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***Corresponding author:** Nikita Shivaji More, Btech in Electronics and Telecommunication Engineering, Sanjeevan Engineering & Technology Institute, Panhala, DBATU Lonere, Maharashtra, India, E-mail: morenikita16@gmail.com

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Research Article

Intelligent library management system

Nikita Shivaji More*

Btech in Electronics and Telecommunication Engineering, Sanjeevan Engineering & Technology Institute, Panhala, DBATU Lonere, Maharashtra, India

Abstract

A library is a collection of sources of information and similar other resources. The emergence of Intelligent Library Management Systems (ILMS) is a key trend in library automation.

In libraries, the management of the book is a very complicated and time-consuming process. A Library includes books, question papers, newspaper journals, and previous year's project details, etc.

The integration of emerging technologies beyond RFID in academic libraries. The introduction lays the groundwork for exploring innovative solutions such as AI, machine learning, and data analytics, aiming to optimize library services and meet evolving user needs.

This paper mainly deals with the description and evolution of library systems and their disadvantages over centuries in different parts of the world. The source of information in an Institution is a Library. Here Librarian plays a very important role in managing the Library functions such as adding new students, book data, date of issuing and returning the book, and entering all the relevant details of the books, etc. For this, the student has to wait for his /her turn as the Librarian enters data student by student. Thus, it is a very time-consuming process and costly because of high manpower requirements.

An innovative Intelligent Library Management System (ILMS) utilizing AI, GSM, and RFID. Their system aims to streamline library operations and improve user experiences through advanced technology integration. This research showcases the potential of ILMS to modernize library services and meet the demands of the digital era.

This paper mainly focuses on the basic library operation and some added features like viewing total books, viewing available books, updating information, searching books, and a facility to request and return books and some alert systems.

This paper examines the amalgamation of AI, GSM, and RFID for advanced library management systems. Results demonstrate enhanced efficiency and user experience, showcasing the efficacy of this integrated approach.

Our project introduces novel advancements in library management, exemplified by its successful deployment in a real college library. This implementation underscores the worth of our work, offering tangible improvements in efficiency and effectiveness.



Introduction

In recent years, libraries have undergone significant transformations propelled by advancements in technology. Traditional library management systems, once reliant on manual processes, are now being reimagined through the integration of cutting-edge technologies such as Artificial Intelligence (AI), Global System for Mobile communication (GSM), and Radio Frequency Identification (RFID). These technologies offer promising solutions to the challenges faced by libraries in managing their resources, enhancing user experience, and improving operational efficiency [1-5].

RFID

Radio Frequency Identification (RFID) technology has been in use since the 1970s. RFID is a form of automatic contact-less data capturing technique using radio frequency electromagnetic waves.

Overall, RFID-based library management systems offer numerous benefits for both library staff and patrons, including increased efficiency, enhanced security, and improved user experiences. As libraries continue to embrace technological advancements, RFID remains a key tool in modernizing library operations and services [2].

This paper delves into the technical intricacies of employing RFID technology and book spine-matching algorithms to optimize book positioning in libraries [6].

Artificial intelligence

Artificial Intelligence (AI), a term coined by John McCarthy in 1955, was defined as "The Science and Engineering of Making Intelligent Machines."

In the past ten years, under the influence of the new technology revolution, smart libraries have realized the physical space intelligence, service mode intelligence, and management method intelligence of libraries with the help of the Internet of things, big data, cloud computing, RFID technology, artificial intelligence, virtual reality, and other new technologies. At present, the booming artificial intelligence (AI) technology is called the fourth industrial revolution by the industry.

Artificial Intelligence (AI) is a transformative technology reshaping library management practices, offering innovative solutions to enhance efficiency, user experience, and resource allocation. In library settings, AI algorithms analyze vast amounts of data to automate tasks such as cataloging, recommending resources, and predicting user preferences [7].

