Center for Management Science Research
ISSN: 3006-5291 3006-5283 Volume 4, Issue 3, 2026

AN ARTIFICIAL INTELLIGENCE BASED BLOOD DONATION SYSTEM USING NATURAL LANGUAGE PROCESSING FOR EMERGENCY BLOOD AVAILABILITY

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DOI: http://doi.org/10.5281/zenodo.21719748

Keywords
Artificial Intelligence, Natural Processing Language, Blood Donation System, Blood groups, Blood banks.

Article History
Received: 07 January 2026
Accepted: 19 February 2026
Published: 17 March 2026

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Abstract
Blood availability during emergencies is a critical challenge, and existing blood donation systems often fail to provide timely assistance. Traditional physical methods require blood seekers to visit blood banks in person, which is time-consuming and risky, particularly when immediate blood transfusion is required or when rare blood groups are needed in large quantities. Online blood donation systems offer an alternative; however, they still involve manual searching, user registration, form filling, and repeated attempts if the required blood is unavailable. These processes increase response time and demand a certain level of digital literacy. In this work, we propose an Artificial Intelligence based blood donation system that improves efficiency and accessibility by using Natural language Processing. Instead of filling out forms, the blood seeker simply sends a text message describing their requirements. The system intelligently extracts key information such as a name, blood group, required quantity, location, and contact number from the message. Based on this extracted data, the system automatically searches nearby blood banks and identifies the best available match. The seeker is then informed promptly, significantly reducing delays. This Artificial Intelligence driven approach ensures faster response, ease of use, and improved support during medical emergencies.

1. INTRODUCTION

Currently, blood donation systems mainly rely on two conventional approaches: physical and online methods. In the physical system, blood seekers must visit blood banks in person to obtain the required blood group and quantity. This process is time consuming and can be critical, especially in emergencies or when a rare blood group is needed in large amounts. The second approach is the online system, where seekers manually search for blood donation services through websites. In this method, the blood seeker is required to register, login and fill out a detailed form. The form typically includes selecting the blood group, entering required quantity, providing a residential address and sharing contact information. After submitting the form, the seeker searches for available blood banks. If the required quantity is not available, the process must be repeated. This

methos not only consumes more time but also requires a certain level of computer literacy.

To overcome these limitations the proposed application leverages Artificial Intelligence (AI) techniques to provide a faster and more efficient solution. The system uses Natural Language Processing (NLP) to understand and extract essential information directly from the seeker's message, similar to how a real human would respond. Key details such as name, blood group, required quantity, location, and contact number are extracted seamlessly. The system then searches for the required blood group from the nearest available blood banks and promptly informs the seeker, significantly reducing response time and improving accessibility.

The research landscape around blood donation systems has been widely explored, with a strong focus on improving traditional methods through the integration of technology. A few research works are given below:

2. Literature Review

A comprehensive solution for effective blood donation and distribution [1] Tanisha Singh discussed the modern architecture of a blood donation management system. Instead of using traditional database management systems, cloud database management system was used to increase scalability. In this way costs were reduced and availability and reliability were enhanced. It also increased the remote accessibility. However, cloud-based database systems [9,10] also present several limitations. These include limited control over the underlying infrastructure, reduced customization in system maintenance, and increase the dependency on the cloud service provider for uptime and data recovery policies. Additionally, long term operational costs may increase with high usage, reliable internet connectivity was required, and network dependency could introduce latency. Concerns related to data privacy due to third party storage and the risk of vendor lock in further highlight the challenges of adopting cloud database.

Design and implementation of an online blood donation system conducted by Tahir Abdul-Gafar [2] in 2024, a system could be designed by adopting software development life cycle. For this purpose, author introduced the agile [6,7,8] methodology to develop online blood donation system. It was a structured and systematic approach to develop the application according to the user requirements. Improved quality of code and application increased the user adoptability. Increased the better testing and reliability. However, this approach required extensive upfront planning and difficulty to handle when requirements were changed. Increased development time due to rigid stages. It was high documentation overhead. The study of e-blood bank application for organizing and ordering the blood donation [3] by Lili Sumaryanti described the e-blood bank application implemented to enable efficient online processing of blood donation data and blood ordering services. The system provided features such as donor management, donation history, online blood ordering, blood type examination processing, transaction handling and real time blood stock monitoring. Traditional methods [11,12,13,14] were used to develop this application. It was costly and was less scalability. More it required more maintenance but provided full control over security policies.

