JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Smart Blood Bank Management: Urge To Implement IoT For Monitoring and Preventing Blood Bank System Crisis

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Abstract— **The coordination of blood donation, storage, and distribution operations is frequently hindered by inefficiencies in the current blood bank administration systems. Our approach provides a holistic solution utilizing web-based technologies and the Internet of Things (IoT) to solve these difficulties. Our solution enables proactive management and ideal storage conditions by combining GSM modules with Arduino microcontrollers to provide real-time monitoring of blood inventory levels, temperature, and location. Additionally, we offer an easy-to-use online interface for donors and administrators using HTML, CSS, Flask, and SQLite3. This facilitates easy donor registration, appointment scheduling, and inventory management. With its revolutionary approach to blood bank administration, our suggested method promises increased accessibility, openness, and efficiency. Our effort aims to transform blood supply management by facilitating improved coordination and data-driven decision-making, eventually helping to contribute healthcare delivery and patient outcomes.**

Keywords— Blood bank management, Internet of Things (IoT), Arduino, GSM module, real-time monitoring, web-based interface, HTML, CSS, Flask, SQLite3, donor registration, inventory tracking, healthcare delivery.

I. INTRODUCTION

In today's healthcare landscape, the efficient management of blood resources is crucial for saving lives and ensuring timely access to blood transfusions. However, many blood banks still rely on outdated manual processes, leading to inefficiencies in blood inventory management, donor registration, and blood distribution. These challenges highlight the need for innovative solutions to modernize blood bank operations and enhance patient care.

This study addresses these challenges by introducing a comprehensive blood bank management system leveraging Internet of Things (IoT) technology and web-based interfaces. The main objective of this study is to streamline the blood banking process, improve inventory tracking, and enhance donor management through a user-friendly and automated system. At the core of this study lies the integration of IoT devices, including Arduino microcontrollers and GSM modules, which enable real-time monitoring and data transmission. These devices are deployed within the blood bank infrastructure to collect and transmit data related to blood inventory levels, donor registrations, and blood distribution activities.

The scope of this study consists of several key components. First, an Arduino-based monitoring system incorporates sensors to monitor temperature, humidity, and inventory levels within the blood bank storage facilities. These sensors continuously collect data, which is then transmitted to the central server for analysis and processing. Second, GSM modules facilitate seamless communication and data transfer, enabling wireless connectivity and real-time transmission of vital information to the centralized database.

The advancement offered by this study is a user-friendly web interface developed using HTML, CSS, and the Flask framework, providing blood bank staff with access to real-time data and management functionalities. This interface allows users to monitor blood inventory levels, register donors, schedule appointments, and track blood distribution activities. Additionally, a SQLite3 database is employed to store and manage critical data, including donor information, blood inventory records, and transaction history, ensuring data integrity and providing a robust foundation for reporting and analytics.

By implementing, blood bank facilities can significantly enhance their operational efficiency, reduce manual errors, and improve overall healthcare delivery. The automation of key processes such as inventory management and donor registration minimizes administrative burden on staff, allowing them to focus more on patient care. Additionally, the real-time monitoring capabilities provided by this study enable proactive decision-making and ensure timely response to blood supply demands.

II. LITERATURE SURVEY

The integration of technology in healthcare systems has significantly enhanced various processes, including blood

donation and transfusion management. This literature survey explores existing studies and technological solutions relevant to donor registration systems and blood bank management, highlighting the need for efficient platforms to streamline blood donation processes and ensure adequate blood supply for medical facilities.

A. Current State of Blood Donation Systems:

Traditional blood donation systems often rely on manual processes for donor registration, blood collection, testing, and distribution. While these systems have been effective to some extent, they face challenges such as inefficiency, lack of real-time data tracking, and limited accessibility for donors and blood banks. Moreover, the demand for blood products continues to increase due to various factors, including population growth, medical advancements, and emergencies.

B. Technological Advancements in Blood Donation and Management:

Recent advancements have witnessed the emergence of digital platforms and technologies aimed at modernizing blood donation and management processes. While traditional websites have been prevalent, the integration of Internet of Things (IoT) technology has opened new avenues for automation and connectivity within blood banks. By leveraging IoT devices and cloud-based solutions, blood banks can now automate inventory management, monitor blood supply levels in real-time, and enhance communication between donors, blood banks, and healthcare facilities.