In libraries, the management of the book is a very complicated and time-consuming process. The location of books could be altered by students, teachers, and anyone around the library. In this proposed method, the librarian has to maintain the database. The users can be able to access their account after showing their ID. After taking the book, if the user does not show the book ID, the user account will be blocked in the main databases. The user can get information about books issued and return dates. If the return date exceeds,

then the fine will be updated automatically in the databases. If the users are misplacing the books, accounts will be blocked. The librarian can only release blocked accounts. The user can get the book without the help of the librarian.

So, allocating the book is not an easy task. So RFID provides a good platform to facilitate indoor positioning. Due to the small width of each book spine, adopting positioning based on RFID alone is not enough to locate the books in a library. We can apply this new method in a library to place certain books. The final results show that the proposed method is highly accurate and robust to the white noise of RFID signals.

This project expounds on the basic situation of smart library and artificial intelligence, analyses the application of artificial intelligence in the field of smart library, and demonstrates the application value of artificial intelligence in library service. Artificial intelligence will be widely used in the development of smart libraries.

Latest uses of AI in different fields

Artificial Intelligence (AI) has permeated various industries, revolutionizing processes and enhancing efficiencies.

In **Healthcare**, AI-powered systems analyze medical data to diagnose diseases, recommend treatments, and predict patient outcomes in real time. For instance, AI algorithms can detect abnormalities in medical images such as X-rays and MRIs, assisting radiologists in diagnosing conditions like cancer with greater accuracy and speed.

In **Finance**, AI-driven algorithms analyze vast amounts of market data to predict stock prices, optimize trading strategies, and manage investment portfolios. High-frequency trading platforms leverage AI to execute trades within microseconds, capitalizing on market trends and generating profits in real time.

Transportation has also benefited from AI technologies, with self-driving cars employing machine learning algorithms to navigate roads, avoid obstacles, and optimize routes in real time. Ride-sharing companies use AI to match drivers with passengers, minimize wait times, and improve overall service efficiency.

Furthermore, AI plays a crucial role in **Power Systems**, optimizing energy distribution, predicting demand, and enhancing grid stability. Smart grids equipped with AI algorithms can dynamically adjust energy flow based on real-time data, improving reliability and efficiency while reducing costs for consumers.

Additionally, **AI-powered chatbots** are employed to provide instant assistance and support to library users, improving overall user experience and engagement [8].

AI's role in smart libraries

The focuses on personalized recommendation systems, automated cataloging, and improved resource accessibility through Natural Language Processing (NLP) technologies [5].



Problem definition and relevance

Problem definition: Library staff handle a tedious task involving sorting, lending, returning, tagging, and eyeing books. In addition, library users encounter problems with finding, borrowing, localizing, renewing the borrowing, queuing, and so forth. To overcome these obstacles, this project proposes a smart library management system based on RFID technology. Using low-cost passive tags in libraries reduces the cost of modernization significantly. As such, integrating RFID into the library management system makes both the library users' and staff's tasks easy, smart, convenient, and practical.

This paper highlights inefficiencies in manual library management, including labor-intensive tasks and limited scalability. The need for AI-based library systems arises to automate tasks, improve accuracy, and enhance scalability for streamlined operations and better user experiences [9].

Relevance:

1. The implementation of a catalog system using a microcontroller gives details information about students and books.
2. It will track the idea of how many books are available in the library and books issued to the students.
3. The project is customizable for any library requirement.
4. Registration of books in the library becomes simple.
5. No need for paperwork.
6. Low power consumption.
7. Long life.
8. Highly sensitive

Major challenges and our original achievements

Challenges: Traditional library management systems face daunting challenges, including manual sorting, lending, and tracking of books, alongside user-facing hurdles in finding and borrowing materials. In response, our manuscript introduces the Intelligent Library Management System (ILMS), a groundbreaking solution that integrates RFID and Artificial Intelligence (AI) technologies. While the technical and theoretical aspects of ILMS are robust, it's essential to underscore the major challenges faced by conventional library systems and articulate our original achievements more explicitly.

Conventional library management is burdened with labor-intensive tasks for staff and accessibility issues for users, prompting the need for automation and optimization.

