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Research Article

Enhancing Donor Eligibility Criteria using Machine Learning to Maximize Blood Donation Efficiency

Dr. Vijay Shelake[1], Suzan DSouza[2], Shagun Agrawal[3], Martina John[4], Dr. Sujata Deshmukh[5],
[12345]*Department of Computer Engineering, Fr. Conceicao Rodrigues College of Engineering, Mumbai*

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ABSTRACT

Introduction: In todays healthcare scenarios, there is need to optimize blood donation processes, ensuring that only eligible donors are selected, thereby improving the efficiency and effectiveness of blood collection and transfusion services.

Objectives: This research aims to investigate the application of machine learning techniques in determining donor eligibility for blood donation based on critical factors such as the last donated month, recency, frequency, and volume of blood donated in CC units.

Methods: This work employs a comprehensive dataset, including historical donor information and various demographic factors, to train machine learning models. These models are designed to predict donor eligibility based on the aforementioned criteria, with the goal of enhancing the accuracy and reliability of donor screening processes.

Results: The findings of this research should significantly progress the field of managing blood donations by providing a way for evaluating a donor's eligibility based on data. Improved donor retention, more efficient blood collection processes, and eventually more lives saved by timely and successful blood transfusions could be the outcomes of this.

Conclusions: The research leverages advanced machine learning algorithms, including Random Forest (RF), Support Vector Machines (SVM), K-Nearest Neighbors (KNN), Decision Trees, and Linear Regression, to analyze the data and identify patterns that correlate with donor eligibility.

Keywords: Healthcare, Machine Learning, Donor, Blood.

INTRODUCTION

In light of significant factors such the amount of blood donated in cubic centimeters (CC) units, the frequency, the proximity, and the month of the prior donation, this study aims to investigate how machine learning algorithms may be utilized to evaluate a donor's eligibility for blood donation. The aim of the contribution is to enhance blood donation protocols by selecting only eligible donors, hence augmenting the effectiveness and efficiency of blood collection and transfusion services. The study makes use of a sizable dataset, which contains demographic and historical donor data, to train machine learning models. These models are designed to predict donor eligibility using the previously mentioned standards, hence increasing the accuracy and reliability of donor screening processes. The study makes use of sophisticated machine learning algorithms [1][2][3][4][5].

Blood collection organizations should think about creating fresh retention plans specifically for blood donors, accounting for the unique characteristics of male and female donors, typical life events, and unique difficulties brought on by varying educational attainment [2]. In [5], the motivations behind the acts of blood donors and non-donors. They draw attention to several factors that affect decision-making regarding donation, including social considerations, the impact of donation on one's personal health, and perceived health benefits.

Wu et al.'s[2] study from 2022 uses machine learning to forecast blood donation intentions during COVID-19 pandemics. It emphasizes how crucial it is to use data science to comprehend and forecast donor behavior, particularly during emergency situations. The study emphasizes how machine learning models may be used to find

trends and indicators of a person's propensity to donate blood, which could be very helpful for blood donation campaigns during public health emergencies. [4] examine self-reported reasons and challenges for blood donation. They find that altruism, health benefits, and social reasons are common motivators, while concerns about health risks and inconvenience are significant barriers. This study underscores the need for strategies to address these concerns to increase blood donation rates. [6] examine gender differences in blood donation behaviors. They find that women are more likely to donate blood than men, with men being more likely to defer donations. This study highlights the importance of considering gender differences in blood donation campaigns. [8] explore what would encourage blood donation in Ireland. They find that factors such as the impact of donation on personal health, perceived health risks, and the convenience of donation are significant.This study emphasizes the importance of considering these factors in blood donation campaigns. [10] the development of a legal framework for blood donation and blood safety in China. They highlight the importance of legal regulations in ensuring the safety and quality of blood donations. This study underscores the role of legal frameworks in promoting blood donation. [7] A study conducted in Leeds, England, to learn why people give blood and why they stop or never donate. The study identifies several factors, including perceived health risks, inconvenience, and the impact of donation on personal health. It suggests that addressing these concerns could improve blood donation rates. [5] The motivations of both blood donors and non-donors. They identify several factors influencing donation decisions, including perceived health benefits, social reasons, and the impact of donation on personal health. Our contribution provides a foundational understanding of the motivational landscape of blood donors.

OBJECTIVES

The problem addressed in this contribution is lack of verification of blood donation at blood donation centers in developing countries which leads to an increased number of donations per individual in exchange of incentives such as money. This can impact the overall health of individuals in developing countries. Thus, it is important that an advanced Machine Learning model can classify individuals eligible to donate based on calculated health parameters and ineligible to donate blood. This research seeks to explore the use of machine learning algorithms to assess blood donor eligibility by analyzing key factors, including the month of the last donation, donation frequency, donation recency, and the total volume of blood donated in CC.