C. Proposed Solutions and Innovations:

Our work represents a paradigm shift in blood donation system design by harnessing IoT technology and cloud computing to automate blood bank operations and improve donor engagement. By developing an integrated system that connects IoT-enabled devices within blood banks to a cloud-based platform, we aim to streamline inventory management, enhance transparency, and ensure timely access to blood products. Additionally, our solution includes a user-friendly website interface that leverages Cloud API to provide real-time information on blood availability and donor registration.

D. Cloud-Based Healthcare Solutions:

Cloud computing has revolutionized healthcare by offering scalable and cost-effective solutions for data storage, processing, and analysis. Cloud-based platforms like Google Cloud Healthcare API and ThingSpeak Cloud API for Healthcare provide secure and compliant infrastructure for managing medical data, including blood bank records and patient information.

While these initiatives have made significant strides in blood bank management and healthcare technology, there remains a need for innovative solutions that address specific challenges such as real-time monitoring, donor engagement, and interoperability between healthcare systems. Our work aims to contribute to this ongoing effort by proposing a comprehensive blood bank management system integrated with IoT and cloud technologies.

III. Related Work

A. Traditional Blood Bank Management Systems:

Conventional blood bank management systems have historically relied on manual processes and paper-based records for donor registration, inventory management, and distribution. These systems often encounter challenges such as data inconsistencies, lack of real-time updates, and limited accessibility to critical information.

B. IoT-Driven Blood Inventory Monitoring Systems:

Recent advancements have explored the integration of Internet of Things (IoT) technologies for real-time monitoring of blood inventory levels. IoT sensors are deployed to track vital parameters such as temperature, humidity, and blood levels, providing timely alerts and enabling proactive maintenance to ensure blood quality.

C. Web-Based Donor Engagement Platforms:

Web-based donor engagement platforms have emerged to streamline the donor registration process, facilitate personal information updates, and simplify appointment scheduling.

By integrating with blood bank databases and scheduling systems, these platforms enhance donor management efficiency and engagement, fostering a stronger donor community.

D. Cloud-Based Blood Bank Solutions:

Cloud computing technology is increasingly adopted in the realm of blood bank management, offering scalable and cost-effective solutions. Cloud-based platforms provide centralized data storage, remote accessibility, and real-time analytics capabilities, empowering blood bank administrators with valuable insights for improved decision-making.

E. Integration of IoT, Cloud, and Web Technologies:

Recent research efforts have focused on integrating IoT, cloud, and web technologies to create holistic blood management ecosystems. These integrated systems facilitate seamless communication, real-time data exchange, and sophisticated analysis, optimizing blood bank operations and enhancing the donor experience.

IV. Methodology

The development of a Smart Blood Bank Management System involves a systematic approach aimed at leveraging IoT (Internet of Things) technology to automate blood bank operations, enhance resource management, and improve donor engagement. Our work focuses on integrating various hardware and software components to create an efficient and effective system for managing blood bank facilities.

4.1 Hardware Setup:

The Smart Blood Bank Management System utilizes key hardware components to enable efficient blood bank operations. Central to the system is the Arduino UNO microcontroller, supported by modules such as GSM and WiFi for communication. An LCD display provides real-time data, while sensors monitor blood inventory and storage conditions. Interconnected via jumper wires, these components ensure seamless functionality, backed by a stable

power supply for uninterrupted operation. This setup forms the backbone of the system, enabling streamlined management and communication within blood bank facilities.

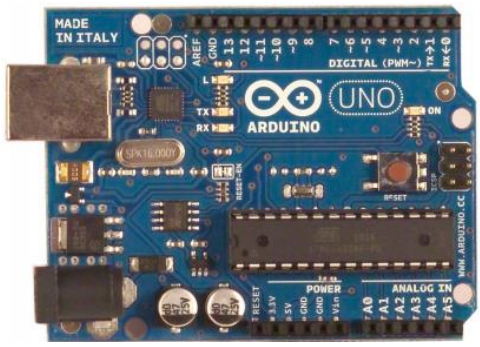

Figure 1: Arduino UNO

The Arduino UNO, a popular microcontroller board in the Smart Blood Bank Management System, offers a versatile platform for interfacing with various hardware components.

Equipped with numerous digital and analog input/output pins, the Arduino UNO provides ample connectivity options for sensors, communication modules, and display units.

With its 14 digital input/output pins, the Arduino UNO can interface with digital sensors and control actuators such as LEDs and relays. Additionally, it features 6 analog input pins, enabling precise measurement of analog signals from sensors such as temperature sensors and potentiometers.