This paper showcases AI-enhanced Library, illustrating transformative changes such as automated cataloging, personalized user experiences, and predictive analytics. In contrast, manual libraries rely on labor-intensive processes, limited personalization, and reactive decision-making,

highlighting the significant advancements AI brings in optimizing library operations and services for the digital age [10].

Original achievements: Our project has been effectively implemented in our college library, showcasing significant enhancements in management practices. Through automation, we've streamlined cataloging, borrowing, and user authentication processes, revolutionizing traditional library operations. This real-world deployment validates the effectiveness of our solution.

Our original achievements lie in the seamless integration of these technologies to create a comprehensive solution that addresses the complex challenges of modern library management. By combining RFID and AI in a unified system, ILMS achieves unprecedented levels of efficiency, accuracy, and user satisfaction, setting a new standard for library management systems.

Furthermore, ILMS leverages RFID technology for efficient book tracking and AI for intelligent decision-making, marking a substantial advancement in library management practices.

The original achievement lies in implementing AI technologies to enhance library services, including personalized recommendations, automated cataloging, and improved user experiences, demonstrating the transformative impact of AI in modernizing library operations [11].

Novelty and worth of this work

The novelty of our work lies in its practical implementation, demonstrating tangible improvements in library management. By automating key processes and integrating seamlessly into existing systems, our solution offers a scalable and efficient approach to modernizing library operations.

Explanation of block diagram

The Block Diagram Figure 1 illustrates the key components and their interactions within the library management system.

AI-driven intelligent library management system, comprising AI algorithms for data analysis, user interaction modules like touch screen terminals, database management servers and RFID readers for resource tracking. This comprehensive diagram delineates the interplay of devices, showcasing how AI technology enhances library operations for optimal user experiences and resource management [12].

The library management system operates as follows:

1. **Power supply:** Provides electrical power to all system components to ensure their proper functioning.
2. **Barcode reader:** Reads barcode information from library materials, enabling quick identification during check-in and check-out processes.
3. **LCD (Liquid Crystal Display):** Displays relevant information such as book details, user instructions, and system status to users and library staff.



BLOCK DIAGRAM:

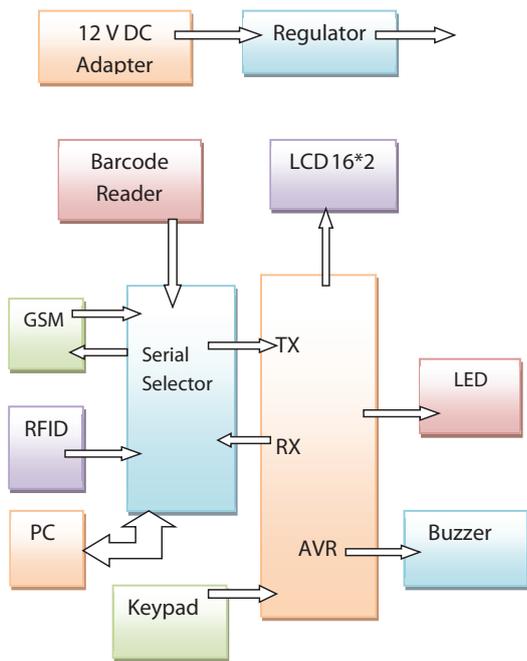


Figure 1: Block Diagram. Image source: Designed by Author.

4. **GSM module:** Facilitates communication between the system and users via text messages, alerts, and notifications. For example, users receive notifications about overdue books or reservation confirmations.
5. **RFID reader:** Reads RFID tags attached to library materials, allowing for efficient inventory management and tracking of book movements within the library.
6. **Serial data detector:** Detects incoming serial data from external devices or sensors, enabling seamless integration with other systems or peripherals.
7. **Microcontroller:** Acts as the central processing unit, coordinating the operation of all system components based on user inputs and sensor data. It executes predefined algorithms and logic to manage library transactions and system behavior.
8. **Keypad:** Allows users to input commands and interact with the system, such as searching for books, registering as library members, or borrowing/returning books.
9. **LED (Light Emitting Diode):** Provides visual feedback to users and library staff, indicating system status, successful transactions, or alerts such as low battery or system errors.
10. **Buzzer:** Produces audible alerts or notifications to attract users' attention or convey important messages, such as overdue book reminders or system malfunctions.