METHODS

In this stage, a machine learning model is developed for flagging the donor, i.e. predicting whether a registered donor is eligible to donate blood. Various machine learning algorithms like Logistic Regression, Support Vector Machine, Random Forest, and Decision Tree are used to train the dataset. The Units include:

- Blood quantity unit - c.c = cubic centimeter
- Where, 1cc=1ml

The following methods are included in our contribution:

1. **Logistic Regression:**

A supervised machine learning technique called the logistic regression algorithm is used to forecast the dependent variable from a set of independent factors.

2. **Decision Tree:**

Decision tree a supervised ML algorithm used for predicting the values based on the input data. In decision trees, internal nodes represent a feature, branches represent a rule and leaf nodes represent the result of the algorithm. The algorithm splits the data in the dataset as each internal node to select the best feature based on various criteria such as information gain or gini impurity.

$$Entropy = -\sum_{i=1}^{n} p_i \log_2(p_i) \quad (1)$$

$$Gain(T, A) = Entropy(T) - Entropy(T, A)$$

$$Gini = 1 - \sum_{i=1}^{n} (p_i)^2$$

3. **Support Vector Machine:**

Support Vector Machine is a supervised machine learning algorithm used mainly for classification but can be used for regression also. It is used for separating data points into different classes by finding an optimal hyperplane into an N-dimensional space. For two input characteristics, the hyperplane can be a line; for three input features, it can be a 2-D plane. Thus, the amount of input features determines the dimension.

4. **Random Forest:**

Random forest is a supervised machine learning algorithm based on the technique of ensemble learning (combining multiple classifiers). In this multiple decision trees are instead of one and then the final output is predicted based on the forest.

The algorithm with the highest accuracy score is then used to predict whether a person can donate blood or not.

RESULTS

This research considers the dataset including various attributes like recency (last time when the blood was donated), frequency (how many times blood is donated), volume (amount of blood donated), Weight, Age, and Haemoglobin. These factors affect whether a person can donate blood or not in the following way:

1. There should be a minimum gap of 2 months for a person to re-donate blood.

2. A person should weigh a minimum of 45kgs to be able to donate blood.

3. For a person to donate blood he/she should be of 18-65 years of age.

4. To donate blood, a donor's hemoglobin level cannot be higher than 20.0g/dL. For female donors, the minimum hemoglobin level is 12.5g/dL, while for male donors, it is 13.0g/dL.

Dataset also contains whether a person can donate blood or not in which if he/she can donate blood then it is represented as '1' and if not it is represented as '0'.

Table I: Results of Machine Learning Algorithm Implementation

Algorithm	***Accuracy***
Logistic Regression	**92**
Decision Tree	**96**
Support Vector Machine	**74**
Random Forest	**98.67**

The findings from below Figure 1 observations reveal a pattern in the behavior of blood donors that is connected to the recentness of contributions. It is reported that people who have donated blood within the last one or five months are more inclined to do so. This implies that the amount of time that has passed since a blood donation influences the decision to make another donation, with those who have contributed most recently being more likely to do so. The data suggests that the likelihood of donating blood may rise as the time since previous donations falls, with a notable decline shown in people who had not given blood in 25 months or more.

