Pulse: A Context-Aware Blood Donation and Emergency Response System

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***Abstract*—Blood donation plays a crucial role in saving lives during medical emergencies, yet traditional blood bank systems suffer from inefficiencies such as manual donor discovery, lack of real-time communication, and absence of donor safety enforcement. In emergency scenarios, delays in locating compatible donors during the critical "Golden Hour" significantly impact patient survival.**

This paper presents Pulse, a modern web-based Blood Donation and Emergency Finder System designed to address these limitations. The system integrates a context-aware smart matching algorithm, secure authentication mechanisms, and automated donor safety protocols. Pulse uses a decoupled architecture with React.js frontend and FastAPI backend, ensuring scalability and high performance.

A key innovation of the system is the implementation of a *56-day automated cooldown protocol*, which prevents unsafe repeated donations. Additionally, the platform provides real-time inventory tracking and centralized administrative control. The proposed system improves emergency response time, ensures donor safety, and enhances healthcare logistics efficiency.

Keywords— Blood Donation, Smart Matching, MERN Stack, FastAPI, Healthcare System, Emergency Response

I. INTRODUCTION

A. Background

Blood transfusion is an essential component of modern healthcare systems. Patients suffering from trauma, surgeries, and medical emergencies depend heavily on the availability of compatible blood. However, traditional blood management systems operate as static databases without real-time intelligence.

Most existing systems rely on manual processes such as phone calls and social media messages to locate donors. This leads to delays, especially during emergencies. Furthermore, these systems fail to utilize biological compatibility rules, limiting the efficiency of donor matching.

B. Problem Statement

The major problems identified in current systems include:

- Manual and slow donor discovery
- Lack of real-time data synchronization
- Absence of donor safety mechanisms
- Decentralized and fragmented information

These limitations result in inefficient healthcare delivery and increased risk during emergencies.

C. Objectives

The objectives of the proposed system are:

- Develop an automated blood donor matching system
- Ensure donor safety through cooldown protocols
- Provide real-time inventory management
- Build a scalable and secure web application

II. LITERATURE REVIEW

Existing blood donation systems have evolved from paper-based records to digital platforms. However, most systems still lack automation and intelligence.

Traditional platforms act as passive registries and require manual intervention for donor discovery. Research indicates that these systems fail to utilize blood compatibility matrices effectively.

Recent advancements suggest the use of intelligent algorithms and real-time systems to improve donor matching. However, many existing solutions do not incorporate donor safety measures or centralized control mechanisms.

The proposed system addresses these gaps by integrating smart matching, real-time processing, and automated safety enforcement.

III. SYSTEM OVERVIEW

A. Proposed System

Pulse is a web-based application designed to connect blood donors with patients in real time. It provides a centralized platform for managing blood donation activities.

The system includes:

- Donor registration and authentication
- Emergency blood request generation
- Smart donor matching
- Inventory management
- Admin dashboard

B. System Architecture

The system follows a three-tier architecture:

- Presentation Layer (React.js)
- Application Layer (FastAPI)
- Data Layer (SQLite Database)

This architecture ensures modularity, scalability, and performance.

IV. METHODOLOGY

A. Smart Matching Algorithm

The system uses a context-aware algorithm that considers:

- Blood group compatibility
- Geographic location
- Donor availability status

Unlike traditional systems, it does not rely on exact matches but uses compatibility rules.

B. Authentication Process

Secure authentication is implemented using JSON Web Tokens (JWT). Passwords are encrypted using hashing techniques to ensure security.

C. Cooldown Protocol

A unique feature of the system is the 56-day cooldown mechanism. After a donation, the donor is marked as unavailable and cannot donate again until the recovery period is complete.

V. SYSTEM DESIGN

A. Database Design

The database consists of the following tables:

- Users
- Appointments
- Inventory
- Audit Logs

Relationships between these entities ensure efficient data management.

B. Data Flow

The system follows a structured data flow:

1) User sends request
2) Backend processes request
3) Database interaction occurs
4) Response is returned to frontend

VI. IMPLEMENTATION

A. Frontend

The frontend is built using React.js and TypeScript. It provides a responsive and user-friendly interface.

B. Backend

The backend is developed using FastAPI. It handles business logic, API communication, and authentication.

C. Database

SQLite is used for data storage. SQLAlchemy ORM ensures secure database interactions.

VII. RESULTS AND ANALYSIS

The system was tested under various conditions, and the following observations were made:

- Faster donor matching compared to traditional systems
- Secure and reliable authentication
- Efficient inventory management
- Improved user experience

Feature	Traditional System	Proposed System
Donor Matching	Manual	Automated
Safety Mechanism	None	56-Day Lock
Speed	Slow	Fast
Data Access	Limited	Real-Time

TABLE I
PERFORMANCE COMPARISON

VIII. DISCUSSION

The proposed system significantly improves the efficiency of blood donation processes. It reduces manual effort and enhances decision-making through automation.

However, the system depends on internet connectivity and does not yet include mobile applications or real-time notifications.

IX. FUTURE SCOPE

Future enhancements include:

- Mobile application development
- AI-based donor prediction
- Integration with hospital systems
- Real-time notification services

X. CONCLUSION

The Pulse system provides a modern solution to blood donation management. By integrating smart algorithms, secure authentication, and automated safety mechanisms, it addresses critical challenges in traditional systems.

The system improves emergency response time, ensures donor safety, and enhances overall healthcare efficiency. Future improvements can further expand its capabilities and impact.

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