STM JOURNALS

International Journal of
Electrical Power and Machine Systems

Volume 2, Issue 2, 2024
July–December
DOI (Journal): 10.37591/IJEPMS

https://journals.stmjournals.com/ijepms

Review IJEPMS

Integration of Raspberry Pi and Arduino for an Intelligent Medicine Dispensing System in Healthcare Facilities

Chinmay Prashant Tawde[1,*], Beena Ballal[2], Makarand Nagvekar[1], Mohammed Ahtesham Shaikh[1], Vaishnavi Phatkare[1]

Abstract

"Automatic Medicine Dispenser Using QR Code" revolutionizes healthcare service delivery by minimizing queue-related inconveniences. Our project created a vending machine using QR code technology in response to the evolving healthcare and technological landscape. The system is powered by an Arduino Mega 2560 and includes key components like a DC gear motor, L298N motor driver, infrared sensor, HC05 Bluetooth module, and a 12 V power supply for drug delivery. The project comprises two teams, each dedicated to software and hardware development. On the software front, one system manages the medicine vending machine (MVM) while the other generates doctor-prescribed QR codes. Hardware components include Arduino Mega 2560, motors, IR sensors, Bluetooth modules, and more, facilitating precise medicine dispensing. Beyond conventional automation, the project tackles medicine unavailability. When prescribed medicine is out of stock, the system promptly notifies the doctor. This real-time communication ensures that patients receive timely care, with doctors offering alternatives or new prescriptions. Challenges encompass handling diverse medicines, suggesting generics, managing inventory, and onboarding doctors. The project embodies a paradigm shift in healthcare, combining efficiency with patient-centric care.

Keywords: Arduino Mega, IoT, vending machines, QR code, smart health technology, wireless sensors, microcontrollers

INTRODUCTION

In response to the changing healthcare and technology landscape, our project developed a vending machine using the QR code technology. The system is powered by an Arduino Mega 2560 with important components, such as a DC gear motor, an L298N motor driver, an infrared sensor, an HC05 Bluetooth module, and a 12 V power supply for drug delivery. The design uses a spring and a motor-mounted wheel to ensure accurate and reliable dispensing. The integration of infrared sensors increases user safety by detecting problems during delivery.

To trigger the automatic dispensing process, users need only scan the QR code associated with the drug. Ensuring public health relies heavily on accessible health care and effective medication management. However, obstacles, such as medication errors, failure to follow prescribed treatments, and insufficient systems in remote or understaffed areas, often impede effective healthcare delivery. Advances in technology provide a practical solution to these challenges by automating the dispensing of medications.

*Author for Correspondence
Chinmay Prashant Tawde
E-mail: chinmay.tawde@vit.edu.in

[1]Student, Department of Electronics and Electrical Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India.
[2]Professor, Department of Electronics and Electrical Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India

Received Date: November 10, 2024
Accepted Date: November 18, 2024
Published Date: November 28, 2024

Citation: Chinmay Prashant Tawde, Beena Ballal, Makarand Nagvekar, Mohammed Ahtesham Shaikh, Vaishnavi Phatkare. Integration of Raspberry Pi and Arduino for an Intelligent Medicine Dispensing System in Healthcare Facilities. International Journal of Electrical Power and Machine Systems. 2024; 2(2): 33–44p.

This study presents the development of a Medicine Dispensing Machine that integrates Raspberry Pi and Arduino controllers. The system takes advantage of the processing power of Raspberry Pi and Arduino's real-time control capabilities to offer a cost-effective and user-friendly approach to automated medication distribution. The key features of the design include precise dispensing, dosage scheduling, user authentication, and remote monitoring [1–11].

Implementing such a system has the potential to minimize human errors, enhance pharmacy efficiency, and promote adherence to prescribed medications, especially in underserved or resource-constrained areas. This paper discusses the design, development, and operation of the system, emphasizing the seamless integration of hardware and software to create a reliable and effective solution.

The Intelligent Medicine Dispensing System (IMDS) represents a significant advancement in the way healthcare facilities manage medication dispensing and administration. By leveraging cutting-edge technologies such as artificial intelligence, robotics, and machine learning, IMDS enhances the efficiency and accuracy of medication distribution, ultimately improving patient safety and care outcomes. These systems are designed to reduce human error, streamline workflows, and ensure that patients receive the correct medications at the right time, thereby decreasing the likelihood of adverse drug events [12–24].

One of the key features of IMDS is its ability to be integrated with electronic health records (EHRs), allowing for real-time updates and tracking of patient medication histories. This integration ensures that healthcare providers have immediate access to critical information about a patient's allergies, current medications, and treatment plans. Additionally, the intelligent algorithms within the system can monitor medication inventory levels, alert staff when supplies are low, and even automatically reorder medications, when necessary, thereby preventing stockouts and ensuring that patients have uninterrupted access to their prescribed therapies.

Furthermore, IMDS improves the patient's experience by enabling more personalized medication regimens. By analyzing data across patient populations, these systems can facilitate adherence programs that remind patients of when to take their medications, provide dosage instructions, and send alerts for follow-up appointments. This level of engagement is essential in chronic disease management, in which adherence to treatment protocols is crucial for maintaining health outcomes. As healthcare moves towards a more patient-centered approach, the IMDS provides a robust solution that not only enhances operational efficiency but also empowers patients to take an active role in their healthcare journey.

The IMDS is transforming the landscape of medication management into healthcare facilities. IMDS is pivotal for enhancing patient safety and health outcomes by improving accuracy, reducing errors, and promoting adherence. As technology continues to evolve, the integration of intelligent medication systems will be crucial in meeting the demands of modern healthcare, ultimately leading to a more efficient, effective, and patient-centered care model [25–36].