The study smart intelligent web based online blood donation system [4] by Putcha Uma Pratyusha in 2021, stated that blood is essential for life, supporting growth and survival. Emerging technologies enabled complex tasks to be completed quickly and efficiently. An online blood donation system reduced manual work, minimized paperwork and improved monitoring. Traditional web development using database management systems offers full control over infrastructure, customization and security but requires high upfront costs, manual maintenance and limited scalability.

In web based online blood donation system [5] Rohit Kumar presented on online blood donation management system designed to connect donors with individuals in need. The web application allowed registered hospitals to check blood availability and request supplies from nearby blood banks and donors. Blood banks cloud also communicate with other centers when needed. An

android application enabled donors to locate nearby blood banks, track centers via maps and facilitate blood requests efficiently. It was using traditional methods and Application Programming Interface (API) [23,24] for integration with web and mobile applications. In this work, we propose an Artificial Intelligence based blood donation system that improves efficiency and accessibility by using NLP [17,18,19,20,21].

3. Problem Statement

In emergency medical situations, finding the required blood group quickly can save lives. However, existing blood donation systems are slow, manual, and inefficient. Physical visits to blood banks consume valuable time, while online systems require registration, form filling and repeated searches, where delays the process further. These systems also assume that users are digitally skilled and able to navigate complex interfaces. As a result, blood seekers may fail to obtain blood on time, especially in urgent or critical cases. Therefore, there is a need for an intelligent, user-friendly system that can understand human language, automate the search process, and provide rapid blood availability with minimal effort from the seeker.

4. Proposed Methodology

Its web-based application, first our system will receive a text message from user (blood seeker). Users must provide information like this,

- Name
- Blood group
- Required quantity
- Location (optional)
- Phone number

After receiving the message, system will convert all text to lower case, remove unnecessary symbols and do words normalizations. Then apply NER + rule-based patterns to extract name, blood group, required quantity in numbers, location and phone number. If location is not provided system will automatically fetch the real time location of the seeker. Then validate the extracted data. Check if blood group is valid and check if quantity > 0 or not given. Retrieve all blood banks from the database and calculate distance between user location and each blood bank. Sort blood banks by nearest first. Then check blood availability. Start with the nearest blood bank. Check if required blood group is available. If available quantity is greater than or equal to required quantity, then allocate and stop working. If available quantity is less than required quantity, then partial allocate and continue searching. Deduct allocated quantity from each blood bank. Continue searching until required quantity is met or all blood banks are checked. If total required quantity is allocated, then update the status = success. If required quantity is not met, then status = partial or not found and inform the blood seeker.

5. Mathematical model

Let input message is M

$$M = \{w_1 + w_2 + w_3 + w_4 + w_5 \dots \dots w_n\},$$

$$f_{NLP(M)} = (N, B, Q, L, P),$$

where,

- N = username
- B = blood group
- Q = required quantity
- L = location
- P = phone number

Example 1.

$$f_{NLP(M)} = (\text{Umar}, O + ,3, \text{Lahore}, 03331234567)$$

Let there be n blood banks, $BB = \{BB1\ BB2\ , BB3, BB1, \dots . BBn\}$. Each blood bank is defined as, $BB_i = (loci, A_i)$, where loc = location and $A_i(B)$ = available quantity of blood group B.

Distance between user and blood bank, $D_i = d(L, Loc_i)$

Blood banks are sorted such as that, $D_1 \leq D_2 \leq D_3 \dots \dots \dots . . D_n$. Let required quantity = Q

Allocated quantity from blood bank $i = x_i$. Constraint, $0 \leq x_i \leq A_i(B)$.

Total allocation condition, $\sum_{i=1}^{n} = x_i \leq Q$, Remaining Quantity, $R - Q \sum_{i=1}^{n} = x_i$.