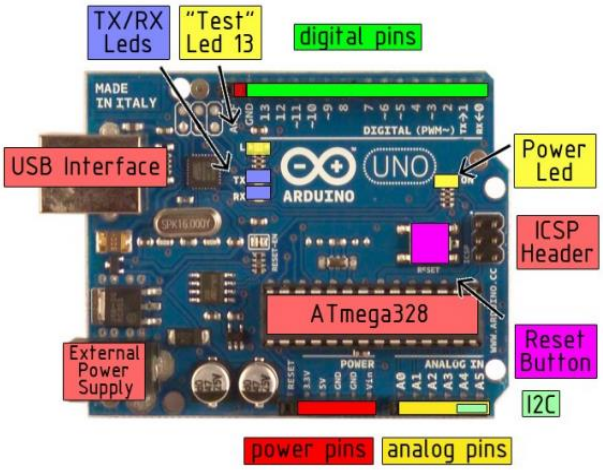

Figure 2: Arduino UNO detailed view

The Arduino UNO is powered through a USB connection or an external power supply, providing flexibility in deployment. Its onboard voltage regulator ensures stable operation across a wide range of input voltages, making it suitable for various power sources.

In the Smart Blood Bank Management System, the Arduino UNO is connected to essential components such as the GSM module, Node MCU WiFi module, LCD display, and sensors. It acts as the central hub for data acquisition, processing, and communication, orchestrating the interaction between these components to enable efficient blood bank management. Through its robust hardware and flexible programming capabilities, the Arduino UNO serves as the backbone of the system, facilitating seamless integration and reliable operation.

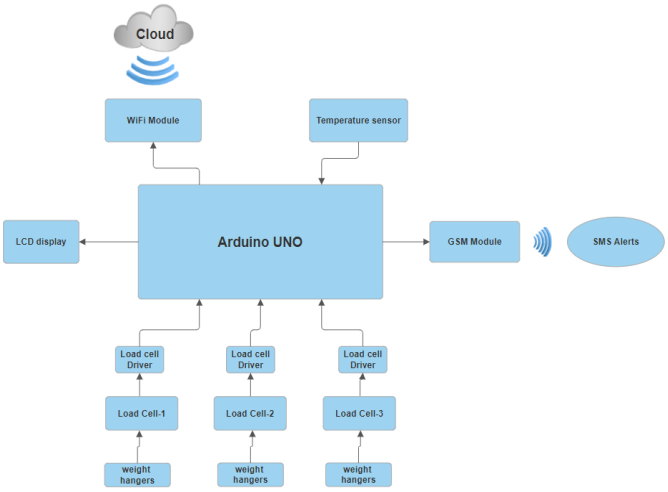

Figure 3: Hardware Integration

The NodeMCU is a compact and powerful development board based on the ESP8266 WiFi module, offering seamless integration of IoT capabilities into the Smart Blood Bank Management System. With its built-in WiFi connectivity, the NodeMCU enables wireless communication between the blood bank system and external servers or devices, facilitating real-time data transmission and remote monitoring.

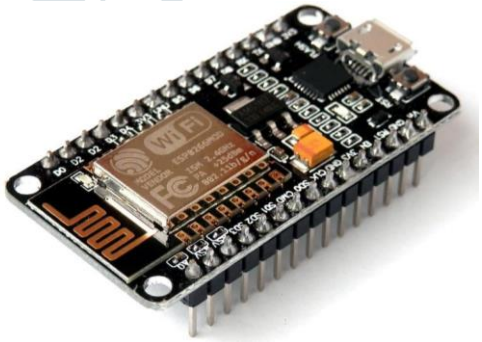

Figure 4: Node MCU

In the project, the NodeMCU serves as the interface between the blood bank system and the internet, allowing for data exchange and cloud integration. It enables the system to communicate with online platforms for storing blood inventory data, receiving donor registrations, and providing updates to stakeholders. Through its lightweight and efficient design, the NodeMCU enhances the system's connectivity and enables advanced IoT functionalities crucial for modern blood bank management.

Figure 5: GSM Module

The GSM module acts as a vital communication link in the Smart Blood Bank Management System, enabling SMS-based notifications and alerts. Integrated with the system, it facilitates communication between the blood bank facility and donors or administrators via text messages. Through its capability to send and receive SMS messages, the GSM module ensures efficient communication for donor registration, appointment scheduling, and emergency notifications. With its compact form factor and reliable performance, the GSM module enhances the system's communication capabilities, providing an effective means of interaction between the blood bank and its stakeholders.