The landscape of healthcare is continually evolving, driven by advancements in technology and the relentless pursuit of improved patient outcomes. One of the significant innovations in reshaping industry is the IMDS. These sophisticated systems are designed to streamline medication management, enhance patient safety, and optimize the overall efficiency of healthcare facilities.

Medication errors are a serious concern in healthcare, contributing to adverse patient outcomes and increased healthcare costs. According to the World Health Organization (WHO), medication errors affect one in ten patients worldwide, leading to serious injury or even death. In an era in which patient safety is paramount, the need for a reliable, accurate, and intelligent system for medication dispensing has never been more critical.

An IMDS integrates advanced technologies such as artificial intelligence (AI), machine learning, robotics, and the Internet of Things (IoT) to automate and manage the complex processes involved in

medication dispensing. These systems can be used in various healthcare settings including hospitals, outpatient clinics, and long-term care facilities.

The following are the key features of IMDS:

1. *Automated dispensing:* The IMDS automates the dispensing process, reducing the likelihood of human error associated with manual medication distribution. This automation includes accurate dose measurement and inventory management.
2. *Real-time monitoring:* The system provides real-time monitoring of medication inventory levels, allowing healthcare providers to replenish stocks as needed and avoid shortages or outdated medications.
3. *Patient-specific dosing:* Patients often have unique medication needs based on their medical histories and treatment plans. IMDS can be programmed to tailor medication dispensing to individual patient requirements to ensure personalized care.
4. *Barcode and RFID technology:* Many IMDS utilize barcode scanning and RFID technology to verify medication administration, ensuring that the patient receives the right medication at the right time.
5. *Data analytics:* The collected data can be analyzed to identify trends in medication usage, adherence patterns, and potential areas for improvement in medication management.

Benefits of implementing IMDS:

1. *Enhanced patient safety:* By minimizing human error and ensuring accuracy in medication dispensing, IMDS significantly enhances patient safety. Real-time alerts for potential drug interactions or allergies will further contribute to safer medication processes.
2. *Increased efficiency:* Automation of the dispensing process saves time for healthcare professionals, allowing them to spend more time on patient care. This increased efficiency can lead to enhanced productivity in healthcare facilities.
3. *Improved compliance:* Adherence to medication regimens is crucial for treatment efficacy. With automated reminders and monitoring features, IMDS can help improve patient compliance by ensuring that patients receive prescribed medications.
4. *Cost reduction:* While initial investment in an IMDS may be significant, long-term savings can be substantial. Reduced medication errors, improved inventory management, and enhanced efficiency contribute to lower operational costs.

Healthcare facilities around the globe are beginning to recognize the myriad benefits of IMDSs. For example, hospitals are implementing IMDS at various points of care, from pharmacies to bedside administration. In outpatient settings, clinics have adopted these systems to manage prescriptions efficiently, improving access to necessary medications for patients.

Several organizations have reported notable success in adopting IMDS technology. For instance, a study conducted in a large urban hospital found that implementing IMDS reduced medication errors by nearly 50%. Additionally, patient satisfaction scores regarding medication access and management showed marked improvement [37–42].

As technology continues to evolve, the future of intelligent medicine dispensing systems is bright. Innovations such as AI-driven predictive analytics, integration with EHRs, and enhanced patient engagement are on the horizon. These advancements will further enhance the capabilities of IMDS and solidify their role as indispensable tools in modern healthcare [43, 44].

The Intelligent Medicine Dispensing System is transforming medication management into healthcare facilities. With its emphasis on patient safety, efficiency, and personalized care, IMDS is not just a technological advancement; it is a critical step toward revolutionizing patient care and optimizing healthcare delivery. As more facilities implement these systems, the vision of an error-free, patient-

centered healthcare system becomes more attainable, making IMDS an essential component of the future of medicine.

This report describes the design, implementation, and potential use of our new system for improving medication utilization and clinical efficiency. The goal of the project was to eliminate the long and stressful queues in hospitals and pharmacies. This study focused on the development and implementation of an automated medicine dispensing system that uses a combination of Raspberry Pi and Arduino microcontroller technologies. These open-source platforms offer a low-cost and flexible solution for automating the dispensing of medications. Raspberry Pi acts as the central control hub, managing tasks such as user interaction, system monitoring, and network connectivity. Meanwhile, the Arduino microcontroller handles physical operations, including controlling motors, sensors, and compartments that store medications.

Objective

The main objective of this system is to automate the medication dispensing process in a precise and secure manner, ensuring that patients receive the correct medications and dosages with minimal human involvement. By leveraging the adaptability and functionality of Raspberry Pi and Arduino, this system is scalable, easy to implement, and can be customized for use in various healthcare settings. This paper discusses the design aspects, technical challenges, and potential advantages of deploying such a system in real-world healthcare environments, with an emphasis on improving the safety and efficiency of the medication dispensing process. The layout of the system is illustrated in Figure 1.