Allocation strategy (greedy nearest First),

$X_i = \min(A_i(B), R)$, Update, $R = R - X_i$, Stop when, $R = 0$ or $i = n$,

Update status, $\text{Status} = \begin{cases} \text{Success, if } R = 0 \\ \text{Partial, if } R > 0 \end{cases}$

6. System Design & Implementation

Logical view is shown in the given figure 1 that is given below,



Figure 1. logical flow diagram

First seeker will send message to the system that needs a specific blood group in a desired quantity. System will receive this raw text and send to the NLP engine. NLP engine will convert this raw text into useful information, i.e. structured data. If seeker does not add the location, system will auto fetch his or her current location. Then system will find the blood in desired quantity from nearest blood bank and notify the seeker through sms and call. If seekers need large quantity of blood, then our system will find the blood quantities from the nearest blood banks and notify the seeker and blood bank as well. Complete records would be saved to our database for future references.

NLP process diagram show in the Figure 2, for this system is given below.

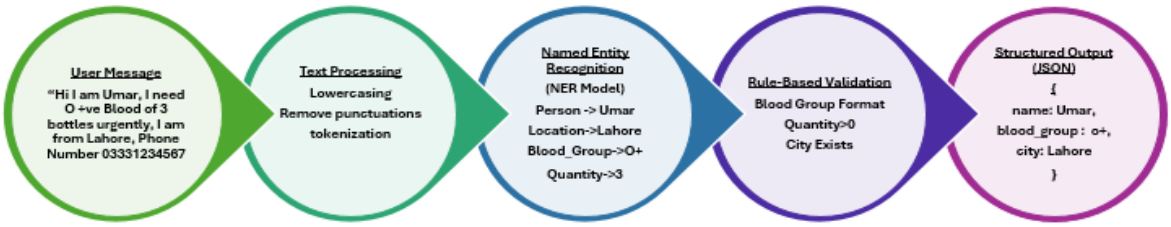


Figure 2. NLP process diagram

In this diagram, we taking an example 1, of blood seeker who wants 3 bottles of $O+ve$ blood group and he belongs to Lahore. NLP engine will take this raw text to do some processing like converting all strings into lower casing, removing punctuations and tokenizing each word. Convert raw text into structured data. Then this data passes to the Named Entity Recognition, where we relate each word to each related entity. Then we apply rule-based validation on each entity and finally we get the structed output in the form of JavaScript Object Notation (JSON).

Blood bank search and allocation process flow diagram is shown in figure 3.