Together, these components work in harmony to create an efficient and user-friendly library management system,

enhancing the overall library experience for both patrons and staff.

Detailed description of each block:

Micro controller (ATmega16): The main block of the system is controller AT mega 16 as depicted in Figure 2. Used to monitor or read all the reader data from the barcode and data from the keypad in digital format. While the book is issuing or submitting events from the barcode and keypad are read and accordingly data managed.

The microcontroller serves as the central component in implementing RFID technology for library accessibility enhancement. It manages RFID readers, processes data from tagged items, and facilitates communication between RFID-enabled library resources and the library management system [13].

Barcode reader: The Barcode reader depicted in Figure 3 is an optical scanner that scans specific code formats generates relative code and sends it to the connected controller or computer via the serial interface. In this project, all the books that are preregistered are scanned for issue and return purposes.

This paper highlights the barcode reader's pivotal role in facilitating AI-driven personalization of library services. It enables efficient identification and tracking of library materials, optimizing user experiences through personalized recommendations and streamlined operational processes [14].

Keypad: The keypad shown in Figure 4 is used to authenticate and register the right person for library facility use. Through the keypad, user identity is entered and the microcontroller will identify the registered user and allow them to scan the required book. If not registered user tries to

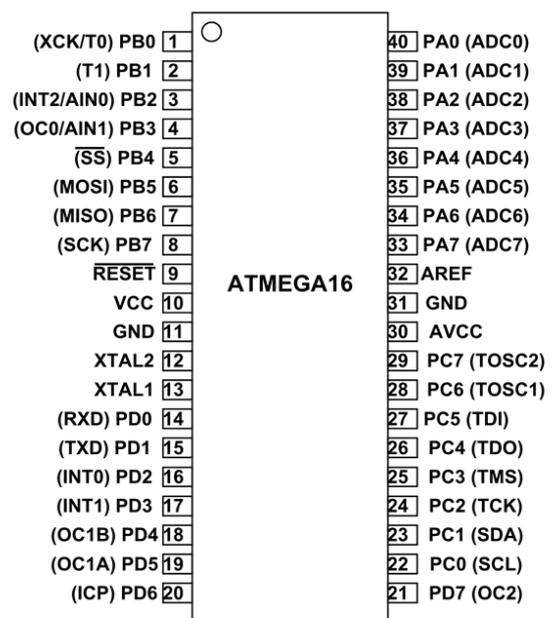


Figure 2: Pinout Diagram of Microcontroller. Image source: Non-copyrighted Google Image.



scan it will alarm to indicate there is something wrong. Figure 5 shows the internal Key Matrix structure of the Keypad.

Serial interface: All the data of books, barcode readers, and users by keypad entry are copies or say mirrors in the PC which is used as a server this is a serial interface. At their user end, this data is reflected through the VB form. The workflow of the Serial Interface is depicted in Figure 6.

Serial interface communication plays a crucial role in various technological applications, enabling the transfer of data between devices in a sequential manner. It encompasses protocols such as UART, SPI, and I2C, offering reliable data transmission over short distances [15].

Buzzer: Every user and book entry operation through the controller is confirmed using a beep signal. Figure 7 shows the Buzzer structure.

LCD: It is an output display device that gives us local operation performed. Figure 8 depicts the detailed pin structure of the LCD.

The main device, featuring a touchscreen interface, allows patrons to conveniently search for books, view catalog information, and check availability without traditional keyboard or mouse inputs [16].