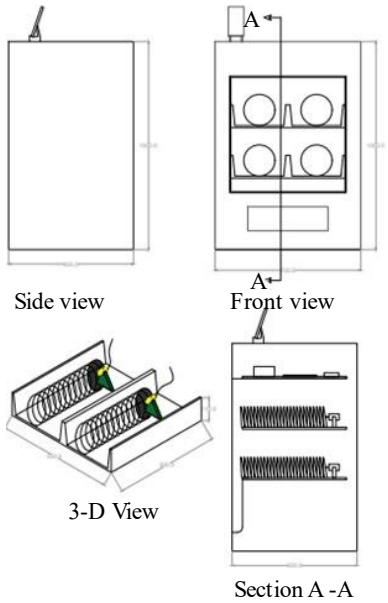
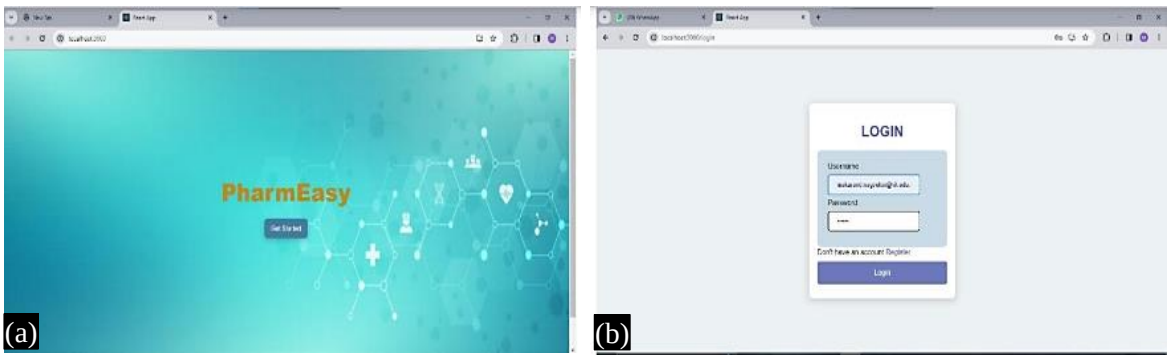


Figure 1. Layout of system.



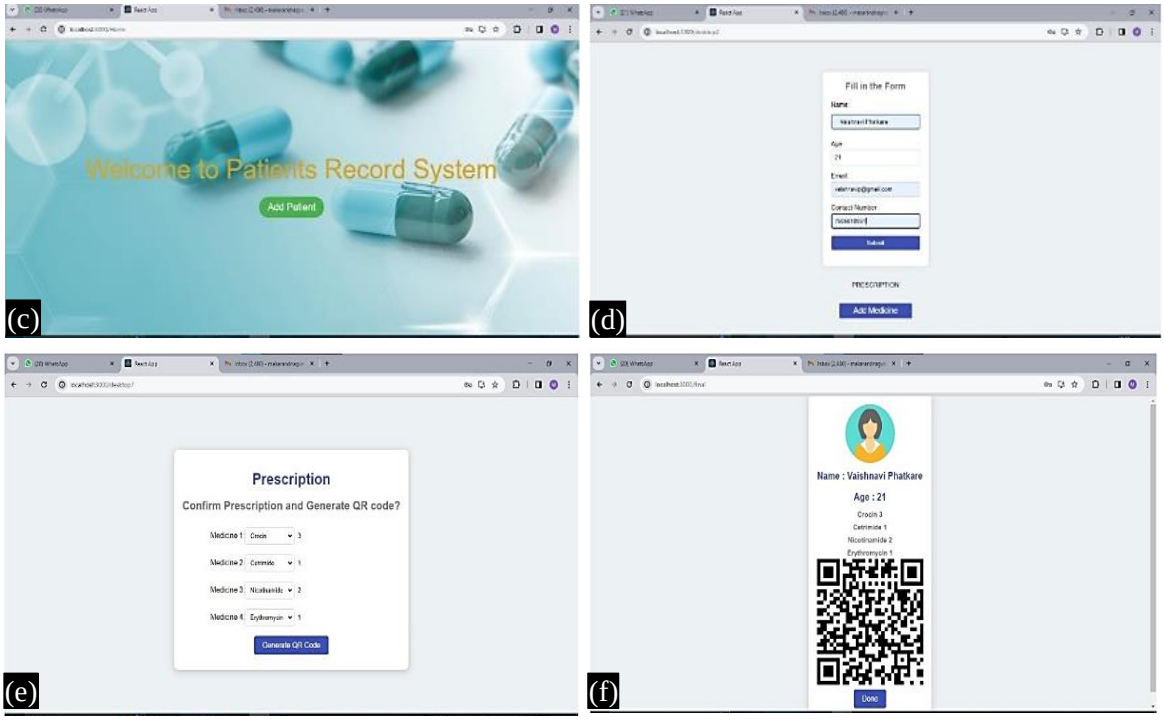


Figure 2. (a)-(f) Software and app implementation.

Implementation of software: Proteus and Firebase software are mainly used in developing automatic dispensing systems. The implementation of app windows is shown in Figures 2(a)–(f), whereas the real-time database window is shown in Figures 3(a) and (b).

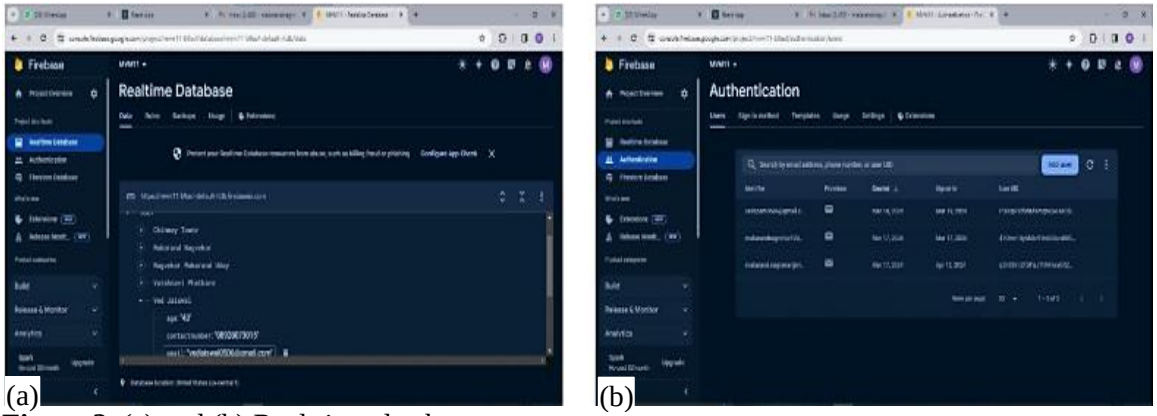


Figure 3. (a) and (b) Real-time database.

