3. TECHNOLOGY AND HARDWARE IN PROJECT

Fig 1 shows Arduino Uno that serves as the central control unit of the Library Automation Robot. It processes input from sensors, executes movement logic, and controls all actuators such as motors and the gripper. It manages the sequence in which the robot performs tasks, including line-following, actuator motion, and gripping operations. By coordinating all components in real-time, the Arduino ensures smooth operation of the robot.

Fig.1 Arduino Uno

A stepper motor is a type of DC electric motor that divides a full rotation into a number of precise steps. This makes them particularly useful in applications where precise control of position, speed, and rotation is required, such as in 3D printers, CNC machines, robotics, and camera systems. Fig.2 shows Stepper Motor

Fig.2 Stepper Motor

Infrared line-following sensors are used to detect the black path laid on the floor. These sensors continuously monitor surface color and send signals to the Arduino, allowing the robot to stay aligned with the track. This enables accurate navigation between shelf locations and return stations without requiring complex navigation algorithms.Fig.3 shows IR sensor.

Fig.3 IR sensor

The linear actuator is used to move the book gripper vertically to reach different shelf levels. It consists of a lead screw, nut mechanism, and a stepper motor that converts rotary motion into linear movement. When the motor rotates, the lead screw drives the nut upward or downward, allowing precise control over the height position. This ensures smooth lifting and accurate placement of books at various levels without vibration or misalignment.Fig.4 shows linear actuator

Fig.4 Linear Actuator

## 4. RESULTS & DISCUSSIONS

The library automation robot testing stage demonstrated that the individual subsystems have been successfully implemented when tested individually. The line-following system was able to identify the black path accurately and track the robot over the track without much instability. The DC motors were able to react appropriately to control signals and the robot was able to move smoothly on straight and curved tracks. Equally, the stepper motor-driven linear actuator delivered the targeted amount of accurate vertical movement and was capable of reaching the desired height levels without vibration or offset. The gripper with the servo also proved to be very reliable and it gripped and released book-weight objects without any damage.

Nevertheless, performance problems were noticed when all the modules were placed into one Arduino program. The combined code was long and complicated, which led to time wastage, a clash in tasks, and command misuse at times. In other instances, the gripper or actuator did not react in time due to several functions that were competing as far as processor time was concerned. These problems came about as a result of blocking delays, unstructured sequencing and absence of modular programming methods.

The primary weakness was in the software integration as opposed to the hardware design. The mechanical structure and electronics work well but the code has to be refined to enhance reliability. With structuring of the program into functions, non-blocking time services (such as the millis() function rather than delay()) and optimization of sensor reading cycles, a lot of performance can be improved.

Altogether, the findings allow stating that the robot hardware is well-designed and can be used to carry out library automation activities. Through proper software optimization, the system is capable of smooth coordination of the navigation, lifting and gripping operations. The project has managed to prove the possibility of creating a low-cost and usable library automation system based on simple components, and the software development in the future will increase the performance and reliability of systems in real-time greatly.

## 5. DESIGN OF CAD MODEL

The fig.5 CAD model consists of following parts Stepper Motors, Base, Gripper , Actuator, Threaded Rods, Aluminium Extrusion

Fig. 5 CAD Model

## 6. ASSEMBLY OF THE PHYSICAL PROTOTYPE

The fig.6 assembly consists of

**Base:** The base is the main structural part of the robot that supports all components including the actuator, motors, battery, and electronics. It provides mechanical stability and maintains alignment during movement and lifting operations.

**IR Sensors:** IR line-following sensors are mounted at the front bottom of the robot. These sensors detect the black path on the floor and guide the robot's motion along predefined tracks.

**DC Motors and Wheels:** DC gear motors are attached to the base frame and connected to the wheels. They enable the robot to move forward, turn left, and turn right smoothly.

**Linear Actuator:** The linear actuator consists of a stepper motor and lead screw assembly. It is mounted vertically on the frame and provides controlled upward and downward motion to the gripper for accessing different shelf levels.

**Servo Gripper:** The gripper is fixed to the actuator carriage and operated by a servo motor. It grips and releases books safely during pick-and-place actions.

**Arduino Controller Board:** The Arduino Uno acts as the brain of the system. It receives signals from sensors and controls all motors and the actuator according to the programmed logic.

**Motor Drivers:** Motor drivers control the power supply to the DC motors and stepper motor, allowing precise speed and movement control.

**Wiring:** All components are interconnected using insulated wires. Proper wiring ensures reliable signal flow and power distribution.

Fig. 6. Assembly of Project

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**REFERENCES**

[1] Suthakorn J, Lim, R, Srisuchinwong, B, & Tuchinda, R Comprehensive Access to Printed Materials Using Mobile Robots in Libraries, ACM Digital Library / IEEE, Vol. 2, Issue 4, 2010, pp. 145–153.

[2] Vivek, V., Vadivel, E. L., Pradeesh, N., Natarajan, M. C., Pravin, M. C., and Prabhu, S. R., Development of a System to Assist Library to Automate the Book Handling Process, IOP Conference Series: Materials Science and Engineering, Vol. 995, Issue 1, 2020, pp. 1–7.

[3] Alim, H. N., Tamami, N., and Alasiry, A. H., Automated Library System Mobile Robot Using A-Star Algorithm, IEEE International Electronics Symposium, Vol. 1, Issue 3, 2022, pp. 355–360.

[4] Asemi, A., Ko, A., and Nowkarizi, M., Intelligent Libraries: A Review on Expert Systems, Artificial Intelligence, and Robots, Library Hi Tech, Vol. 39, Issue 2, 2021, pp. 412–434.

[5] Alshahrani A, & Rahman, M , Autonomous Library Robot Using SLAM and LiDAR Technology, IEEE Access, Vol. 10, Issue 6, 2022, pp. 24518–24530.

[6] Mukherjee D, & Sinha R A Cost-Effective Library Robot for Academic Use with IR Sensors. International Journal of Educational Technology and Robotics, Vol. 6, Issue 3 , pp. 130–140, 2022.

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