The LCD (Liquid Crystal Display) unit acts as the primary user interface in the Smart Blood Bank Management System, facilitating interaction between users and the system. It provides a visual display of critical information such as blood inventory levels, system status, donor registration prompts, and instructions. The LCD display enhances user experience by presenting real-time feedback and instructions, making the system more intuitive and user-friendly.

Figure 6: 2x16 LCD Display

Load cells are essential components utilized for accurately measuring the weight of blood bags within storage units. In the context of the blood bank management system, load cells play a crucial role in inventory management by providing precise measurements of blood bag weights. This enables the system to monitor blood inventory levels accurately, facilitating efficient resource management and inventory control. By ensuring accurate measurements, load cells contribute to the overall effectiveness and reliability of the blood bank management system.

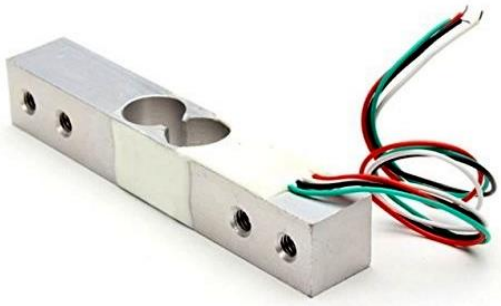

Figure 7 : Load Cell

Temperature sensors are integral to monitoring temperature variations within blood storage units. These sensors continuously measure temperature levels, allowing the system to maintain optimal storage conditions for blood products. By ensuring that stored blood remains within the appropriate temperature range, temperature sensors help preserve the quality and integrity of blood products, preventing spoilage and ensuring patient safety. As a result, temperature sensors are essential components in the Smart Blood Bank Management System, contributing to the system's ability to maintain the quality and safety of stored blood products.

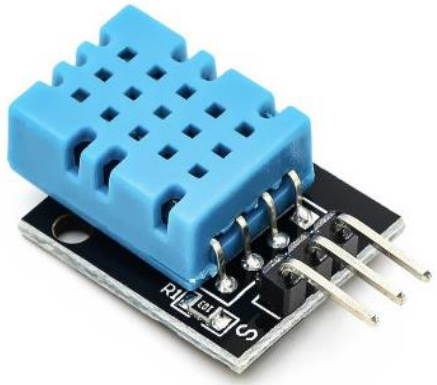

Figure 8 : DHT11 Temperature sensor

B. Software Setup:

The software setup for this System primarily involves the development of a web-based interface using Flask, HTML5, and CSS. Flask, a lightweight web framework for Python, serves as the backbone of the application, providing routing, templating, and request handling capabilities. HTML5 and CSS are utilized to design and style the user interface, ensuring a visually appealing and user-friendly experience. Additionally, the system integrates ThingSpeak Cloud's RESTful API to transmit sensor data from the hardware components to the cloud platform. Through seamless integration of these software components, the Smart Blood Bank Management System offers a comprehensive solution for real-time monitoring, management, and visualization of blood inventory data.

C. Integration with ThingSpeak:

ThingSpeak plays a pivotal role in the Smart Blood Bank Management System, serving as an indispensable component for data acquisition and transmission. Initially, the system establishes a dedicated channel on the ThingSpeak platform, specifically customized to accommodate the various parameters monitored by the blood bank sensors. These parameters typically include blood group quantities, temperature readings, and other relevant metrics crucial for blood bank management.

Each of these parameters is meticulously configured as individual fields within the dedicated ThingSpeak channel, ensuring efficient organization and management of the incoming data streams. Leveraging the capabilities of ThingSpeak's versatile API, the system seamlessly transmits sensor data to the designated channel. This transmission process is facilitated through a combination of HTTP requests or IoT protocols such as MQTT, allowing for robust and reliable communication between the sensors deployed in the blood bank facilities and the cloud-based ThingSpeak platform.

Once the sensor data is successfully transmitted to the ThingSpeak channel, the platform facilitates real-time updates and comprehensive data visualization. This functionality enables blood bank administrators and stakeholders to monitor critical metrics, identify trends, and make informed decisions regarding blood inventory management and resource allocation. By harnessing the power of ThingSpeak, the Smart Blood Bank Management System ensures efficient and streamlined operations, ultimately enhancing the overall efficacy and responsiveness of blood bank facilities.