Components

1. The *Arduino Mega 2560* is a highly capable and flexible microcontroller board that uses an ATmega2560 chip, as shown in Figure 4. As part of the Arduino family, it is specifically designed for projects that require more I/O pins, larger memory capacity, or greater functionality than smaller boards, such as the Arduino Uno.
   Key features
   - *Microcontroller:* The ATmega2560 offers impressive processing power for handling complex tasks.
   - *I/O Pins:* This board includes 54 digital I/O pins, with 15 capable of generating Pulse Width Modulation (PWM) outputs, and 16 analog input pins, ideal for connecting sensors and gathering data.

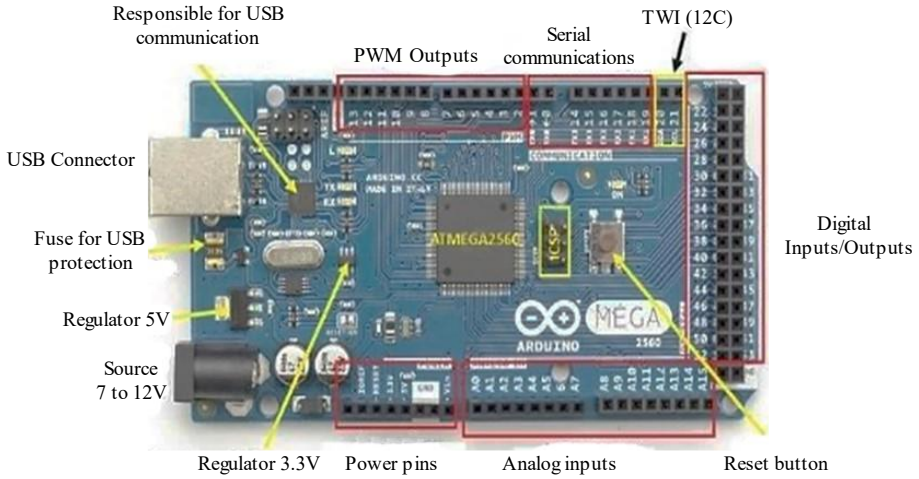


Figure 4. Arduino Mega 2560.

The Arduino Mega 2560 is perfect for projects that need to handle multiple sensors, actuators, or complex calculations, owing to its abundance of I/O pins and memory. Furthermore, the Arduino Integrated Development Environment (IDE) offers a straightforward platform for programming, making it suitable for users of all skill levels from beginners to experts.

Overall, Arduino Mega 2560 is a dependable and easy-to-use option for projects that require more resources than smaller boards.

2. *L298N* as shown in Figure 5. is a widely used motor-driver IC designed to control DC motors, stepper motors, and other inductive loads. It is capable of driving motors in both directions, making it particularly useful for applications that require bidirectional control, such as robotics and automation systems.

   Key features

   - *Dual H-bridge design:* The L298N includes two H-bridge circuits, which allow it to control two DC motors at the same time or one stepper motor. This design enables the motor to rotate in both the forward and reverse directions.
   - *Voltage and current ratings:* The IC operates with a motor supply voltage ranging from 4.5V to 46V and can handle up to 2A of continuous current per channel, making it suitable for medium-power motors.
   - *Motor speed control:* The L298N supports motor speed control through PWM, providing smooth and efficient motor operation.
   - *Protection features:* It comes with built-in safeguards, including thermal shutdown to prevent overheating and overcurrent protection to protect both the IC and the connected motors.
   - *User-friendly:* The L298N module is designed with convenient pins to connect external power supplies, motors, and control signals, making it easy for both beginners and experienced users to work with.

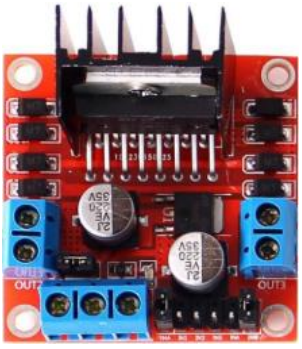


Figure 5. L298N motor driver.

Figure 6. HC-05 Bluetooth.

Overall, L298N is a versatile and reliable motor driver that is suitable for various electronic and robotics projects requiring motor control.

3. *HC-05 Bluetooth* as shown in Figure 6. The module is a widely used and adaptable component that is designed to facilitate wireless communication between microcontrollers and Bluetooth-enabled devices. It is commonly utilized in various electronic projects, particularly for connecting devices such as smartphones, tablets, and computers to microcontrollers such as Arduino, enabling data exchange or remote-control functionalities.
   Key features
   - *Bluetooth version:* HC-05 operates on Bluetooth 2.0, offering stable connectivity for short-range communication, typically up to 100 m.
   - *Master/slave modes:* This module can operate in either the master or slave mode. In the master mode, it can establish connections with other Bluetooth devices, whereas in the slave mode, it waits to accept incoming connections.
   - *Simple communication:* It uses a Universal Asynchronous Receiver-Transmitter (UART) serial interface, making it easy to link with microcontrollers, such as Arduino, for data transmission and reception.
   - *Versatile applications:* HC-05 is useful for various applications including wireless data transfer, remote control of robotic systems, wireless sensor networks, and home automation.
   - *Power requirements:* The module typically runs from 3.3 V to 5 V, ensuring compatibility with most microcontrollers, including Arduino boards.