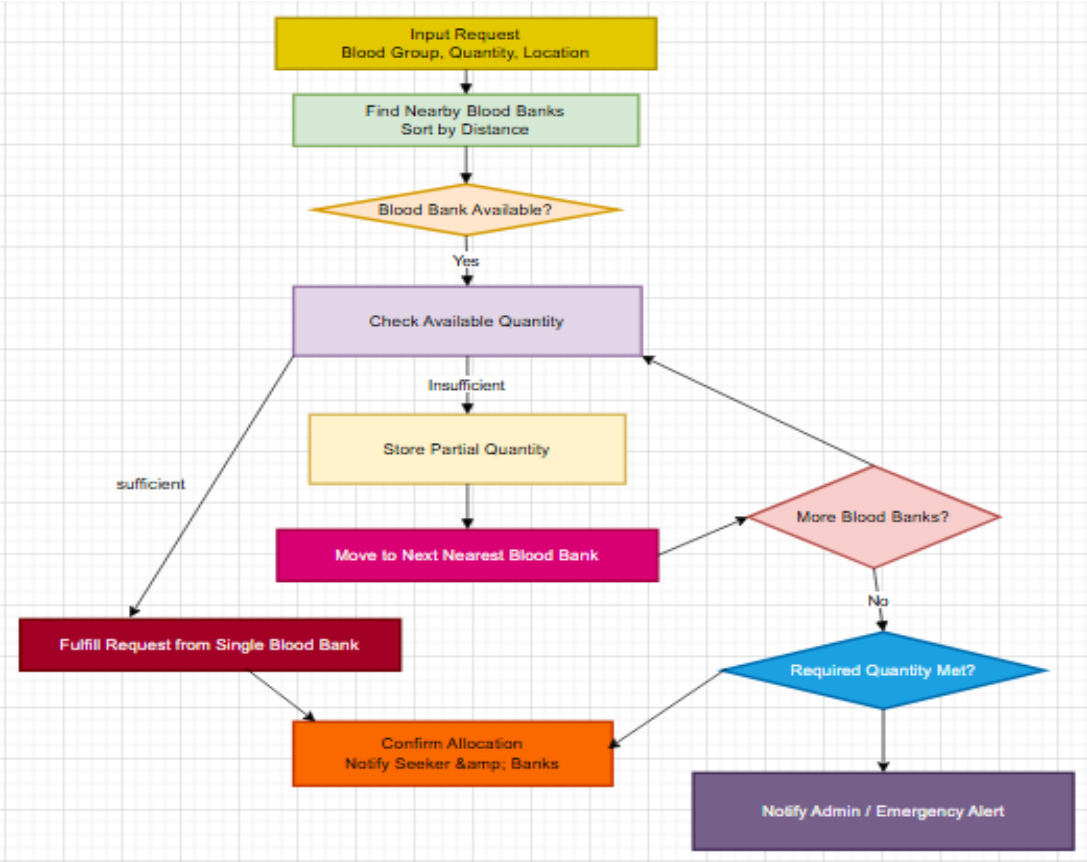


Figure 3: Blood bank search and allocation process flow diagram

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As mentioned in figure 3, first seeker sends requests for blood group along with quantity and location, system will search for the blood group from the nearest blood bank. To do that system will sort the blood banks by distance. Check desired quantity in the blood bank if yes then fulfill the seeker request and notify the seeker and blood bank as well. On the other hand, if blood bank does not have enough quantity, then search again into the nearest bank until reaching the desired blood quantity. If blood group has not been found, then inform the seeker and admin as well to arrange blood group on urgent bases.

To develop this application, we using python flask and MySQL. We aslo using different python libraries for location tracking NLP and blood allocation. Details of libraries and packages are given in table 1.

Table1. List of packages or libraries used in this application

Package / Library	Purpose of usage
Flask	To create the web application and define routes/endpoints
request	To receive incoming user data (text/message) from HTTP requests.
jsonify	To send structured JSON responses to the client.
render_template	To render HTML pages using Jinja templates.
extract_information (nlp_extractor)	To extract name, blood group, location, etc. from user text using NLP.
From flask_simple_geoip import SimpleGeoIP	Server-side location finder by IP

fetch_blood_banks (db)	To retrieve matching blood bank records from the database.
allocate_blood (allocator)	To apply logic for distributing available blood to the requester.
re	To perform pattern matching and text extraction using regular expressions.
spacy	To perform advanced NLP tasks like entity recognition and text parsing.

Table1, is displaying the list of packages and libraries used to develop this web application. To develop this application, we discuss database-first approach. First, we created database in MySQL then connected this database to my flask application. In flask we have used libraries and packages mentioned in table1, to make my application according to the requirements.