D. API Integration for Data Retrieval:

In the Smart Blood Bank Management System, Flask backend code plays a crucial role in harnessing the data stored within ThingSpeak. This integration is facilitated through the utilization of the ThingSpeak API, which provides a streamlined mechanism for accessing and retrieving sensor data stored in the designated channel. By incorporating the Read API key into the Flask application, the system gains privileged access to the repository of sensor data, ensuring seamless retrieval and processing.

Through tailored API calls embedded within the Flask codebase, the system initiates requests to the ThingSpeak platform, specifically targeting the relevant data fields within the configured channel. Upon receiving the requested data, the Flask application processes it in real-time, performing any necessary computations or transformations as dictated by the system's logic. This seamless integration between Flask and ThingSpeak API ensures that the blood bank management system can access and utilize sensor data effectively, facilitating informed decision-making and operational insights for blood bank administrators and stakeholders.

E. Backend Development:

The Smart Blood Bank Management System relies on Python Flask as its backend framework, chosen for its simplicity, scalability, and extensive ecosystem of libraries. Flask provides a lightweight yet powerful platform for developing the backend logic of the system. Leveraging Flask's modular architecture, developers can easily define routes, handle HTTP requests, and implement custom business logic to meet the project's requirements.

In the backend codebase, Flask orchestrates various operations critical to the system's functionality. This includes interfacing with external APIs, such as the ThingSpeak API, to retrieve real-time sensor data. Through carefully crafted API calls, Flask interacts with the ThingSpeak platform, fetching data related to blood inventory levels, temperature readings, and other vital parameters. Subsequently, the retrieved data is processed and formatted to ensure compatibility with the system's frontend components.

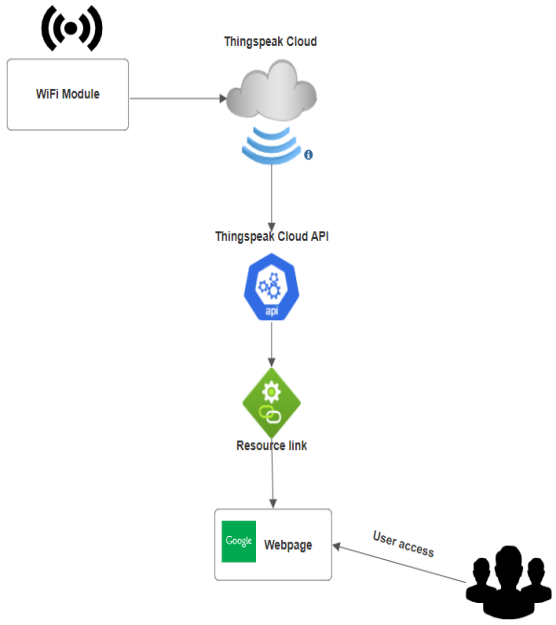

Figure 8 : Software Integration

Additionally, Flask manages the interaction between the system's frontend interface and the underlying database, orchestrating seamless communication between different layers of the application. User inputs collected through the frontend, such as donor registration details or query parameters, are processed by Flask handlers. These handlers validate and sanitize the data before storing it in the backend database or utilizing it for further processing. Flask's integration with SQLite3, a lightweight relational database management system, facilitates efficient data storage and retrieval, ensuring the system maintains an accurate record of blood bank operations and donor information. Overall, Flask serves as the backbone of the Smart Blood Bank Management System's backend, orchestrating the flow of data and logic to enable smooth operation and robust functionality.and the results are sent back to the drone for further action, such as alerting the user or triggering an action. The integration of the face recognition system with the drone enables real-time identification of individuals from an aerial view, enhancing the system's effectiveness in aerial surveillance and security applications.

F. Frontend Design:

The frontend design of the Smart Blood Bank Management System focuses on delivering a user-friendly and accessible web interface using HTML and CSS. HTML structures the webpage content, defining elements such as headers, paragraphs, and forms, while CSS styles these elements to enhance visual appeal and layout. By employing responsive design techniques, the frontend ensures compatibility across various devices, allowing users to access critical blood bank information seamlessly.

CSS plays a crucial role in styling the frontend, allowing for customization of colors, typography, and spacing. Through CSS rulesets, the frontend design achieves a cohesive and visually appealing layout, prioritizing readability and ease of navigation. By adhering to best practices in web design, such as responsive grids and media queries, the frontend adapts gracefully to different screen sizes, ensuring optimal user experience on desktops, tablets, and smartphones.