Dropbox: If the library is closed and we want to submit we can submit the book by using Dropbox. To submit the book we

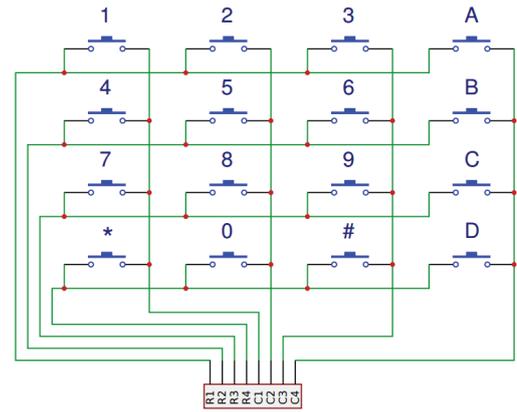


Figure 5: 4*4 Keypad Matrix. Image source: Non-copyrighted Google Image.

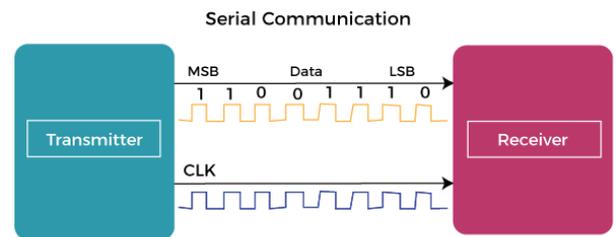


Figure 6: Serial Communication Mechanism. Image source: Non-copyrighted Google Image.



Figure 7: Buzzer & Its Pinout. Image source: Non-copyrighted Google Image.



Figure 3: Barcode Reader. Image source: Non-copyrighted Google Image.

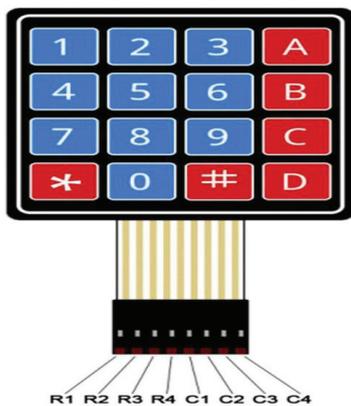


Figure 4: Keypad. Image source: Non-copyrighted Google Image.

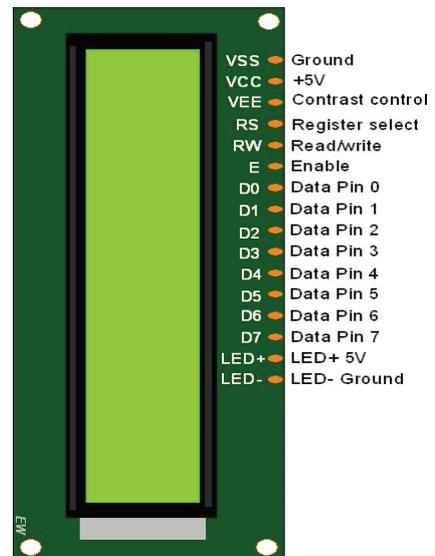


Figure 8: 16*2 LCD Configurations. Image source: Non-copyrighted Google Image.



will scan the barcode of the book in the scanner and input the user ID.

RFID: Radio Frequency Identification (RFID) is a wireless non-contact system that uses radio frequency to transfer data from a tag attached to an object and it is also used for automatic identification and tracking. Figure 9 illustrates the internal Chip structure of RFID. The working of RFID is shown in Figure 10.

At the core of the Wireless Library Book Catalog System lies a central server interfacing with RFID technology. This integration allows for efficient tracking and management of library resources, optimizing cataloging processes and enhancing user accessibility [17].

GSM: Global System for Mobile Communication. It is a wireless modem that works with a GSM wireless network. Dial-up modems send and receive data through radio waves. In order to operate, a GSM modem requires a SIM card from a wireless carrier. GSM modem can be controlled by AT Commands of the PC. GSM frequency range is 900/1800 MHz

This project is completely based on GSM and RFID modules. First, we send the message to the GSM modem. GSM is believed as an efficient and fast enough technique that can perform efficient, real-time object identification and fast reporting. RFID technology facilitates automatic wireless identification using electronic passive and active tags with suitable readers. To improve the library facility automation, we proposed a module that has an RFID reader in addition, to general library software with GSM support. Figure 11 provides the smooth working of the GSM mechanism.