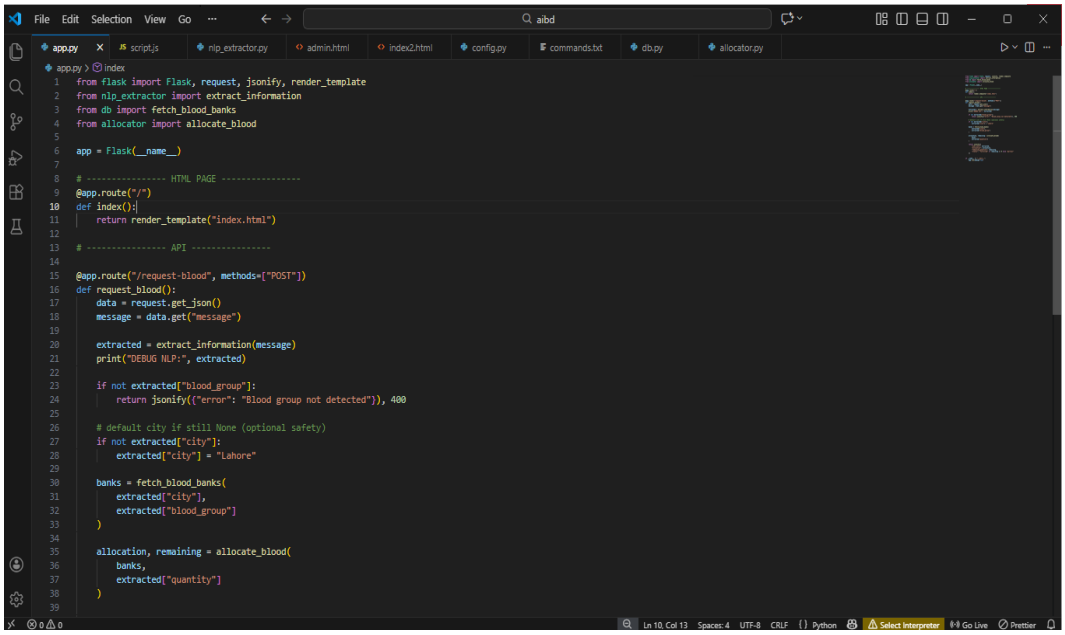


Figure 4. sample code in python

Sample code is shown in figure 4. In figure 4, we present app.py file. This is the entry point of flask application. We also defined routes and their functionalities.

7. Results and Evaluation

we run this application.

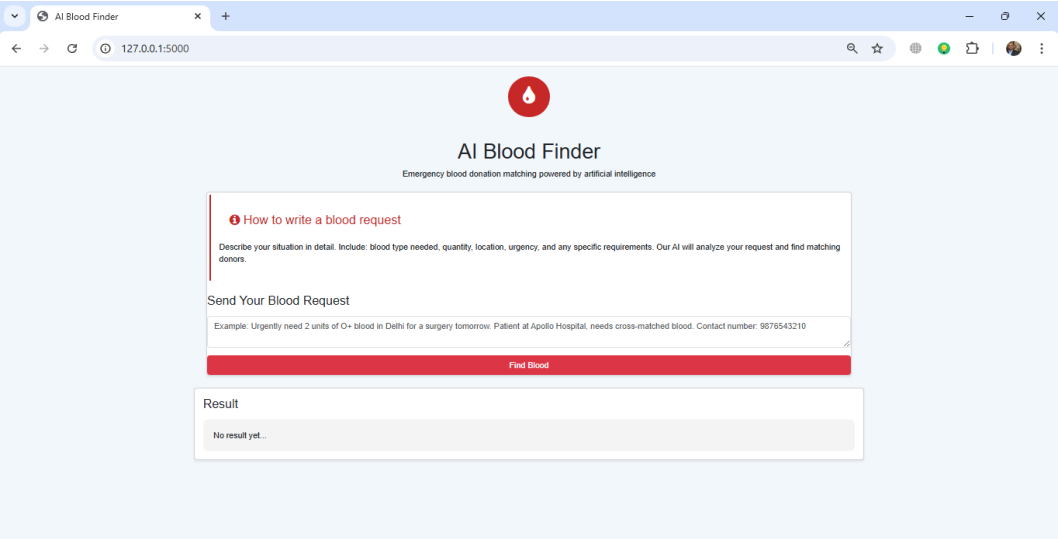


Figure 5. application interface

Figure 5, shows the graphical user interface for our application. Our application interface facilitates the user entering the request of required blood group along with the quantity and contact number. Location is optional if user does not enter the location system will fetch the location automatically.