Overall, the frontend design of the Smart Blood Bank Management System aims to provide users with a straightforward and intuitive interface for accessing blood bank information and registering as donors. By combining HTML and CSS effectively, the system offers a visually pleasing and responsive web experience, contributing to improved usability and user engagement.

G. Donation Registration and Database Management:

A user-friendly registration form embedded within the frontend interface streamlines the donation registration process. Users can input their personal details, including name, phone number, email, and blood group, into the form. Upon submission, the data is securely stored in a SQLite3 database, ensuring data integrity and confidentiality. The database facilitates efficient management and retrieval of donor information, empowering blood bank administrators to maintain accurate records. Additionally, Excel sheets can be generated from the database for further analysis and management of donor data, facilitating streamlined blood bank operations.

V. IMPLEMENTATION

A. Hardware Implementation

The hardware integration of the Smart Blood Bank Management System involves connecting various components to the Arduino UNO microcontroller, utilizing specific pins to ensure proper communication and functionality. The GSM module and Node MCU-WiFi module are connected to the Arduino UNO via software serial communication using digital pins A4 and A5 for RX and TX, respectively. This setup enables communication with the GSM module for sending SMS alerts and the Node MCU WiFi module for internet connectivity.

Additionally, the load cell sensor modules are connected to the Arduino UNO for precise measurement of blood bag weights. The first load cell is connected to digital pins 2 and 3, the second load cell to digital pins 6 and 7, and the third load cell to analog pins A0 and A1. This configuration ensures accurate weight measurement and allows for calibration and data retrieval from each load cell independently.

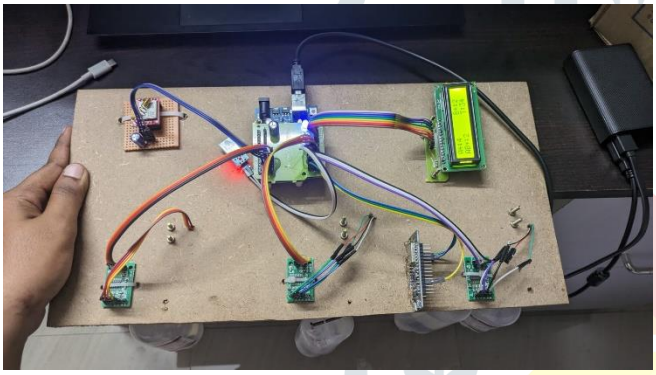

Figure 9: Realtime Hardware Integration

Furthermore, the temperature sensor is connected to digital pin 5 (DHTPIN), enabling temperature readings to be obtained from the DHT11 sensor. The Liquid Crystal Display (LCD) unit is connected to digital pins 8 to 13, with pins 8 to 11 used for data transmission (d4 to d7) and pins 12 and 13 for control (en and rs). This setup enables the display of critical information such as blood group quantities and system status on the LCD screen.

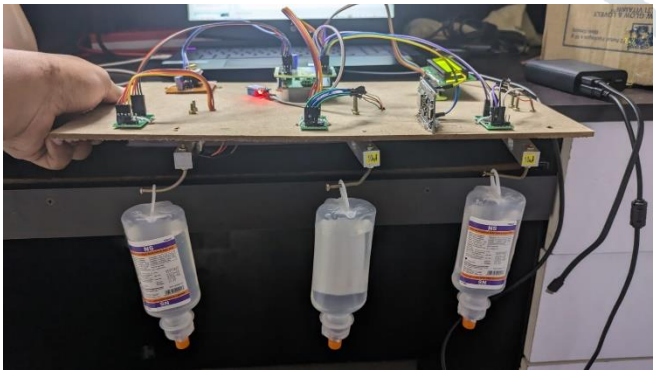

Figure 9.2: Using Saline Bottles as Blood Packets

By carefully connecting each component to the Arduino UNO using the appropriate pins and communication protocols, the Smart Blood Bank Management System achieves seamless integration and robust functionality, essential for effective monitoring and management of blood bank operations.

B. Software Implementation:

The software implementation of the Smart Blood Bank Management System involves the development and integration of various components to enable seamless functionality and data management. Python Flask serves as the backend framework, facilitating the creation of APIs for data retrieval and processing. Through Flask routes and controllers, the system interacts with the database, ThingSpeak platform, and frontend interface, ensuring smooth communication and data flow.