   Overall, the HC-05 Bluetooth module is favored owing to its flexibility, ease of use, and suitability for numerous wireless communication tasks.

METHODOLOGY

Step 1: Prescription Generation

1. *Doctor Generates Prescription:* The process begins when a doctor generates a prescription for a patient using specialized software. This prescription includes essential patient information, medical instructions, and details of medications required.

Step 2: Prescription QR Code

1. *QR Code Generation:* The software generates a unique QR code based on information within the prescription. A QR code acts as a digital representation of prescriptions.

Step 3: Scanning the Prescription

1. The patient approaches the automatic medicine bending machine (MVM), which is equipped with a scanner and user interface.
2. *QR code scanning:* The patient scans the QR code using the scanning interface of the medicine vending machine (MVM).

Step 4: Data Processing

1. *QR code interpretation:* The MVM software processes the scanned QR code and extracts all the data encoded within it.
2. *Medication identification:* The software identifies the prescribed medications, their quantities, and any specific instructions.

Step 5: Medicine Selection

1. *User interaction:* The user interface of the medicine-vending machine prompts the patient to confirm the selection. The patient verified the list of medications to be dispensed.
2. *Confirmation and dispensing:* Once the patient confirms, the MVM software activates the dispensing process.

Step 6: Dispensing Medications

1. The hardware components of the medicine-ending machine, including motors and sensors, are engaged.
2. *Medication rotation:* The motors rotate a spiral mechanism that holds the medications. Rotation of the spiral dispenses the required medications into the collection area.

Step 7: Medication Collection

1. *Collection point:* The dispensed medications are collected by the patient from a designated collection point within the medicine-vending machine.

Step 8: Completion

1. *Notification:* The MVM software sends a completion notification to the patient and records the transaction.

Step 9: Inventory Management

1. Inventory Tracking: The system updates the inventory of available medications to maintain stock levels.

WORKING

The project workflow begins when a user scans the QR code associated with a specific drug on the vending machine. The QR code triggers the Arduino Mega 2560, which acts as the brain of the system. The Arduino processes information and activates the DC gear motor, controlled by the L298N motor driver, to initiate the dispensing mechanism. A circuit Diagram is shown in Figure 7.

As the motor starts, integrated infrared sensors play a crucial role in ensuring safe and reliable delivery of medication. These sensors constantly monitor the dispensing process and detect anomalies or issues, thereby enhancing user safety. If a problem is detected, the system can halt the process and alert the users or administrators. The dispensing mechanism relies on a spring and a motor-mounted wheel, providing accuracy and reliability in delivering the prescribed medication. The HC05 Bluetooth module facilitates communication and connectivity, allowing for seamless interaction between the user's scanning action and dispensing process. The entire system is powered by a 12V power supply, ensuring sufficient energy to drive the components effectively. The first step in designing a website interface is to create a digital prototype, which is often performed using Figma. Figma enables the translation of concepts into interactive prototypes, allowing the structuring of screens, the addition of design elements, and the simulation of user interactions. For the front-end, essential technologies include HTML for structure, CSS for presentation and layout, and JavaScript for interactivity. This innovative solution aims to streamline medication dispensing, reduce queues, and enhance clinical efficiency for a user-friendly healthcare experience. A flowchart of the information flow is shown in Figure 8.

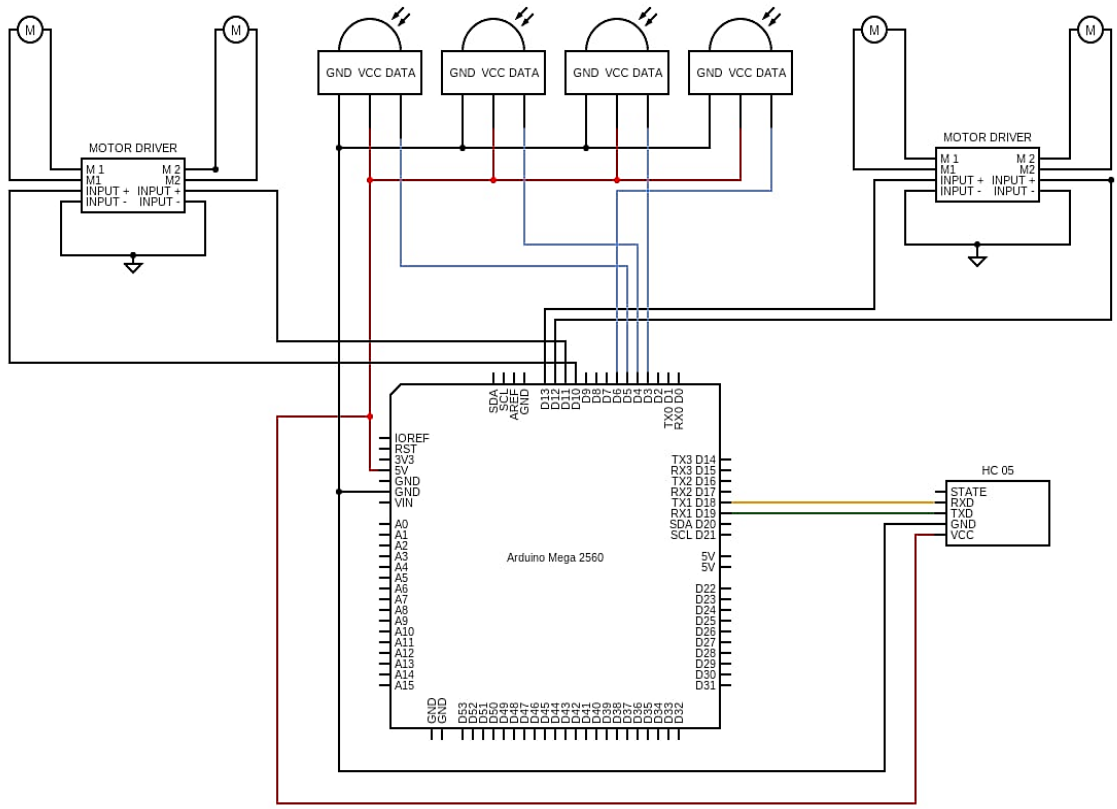


Figure 7. Circuit diagram.