Case 1. When user enters correct quantity and location

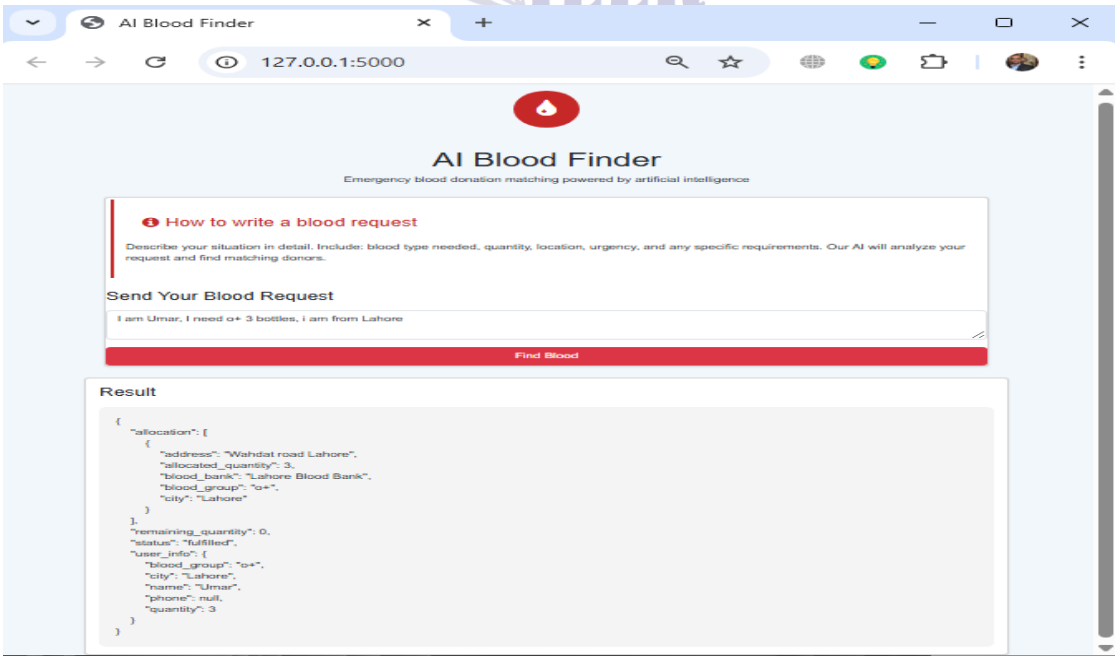


Figure 6. When user enters correct quantity and location

Figure 6, shows that when user enters correct quantity and location, system will search for the required quantity from the nearest blood bank and inform the user.