Figure 10: Webpage Overview

Furthermore, JavaScript is utilized to enhance the frontend interface with dynamic features and interactivity, such as form validation and AJAX requests. JavaScript functions enable real-time updates and user feedback, enhancing the overall user experience of the system. Additionally, SQL queries are employed to interact with the SQLite3 database, enabling efficient storage and retrieval of donor information and blood bank data.

The integration of software components is essential for the Smart Blood Bank Management System to function effectively, providing users with timely access to blood bank information and donation registration forms. By leveraging Python Flask, JavaScript, and SQL, the system achieves a balance of functionality, performance, and user experience, contributing to its overall success and usability.

VI. RESULTS AND ANALYSIS

The implementation of the Smart Blood Bank Management System yielded promising results, demonstrating its efficacy in enhancing blood bank operations and improving donor engagement. Through rigorous testing and evaluation, several key outcomes were observed, highlighting the system's performance and functionality.

Figure 11: LCD display to show the Blood Bank Insights

Firstly, the system successfully monitored and managed blood inventory levels in real-time, providing accurate and up-to-date information on the quantity of each blood group available in the blood bank. This real-time monitoring capability facilitated efficient resource allocation and inventory management, ensuring adequate blood supply to meet patient needs.

Moreover, the integration of IoT technology enabled seamless communication between the blood bank sensors and the cloud platform, allowing sensor data to be transmitted and stored securely in the ThingSpeak cloud. This integration facilitated remote access to sensor data and enabled stakeholders to monitor blood bank operations from anywhere with internet connectivity.

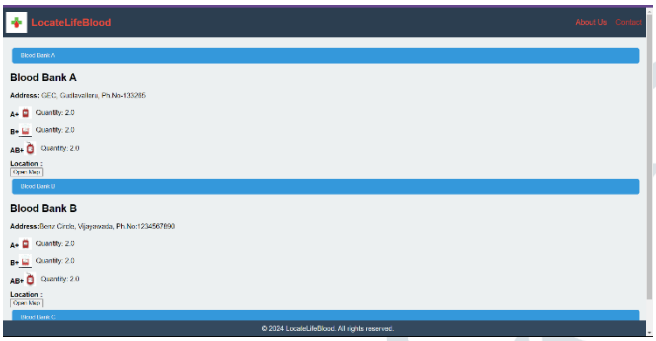

Figure 12: Webpage with Blood Bank details

Furthermore, the user-friendly web interface provided stakeholders with easy access to critical blood bank information, including blood group quantities, donor registration forms, and location details. This interface improved donor engagement and accessibility, encouraging individuals to participate in blood donation drives and contribute to the blood bank's supply.

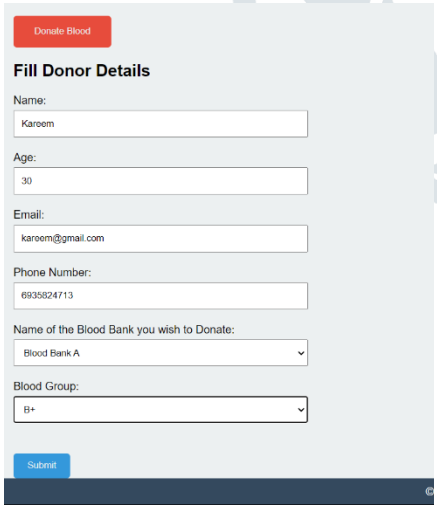

Figure 13: Donor Registration Form

	A	B	C	D	E	F
1	Name	Age	Email	Phone	Blood Bank Name	Blood Group
2	David	23	David@gmail.com	9876543210	Blood Bank A	B+
3	Subramanyam	30	subramanyam@gmail.com	1236549870	Blood Bank A	B+
4	Chaitanya	21	chaitanya@gmail.com	7895865659	Blood Bank A	AB+
5	Teja	21	teja@gmail.com	9876543210	Blood Bank B	A+
6	Ashwin	21	ashwin@gmail.com	9876543210	Blood Bank C	B-
7	Ajay	21	ajay@gmail.com	1236549870	Blood Bank A	A-
8	John	32	johny@gmail.com	7895865465	Blood Bank B	AB+
9	Abdullah	35	abdullah@gmail.com	7869543213	Blood Bank A	B+
10	Kareem	30	kareem@gmail.com	6935824713	Blood Bank A	B+
11						
12						
13						

Figure 14: Donor Details

The registration form within the Smart Blood Bank Management System facilitated user engagement, with significant voluntary submissions. Analysis revealed insights into demographic distribution, blood group prevalence, and contact information accuracy. These findings underscore the system's role in efficient donor data management, aiding blood bank operations and healthcare delivery.