This paper highlights GSM's pivotal role in fortifying library security, serving as the backbone for remote monitoring and control systems. It enables seamless communication between security devices and library personnel, ensuring rapid responses to security threats and enhancing overall safety measures [18].

Software architecture

The books borrowing module is used by the library operator for borrowing books operation. If the borrowing operation is

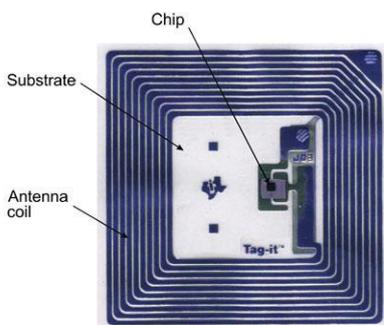


Figure 9: RFID Chip. Image source: Non-copyrighted Google Image.



Figure 10: Process of RFID. Image source: Non-copyrighted Google Image.

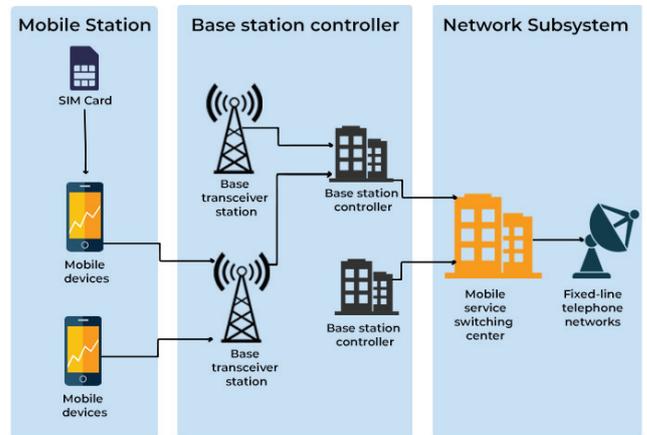


Figure 11: Working of GSM Network. Image source: Non-copyrighted Google Image.

allowed, the module displays the name of each book and its legitimacy for borrowing to the operator. The operator selects the allowed books and changes their status to be borrowed.

Diplomatically this paper navigates the software architecture process, emphasizing its crucial role in leveraging artificial intelligence for enhancing library user experiences. This methodical approach involves careful planning, collaboration, and iteration to design flexible and scalable systems. By integrating AI algorithms seamlessly, the process aims to balance functionality, usability, and efficiency to meet the diverse needs of library patrons while ensuring smooth system operation and maintenance [19].

Figure 12 demonstrates the detailed working of software architecture. Here are the steps for issuing books, returning books, and the book scanning confirmation mechanism:

1. Issuing books:

- The user selects book(s) from the catalog.
- Library staff scans book barcodes or RFID tags.
- The system verifies availability and user eligibility.
- The system updates the database and confirms the transaction.

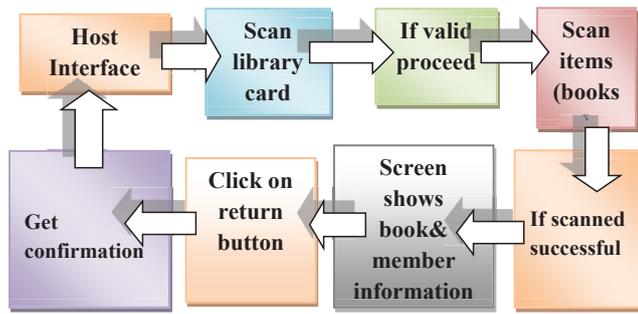


Figure 12: Flow Diagram of System. Image source: Designed by Author.

2. Returning books:

- The user presents borrowed book(s) at the desk.
- Staff scans book barcodes or RFID tags.
- The system updates the database and calculates fines.
- Confirmation of return provided to the user.