Case 2. when quantity is exceeded

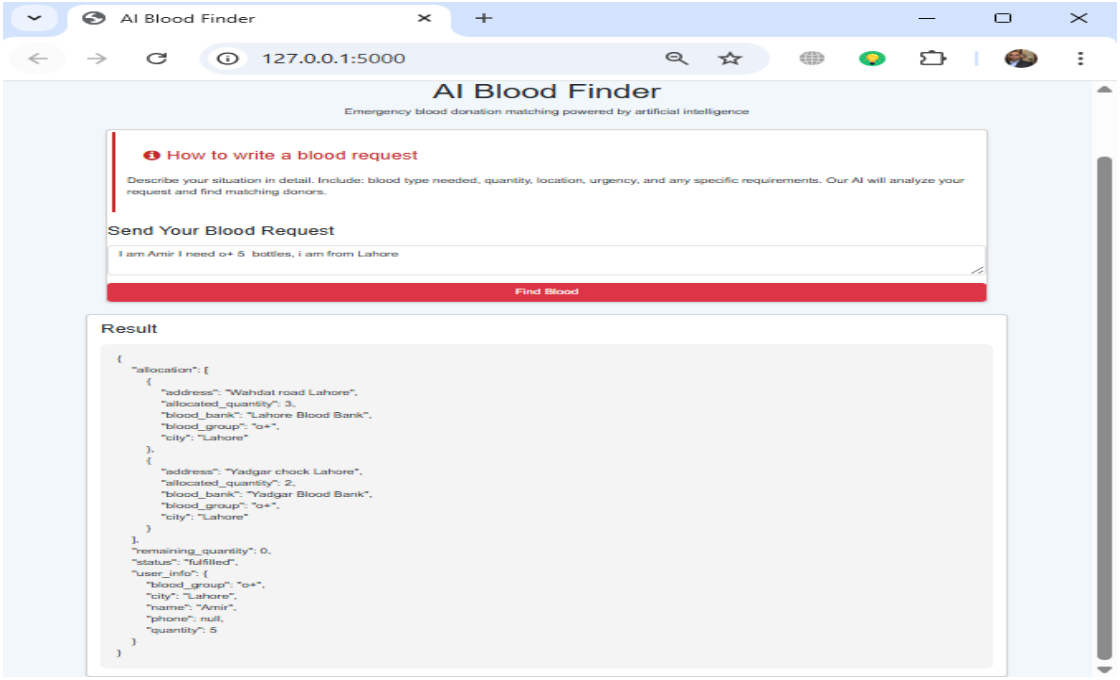


Figure 7. when quantity exceeded

Figure 7, shows that when quantity is exceeded, system will search for another blood bank until the required quantity is reached and informs the user. If desire quantity is not available in any blood bank, system will immediately inform the user to save life.

Case 3. Location is not provided

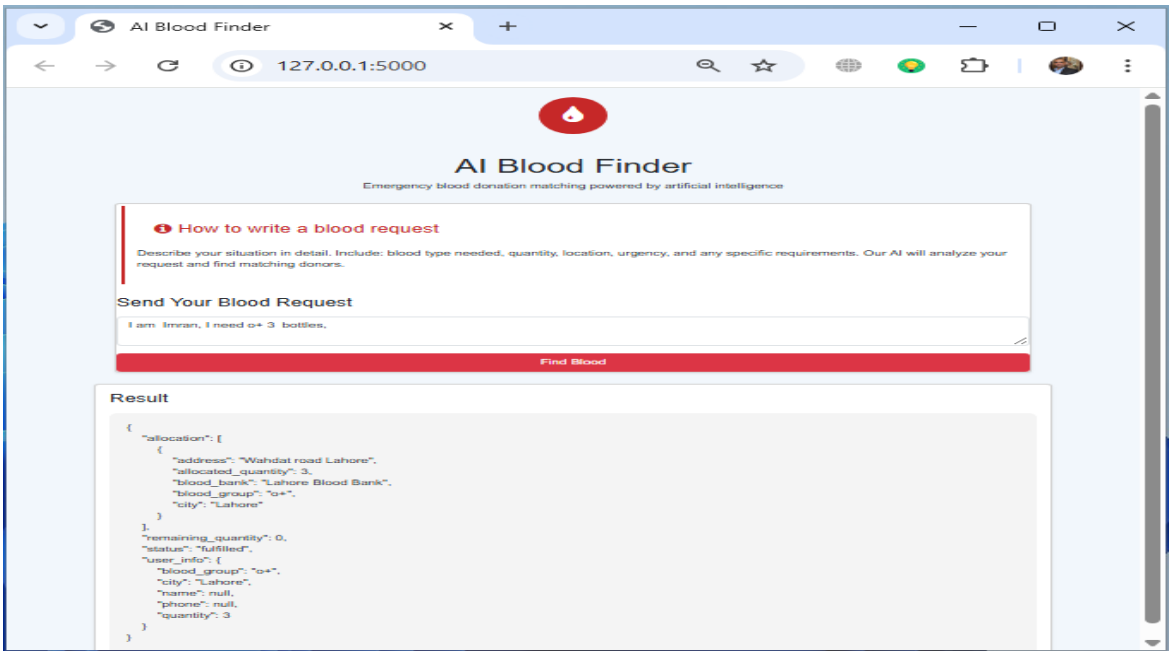


Figure 8. Location is not provided

Figure 8, shows that when location is not provided, system will fetch the real time location of the user and search the quantity from the nearest blood bank