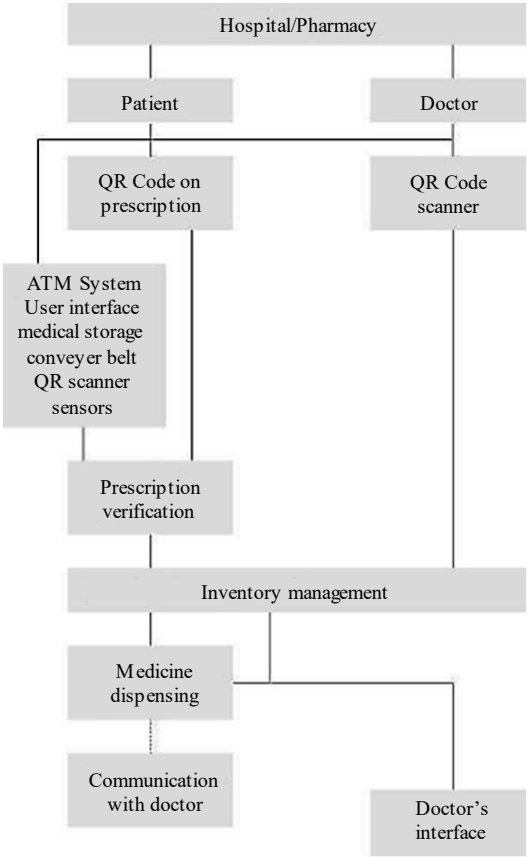


Figure 8. Flowchart of the flow of information.

CONCLUSION

In conclusion, the QR code-enabled medication dispensing system, powered by the Arduino Mega 2560, represents a significant leap forward in healthcare technology. By seamlessly integrating components, such as DC gear motors, L298N motor drivers, infrared sensors, and the HC05 Bluetooth module. It is an efficient and user-friendly solution for alleviating the challenges of long queues in hospitals and pharmacies. The design's reliance on a spring and motor-mounted wheel ensures precise and reliable medication delivery, whereas the integration of infrared sensors enhances user safety by promptly detecting and addressing any issues during the dispensing process.

Drawback

Technical Issues and Reliability: Software or hardware malfunctions can disrupt services. - Network Dependence Requires stable Internet connectivity, which may not be available in all areas. QR Code Scanning Issues: Poor QR code quality or scanner malfunction can prevent dispensing. Security and privacy concerns data reach: Digital prescriptions and personal health information can be vulnerable to hacking. Misuse of Information: Unauthorized access to sensitive patient data; Accessibility Issues: Elderly and Technologically Challenged Users: Some patients might struggle with using QR codes and digital interfaces. Physical Accessibility Machines may not be accessible to disabled individuals.

REFERENCES

1. Anusha M, Chandana J, Harshitha AU, Shruthi TV. Any Time Medicine Vending Machine. Int J Res Appl Sci Eng Technol. 2022;10(7):949–54. DOI: 10.22214/ijraset.2022.45125.
2. Brolin A, Mithun R, Gokulnath V, Harivishanth M. Design of automated medicine vending machine using mechatronics techniques. IOP Conf Ser Mater Sci Eng. 2018;402:012044. DOI: 10.1088/1757-899X/402/1/012044.
3. Karthik BR, Rakshitha P, Ritesh M, Vinutha A, Kavitha KS. 24/7 General Medicine Vending Machine. J Emerg Technol Innov Res. 2020 Oct;7(10):3400-3402.
4. Sivasubramaniyan S, Srivarshini M, Deepthi PS, Janarthanan P. Any time medical assistance and medicine vending machine using machine learning. Int J Adv Res Ideas Innov Technol. 2019;5(2):628-31.
5. Kulmukhanova N, Daribay A, Temirtayev I, Bassembek U. ZhardEM Medicine Vending Machine. 2018 International Conference on Computing and Network Communications (CoCoNet). IEEE; 2018:108-113. DOI: 10.1109/CoCoNet.2018.8476912.
6. Desai P, Pattnaik B, Dey S, Aditya TS, Rajaraman K, Aarthy M. All Time Medicine and Health Device. 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS), Coimbatore, India. 2019. pp. 5-9. doi:10.1109/ICACCS.2019.8728306.
7. Kumar MA, Jilani SAK, Sreenivasulu US, Hussain SJ. Automated Color Recognition System for Visually Challenged and Achromatopsia People using Arduino and Mobile App. Int J Adv Res Electron Commun Eng. 2015;4(8):2106–10.
8. Liyakat KKS. Machine Learning Approach Using Artificial Neural Networks to Detect Malicious Nodes in IoT Networks. In: Udgata SK, Sethi S, Gao XZ, editors. Intelligent Systems. ICMIB 2023. Lecture Notes in Networks and Systems, vol 728. Singapore: Springer; 2024. pp. 123–34. DOI: 10.1007/978-981-99-3932-9_12.
9. Pradeepa M, Jamberi K, Sajith S, Bai MR, Prakash A, Kazi KSL. Student health detection using a machine learning approach and IoT. 2022 IEEE 2nd Mysore Sub Section International Conference (MysuruCon), Mysuru, India. 2022. pp. 1-5. DOI: 10.1109/MysuruCon55714.2022.9972445.
10. Liyakat KKS. Detecting malicious nodes in IoT networks using machine learning and artificial neural networks. 2023 International Conference on Emerging Smart Computing and Informatics (ESCI), Pune, India. 2023. pp. 1–5. DOI: 10.1109/ESCI56872.2023.10099544.
11. Kasat K, Shaikh N, Rayabharapu VK, Nayak M, Sayyad Liyakat KK. Implementation and recognition of waste management system with mobility solution in smart cities using Internet of Things. 2023 Second International Conference on Augmented Intelligence and Sustainable Systems (ICAISS), Trichy, India. 2023. pp. 1661–5. DOI: 10.1109/ICAISS58487.2023.10250690.