3. Book scanning confirmation:

- Staff scans book barcodes or RFID tags.
- The system displays confirmation on the screen.
- Staff verifies information for accuracy.
- An audible or visual signal confirms the transaction.

These streamlined steps ensure efficient book transactions and accurate confirmation in the library system.

This paper explores AI's role in library cataloging, assessing various design strategies to streamline metadata creation and resource organization, ultimately improving usability and accessibility [20].

Algorithm

1. Start the system
2. Initialize microcontroller peripherals & port pin directions
3. Initialize LCD, and GSM by sending appropriate commands
4. Check if the RFID is scanned. If it is scanned, get the student information & display it on a computer screen
5. If the barcode is scanned, display information about the book
6. If Issue the book: store the date & time of issue of the corresponding student
7. If return the book: calculate the days of the book issued for that student & if the late fee, display it on a computer screen

8. Repeat from step 4

9. End

The algorithm integrates AI and GSM technologies to enhance library circulation systems. AI algorithms analyze user borrowing patterns and preferences to optimize resource allocation and recommend relevant materials. Meanwhile, GSM technology facilitates real-time communication, sending notifications to users about overdue items and enabling remote book renewal and reservation [21].

Requirement: Hardware/software

Hardware requirements:

1. ATmega16 Controller
2. Barcode reader
3. Keypad 4*4
4. LCD 16*2
5. Serial interface (USB connector)
6. Serial Selector 74125
7. LED
8. Buzzer
9. Reset circuit
10. Clock Circuit
11. Micro switch
12. Signal conditioning resistor-capacitor
13. Power supply
14. Resistors (330, 470, 1k, 10k)
15. Diode (IN4007)
16. Regulators 7805 (5V), LM317(3.3V)
17. Capacitor 1000mF, 10mF

Software requirements:

1. Circuit Design: NI Multisim Ultiboard
2. Proteus for simulation
3. Atmel Studio for programming of AVR Microcontroller
4. Software: Visual Basic

Advantages:

- The implementation of a catalog system using a microcontroller gives details information about students and books.
- It will track the idea of how many books are available in the library and the books issued to the students.



- The project is customizable for any library requirement.
- Registration of books in the library becomes simple.
- No need for paperwork, all data will be saved on the computer.
- Low power consumption.
- Long life.
- Highly sensitive.

Applications of artificial intelligence in smart library:

- Artificial intelligence covers almost all of the business activities of the Smart Library.
- It can automatically collect and integrate all users' personalized demand information and various types of document resource information through a deep learning mechanism.
- case analysis and systematic review of a large number of domestic and foreign literature and practical applications.

This paper emphasizes the efficiency of AI in library outreach and communication. AI algorithms personalize outreach efforts and chatbots provide instant support, enhancing user engagement and satisfaction [22].

Conclusion

In conclusion, the integration of Artificial Intelligence (AI), Radio Frequency Identification (RFID), and Global System for Mobile communication (GSM) technologies represents a transformative leap forward in library management systems. Through the strategic utilization of these cutting-edge tools, libraries are poised to revolutionize their operations, enhance user experiences, and adapt to the evolving needs of patrons in the digital age.

The synergistic combination of AI's predictive analytics, RFID's efficient inventory management, and GSM's seamless communication capabilities has empowered libraries to streamline processes, optimize resource allocation, and provide personalized services to users. By leveraging the power of intelligent algorithms and data-driven insights, libraries can anticipate user needs, tailor services to individual preferences, and foster a more engaging and enriching learning environment.

Looking forward continued research and innovation in Intelligent Library Management Systems will be essential to unlock their full potential and address emerging challenges. Collaboration between researchers, librarians, and technology developers will drive further advancements, ensuring that libraries remain at the forefront of knowledge dissemination and community engagement.

In essence, the adoption of AI, RFID, and GSM technologies heralds a new era of innovation and possibility for libraries,

enabling them to fulfill their mission of providing equitable access to information, promoting lifelong learning, and enriching the lives of individuals and communities worldwide.

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