Case 4. when blood bank is not available in the given location or city

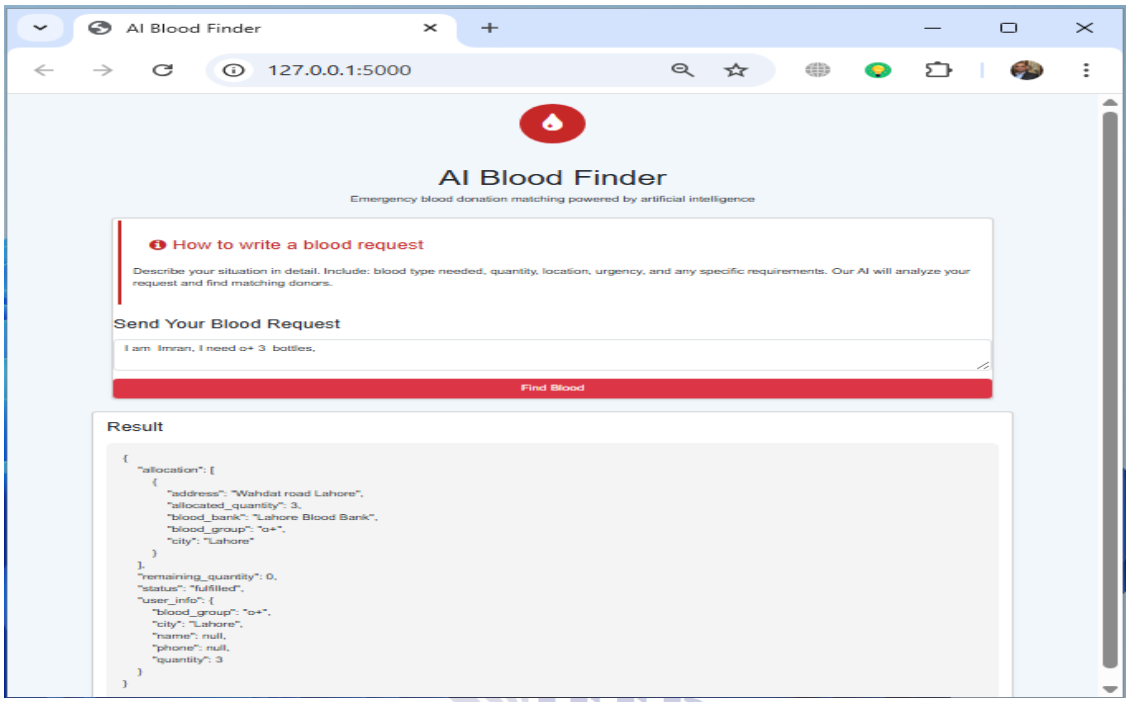


Figure 9. Blood Bank is not available

Figure 9, shows that when blood bank is not available in the given city or location, then system will search for a blood bank and blood group quantity from nearest available locations.

8. Discussion

It is a web-based application created in python, flask, html, CSS and bootstrap. It generates results in JSON format so we can use it as API for web, mobile and desktop applications. Application is fully compatible with mobile and web applications. Application can be reuseable. Application can be integrated with existing blood donation systems. Application provides fast, efficient and accurate results with less use of memory. Application is also testable and analyzable.

9. Conclusion

Using modern AI technique, we come with an efficient, fast and more accurate blood donation system. In this application we introduce NLP techniques to get the user message and response more quickly and efficiently. In this way, we also improve the performance of the application as well. Currently this application is working efficiently as a web-based application but in future we can integrate it with mobile applications using API endpoints. This application can also be reusable. Application can be integrated with existing native applications to make them efficient and fast. Additionally, the application can be enhanced to support scalability, performance optimization, and advanced security features. Its modular architecture ensures reliability, portability, flexibility, and ease of maintenance. Future enhancements may also include automated testing, continuous integration and deployment in dedicated testing and production environments to ensure robustness and long-term sustainability.

Funding: This research received no external funding.

Data Availability Statement: No data set is used in this study.

Declaration Statement: The authors declare no conflicts of interest.

Author Contributions: Conceptualization, (H.M.U.H).; methodology and mathematical modeling,(F.A).; application development, validation, (M.I) and (H.M.U.H) .; formal analysis, (F.A); investigation, (H.M.U.H).; resources, (M.I); data curation, (M.I); writing-original draft preparation (F.A); writing-review and editing (M.I); supervision, (F.A) All authors have read and agreed to the published version of the manuscript.

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