12. Liyakat KKS. Machine Learning Approach Using Artificial Neural Networks to Detect Malicious Nodes in IoT Networks. In: Udgata SK, Sethi S, Gao XZ, editors. Intelligent Systems. ICMIB 2023. Lecture Notes in Networks and Systems, vol 728. Singapore: Springer; 2024. DOI: 10.1007/978-981-99-4577-1_3.
13. Kazi K. AI-Driven IoT (AIIoT) in Healthcare Monitoring. In: Nguyen TVT, Vo NTM, editors. Using Traditional Design Methods to Enhance AI-Driven Decision Making. Hershey, PA: IGI Global; 2024. pp. 77-101. DOI: 10.4018/979-8-3693-0639-0.ch003.
14. Kazi K. Modelling and simulation of electric vehicle for performance analysis: BEV and HEV electrical vehicle implementation using Simulink for E-mobility ecosystems. In: Kassarwani N, Nagpal N, editors. Hershey, PA: IGI Global; 2024. pp. 295–320. DOI: 10.4018/979-8-3693-2611-4.ch014.
15. Kazi KS. Computer-aided diagnosis in ophthalmology: A technical review of deep learning applications. In: Garcia MB, Almeida RPP, editors. Transformative Approaches to Patient Literacy and Healthcare Innovation. Hershey, PA: IGI Global; 2024. pp. 112–35. DOI: 10.4018/979-8-3693-3661-8.ch006.
16. Liyakat SKK, Magadum PK. Machine learning for predicting wind turbine output power in wind energy conversion systems. Grenze. 2024;10(1):2074-80.
17. Neeraja P, Kumar RG, Kumar MS, Kazi KSL, Vani MS. DL-based somnolence detection for improved driver safety and alertness monitoring. 2024 IEEE International Conference on Computing, Power and Communication Technologies (IC2PCT), Greater Noida, India. 2024. pp. 589–94. pp. 589–94. DOI: 10.1109/IC2PCT60090.2024.10486714.
18. Kamaraj AA, Acharjya DP, editors. Explainable Artificial Intelligence in Healthcare Systems. Computer Science, Technology and Applications Series. Hauppauge, NY: Nova Science Publishers, Incorporated; 2024. DOI: 10.52305/GOMR8163.
19. Liyakat KKS. ChatGPT: An automated teacher's guide to learning. In: Bansal R, Chakir A, Hafaz Ngah A, Rabby F, Jain A, editors. AI Algorithms and ChatGPT for Student Engagement in Online Learning. Hershey, PA: IGI Global; 2024. pp. 1–20. DOI: 10.4018/979-8-3693-4268-8.ch001.
20. Veena C, Sridevi M, Kazi KSL, Saha B, Reddy SR, Shirisha N. HEECCNB: An efficient IoT-cloud architecture for secure patient data transmission and accurate disease prediction in healthcare systems. 7th International Conference on Image Information Processing (ICIIP); Solan, India. 2023. pp. 407–10. DOI: 10.1109/ICIIP61524.2023.10537627.
21. Prasad KR, Karanam SR, Ganesh D, Kazi KSL, Talasila V, Purushotham P. AI in public–private partnership for IT infrastructure development. J High Technol Manag Res. 2024;35:100496. DOI: 10.1016/j.hitech.2024.100496.
22. Kazi KSL. IoT driven by machine learning (MLIoT) for the retail apparel sector. In: Tarnanidis TK, Papachristou E, Karypidis M, Ismyrlis V, editors. Driving Green Marketing in Fashion and Retail. Hershey, PA: IGI Global; 2024. pp. 63–81. DOI: 10.4018/979-8-3693-3049-4.ch004.
23. Kazi KSL. Machine learning (ML)-based braille Lippi characters and numbers detection and announcement system for blind children in learning. In: Sart G, editor. Social Reflections of Human–Computer Interaction in Education, Management, and Economics. Hershey, PA: IGI Global; 2024. pp. 16–39. DOI: 10.4018/979-8-3693-3033-3.ch002.
24. Kazi KSL. Artificial intelligence (AI)-driven IoT (AIIoT)-based agriculture automation. In: Satapathy S, Muduli K, editors. Advanced Computational Methods for Agri-Business Sustainability. Hershey, PA: IGI Global; 2024. pp. 72–94. DOI: 10.4018/979-8-3693-3583-3.ch005.
25. Kutubuddin K. Vehicle Health Monitoring System (VHMS) by employing IoT and sensors. Grenze Int J Eng Technol. 2024;10:5367–74.
26. Kutubuddin K. A novel approach on ML-based palmistry. Grenze Int J Eng Technol. 2024;10:5186–93.
27. Kutubuddin K. IoT-based boiler health monitoring for sugar industries. Grenze Int J Eng Technol. 2024;10:5178–85.
28. Liyakat KKS. Explainable AI in healthcare. In: Kamaraj AA, Acharjya DP, editors. Explainable Artificial Intelligence in Healthcare Systems. Computer Science, Technology and Applications Series. Hauppauge, NY: Nova Science Publishers, Incorporated; 2024. pp. 271–84.