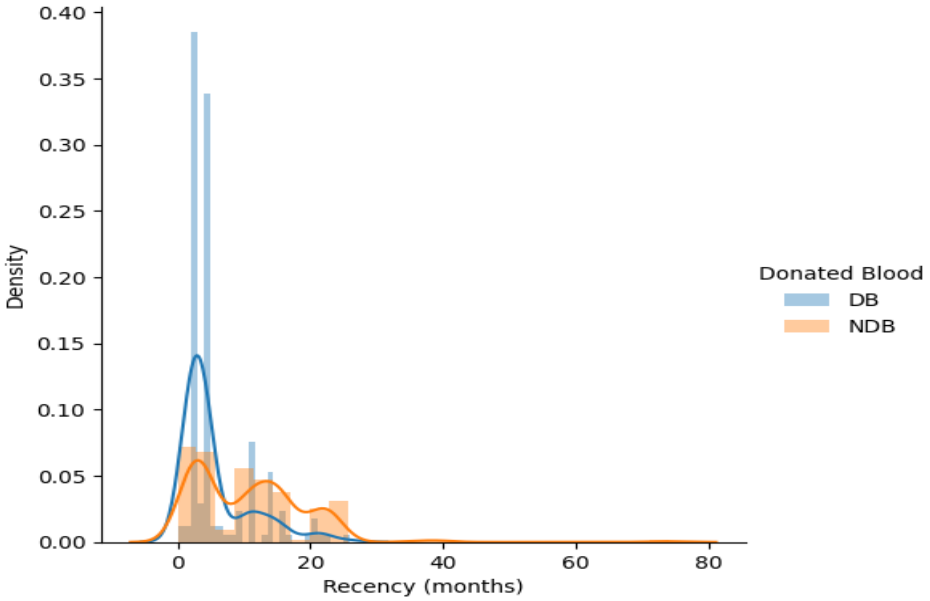

Fig. 1. Density vs Recency of Blood donation in Months

The findings presented in Figure 2 demonstrate a clear trend in the behavior of blood donors, especially with regard to the frequency of donations. It has been observed that those whose overall frequency of donations falls between one and five are more likely to abstain from blood donation. This implies that the frequency of a person's prior blood donations may have an impact on their decision to give. The data suggests that the probability of donating blood may decline with increasing donation frequency; a notable decline is noted for individuals who have made 22 or more donations.

This result is consistent with the general idea that a person's decision to donate blood is influenced by a number of factors, such as their own health, how often they donate, and how they perceive the donation's impact on their health.

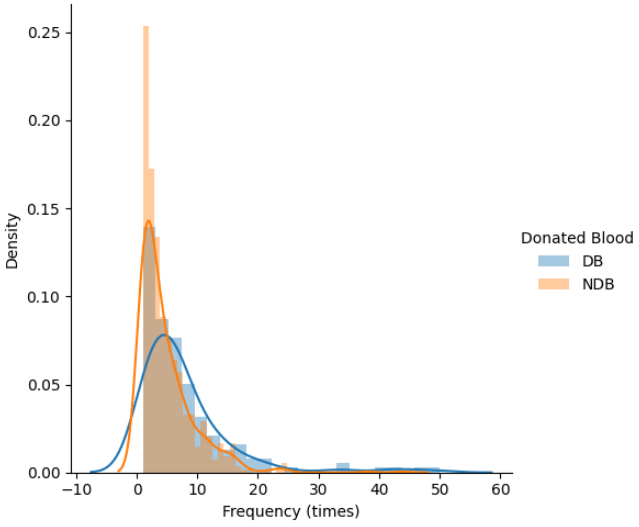

Fig. 2. Density vs Frequency of donation in number of times

The findings from Figure 3 indicates a significant trend in blood donation behavior, particularly among individuals with a monetary value of total blood donated ranging from 100 to 1200 cubic centimeters (c.c). This range suggests a substantial volume of blood donated, which could imply a long-term or frequent donor. The data reveals that individuals within this monetary range are more likely to choose not to donate blood, suggesting a potential decrease in donation frequency or a shift in donation behavior.

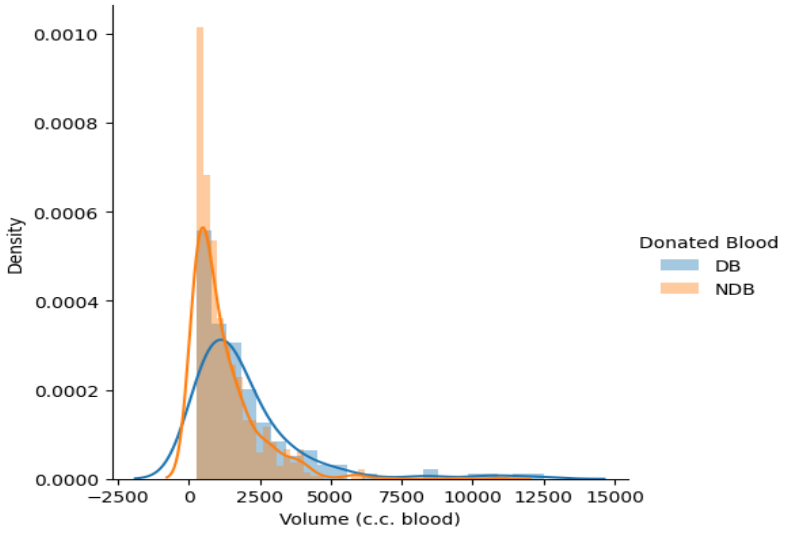

Fig. 3. Density vs Volume in c.c of blood

DISCUSSION

In conclusion, the research successfully demonstrates the potential of machine learning in enhancing the efficacy and efficiency of blood donation procedures by accurately predicting donor eligibility based on multiple factors like last donated month, recency, frequency, and volume of blood donated. Advanced machine learning techniques (SVM, RF, linear regression, and decision trees) have shown promising results in identifying patterns and correlations in donor information that significantly impact the decision-making process in blood donation centers.

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