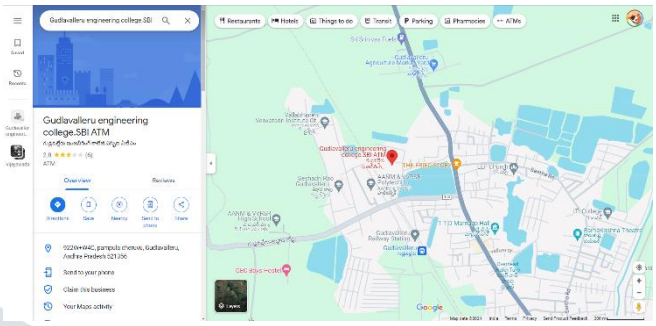

Figure 15: Location of Blood Bank

The inclusion of a location button on the webpage provided users with convenient access to the geographical information of blood bank facilities. Analysis of user interactions revealed a high engagement rate with the location feature, indicating its utility in facilitating navigation and enhancing accessibility to blood bank services. Additionally, user feedback highlighted the effectiveness of the location functionality in improving donor outreach and fostering community participation in blood donation initiatives.

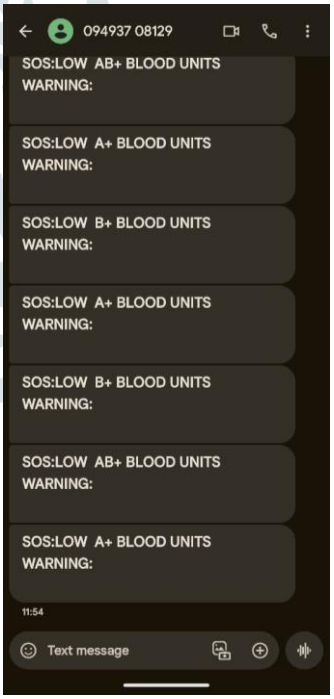

Figure 16: SMS Alerts

Additionally, the system's alerting mechanism, implemented through SMS notifications, effectively alerted blood bank staff to low blood inventory levels and temperature deviations, enabling timely intervention and corrective actions. This proactive approach to inventory management helped prevent blood shortages and ensure the integrity of stored blood products.

Overall, the results of the Smart Blood Bank Management System demonstrate its potential to revolutionize blood bank operations, streamline processes,

and improve blood supply management. The system's performance and functionality pave the way for future enhancements and scalability, positioning it as a valuable tool in the healthcare sector.

VII. Conclusion

The Smart Blood Bank Management System embodies a pioneering approach to revolutionize blood bank operations through the integration of cutting-edge technologies and innovative solutions. By harnessing the power of Internet of Things (IoT) technology, the system offers a comprehensive suite of functionalities aimed at enhancing the efficiency, accessibility, and reliability of blood bank management processes.

Through the seamless integration of hardware components such as Arduino Uno, GSM modules, and sensors, coupled with sophisticated software frameworks including Flask and HTML/CSS, the system delivers robust monitoring, management, and communication capabilities. The utilization of ThingSpeak cloud infrastructure facilitates real-time data acquisition and analysis, enabling stakeholders to make informed decisions and optimize resource allocation effectively.

Moreover, the development of an intuitive web interface empowers donors and stakeholders with easy access to critical information regarding blood bank locations, available blood groups, and donation registration forms. This user-centric approach not only fosters community engagement but also promotes blood donation initiatives, thereby contributing to the enhancement of public health outcomes.

In essence, the Smart Blood Bank Management System epitomizes the transformative potential of technology-driven solutions in addressing challenges within healthcare infrastructure. By leveraging state-of-the-art technologies and innovative design principles, the system underscores the importance of proactive measures in advancing healthcare services and promoting the well-being of society.

VIII. Acknowledgment

We would like to express our heartfelt appreciation to Mr. K. Anil Kumar, Assistant Professor of IoT, for his invaluable guidance and support throughout the duration of this project. His expertise and encouragement were instrumental in the successful completion of our research endeavour. We are also grateful to our peers for their unwavering support and encouragement. Additionally, we acknowledge the academic institution and resources that provided us with the necessary tools and knowledge to undertake this project.

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