29. Kazi KSL. Machine learning-based pomegranate disease detection and treatment. In: Revolutionizing Pest Management for Sustainable Agriculture (edited by M. Zia Ul Haq & I. Ali). Hershey, PA: IGI Global; pp. 469–98. DOI: 10.4018/979-8-3693-3061-6.ch019.
30. Kazi KSL. IoT Technologies for the Intelligent Dairy Industry: A New Challenge. In: Designing Sustainable Internet of Things Solutions for Smart Industries (edited by S. G. Thandekkattu & N. R. Vajjhala). Hershey, PA: IGI Global; pp. 321–50. DOI: 10.4018/979-8-3693-5498-8.ch012.
31. Kazi KSL, Mahant MA. Machine Learning-Driven Internet of Things (MLIoT)-Based Healthcare Monitoring System. In: Digitalization and the Transformation of the Healthcare Sector (edited by N. Wickramasinghe). Hershey, PA: IGI Global; pp. 205–36. DOI: 10.4018/979-8-3693-9641-4.ch007.
32. Sayyad K, Kazi LK. Machine learning-driven Internet of Medical Things (ML-IoMT)-based healthcare monitoring system. In: Soufiene BO, Chakraborty C, editors. Responsible AI for Digital Health and Medical Analytics. Hershey, PA: IGI Global; 2025. p. 38. doi: 10.4018/979-8-3693-6294-5.ch003.
33. Liyakat KKS. Heart Health Monitoring Using IoT and Machine Learning Methods. In: Shaik A, editor. AI-Powered Advances in Pharmacology. Hershey, PA: IGI Global; pp. 257–82. DOI: 10.4018/979-8-3693-3212-2.ch010.
34. Kazi KSL. AI-Powered-IoT (AIIoT)-Based Decision-Making System for BP Patient's Healthcare Monitoring: KSK Approach for BP Patient Healthcare Monitoring. In: Aouadni S, Aouadni I, editors. Recent Theories and Applications for Multi-Criteria Decision-Making. Hershey, PA: IGI Global; pp. 205–38. DOI: 10.4018/979-8-3693-6502-1.ch008.
35. Kazi KSL. AI-Driven-IoT (AIIoT)-Based Decision Making in Drones for Climate Change: KSK Approach. In: Aouadni S, Aouadni I, editors. Recent Theories and Applications for Multi-Criteria Decision-Making. Hershey, PA: IGI Global; pp. 311–40. DOI: 10.4018/979-8-3693-6502-1.ch011.
36. Kazi K. Artificial neural networks for detecting malicious nodes in Internet of Things networks: A machine learning method. In: Pundge A, Pandey B, Tiwari DS. Multidisciplinary approach to cyber physical systems and IoT security. Hershey, PA: IGI Global; 2025. p. 300. doi: 10.4018/979-8-3693-3019-7.
37. Kazi KSL. Machine Learning-Driven Internet of Medical Things (ML-IoMT)-Based Healthcare Monitoring System. In: Soufiene BO, Chakraborty C, editors. Responsible AI for Digital Health and Medical Analytics. Hershey, PA: IGI Global; pp. 49–86. DOI: 10.4018/979-8-3693-6294-5.ch003.
38. Kazi KSL. Transformation of Agriculture Effectuated by Artificial Intelligence-Driven Internet of Things (AIIoT). In: Garwi J, Dzingirai M, Masengu R, editors. Integrating Agriculture, Green Marketing Strategies, and AI. Hershey, PA: IGI Global; pp. 449–84. DOI: 10.4018/979-8-3693-6468-0.ch015.
39. Kazi KSL. AI-Driven-IoT(AIIoT)-Based Decision Making in Kidney Diseases Patient Healthcare Monitoring: KSK Approach for Kidney Monitoring. In: Özgür Polat L, Polat O, editors. AI-Driven Innovation in Healthcare Data Analytics. Hershey, PA: IGI Global; 2024. pp. 277–306. DOI: 10.4018/979-8-3693-7277-7.ch009.
40. Kazi KSL, Mahant MA. Machine Learning-Driven Internet of Things (MLIoT)-Based Healthcare Monitoring System. In: Wickramasinghe N, editor. Digitalization and the Transformation of the Healthcare Sector. Hershey, PA: IGI Global; 2024. pp. 205–36. DOI: 10.4018/979-8-3693-9641-4.ch007.
41. Kazi K. Red Deer algorithm based polycystic ovarian syndrome by using Random forest classifier. In: Mulani A, Cengiz K, Tripathi S, editors. AI, Machine Learning, and IoT for Communication and Medical Applications. Hershey, PA: IGI Global; 2024.
42. Liyakat KKS. Malicious node detection in IoT networks using artificial neural networks: a machine learning approach. In: Singh VK, Sagar AK, Nand P, Astya R, Kaiwartya O, editors. Intelligent networks: techniques and applications. Boca Raton: CRC Press; 2024. doi: 10.1201/9781003541363.
43. Mishra SB. AI-driven-IoT (AIIoT)-based decision making in manufacturing processes in mechanical engineering. J Mech Robot. 2024;9:27–38.
44. Mishra SB. AI-driven-IoT (AIIoT)-based decision-making in molten metal processing. J Indust Mechanics. 2024;9:45–56.

