Blood Group Detection Using Machine Learning

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Abstract - This paper introduces a web-based application that predicts a person's ABO-Rh blood group from fingerprint images using machine learning. The system provides a non-invasive, fast, and accessible solution for estimating blood groups, especially useful in emergency or low-resource settings. The application uses Histogram of Oriented Gradients (HOG) to extract key features from fingerprint images. These features are then analyzed using a Support Vector Machine (SVM) classifier trained on a labeled dataset of fingerprint samples across different blood groups. The model uses class balancing techniques to improve prediction fairness across all classes. Users upload fingerprint images through a simple web interface, and the system provides real-time predictions with confidence scores and probability breakdowns. It also allows users to correct or confirm predictions, which helps improve the model over time by saving corrected samples to the dataset.

Keywords: Fingerprint, Blood Group, SVM, HOG, Machine Learning.

1. INTRODUCTION

Blood group identification is a critical requirement in healthcare. It is especially important for blood transfusions, organ transplantation, prenatal care, and emergency medicine. Traditional methods rely on serological testing, which is accurate but invasive, time-consuming, and requires laboratory infrastructure. These limitations create challenges in rural healthcare, mass screenings, and disaster

relief scenarios where quick and non-invasive methods are essential.

Biometric technologies have recently gained attention for secure and individualized data acquisition using traits such as iris patterns, facial features, and fingerprints. Among these, fingerprints are unique, stable throughout life, and easily captured using inexpensive devices. Dermatoglyphic studies have also suggested potential correlations between fingerprint ridge patterns and biological characteristics, including blood group.

Motivated by these findings, we propose Blood Group Detection**,** a machine learning-based system for non-invasive blood group prediction using fingerprint images. The hypothesis is that inherent ridge flow and minutiae patterns can indirectly indicate an individual's ABO-Rh blood group.

The system workflow involves preprocessing fingerprint images, enhancing their quality, and extracting features using the Histogram of Oriented Gradients (HOG) technique. These features are then classified using a Support Vector Machine (SVM)**,**optimized with class weights to manage uneven distribution of blood group samples. A dataset of 570 fingerprints, covering all eight blood groups, is used for training and evaluation.

To make the system user-friendly, it is deployed as a Flask-based web application. Users can upload fingerprint images and receive predictions along with confidence scores and probability distributions. The interface also provides visualization of feature representations and classification results for better interpretability.

This research highlights the potential of fingerprint-based blood group prediction as a supplementary diagnostic tool. Future enhancements may include deep learning for automated feature extraction, use of multiple fingerprints for higher accuracy, and larger datasets for improved generalization.

Thus, fingerprint-driven blood group prediction offers a promising, non-invasive, and cost-effective solution that could strengthen healthcare systems in both clinical and emergency contexts.

2. LITERATURE SURVEY

Nikitha V (2024) in her work "Advanced Image Processing for Fingerprint-Based Blood Grouping" proposes a non-invasive blood group detection system by analyzing fingerprint patterns through grayscale conversion and image enhancement techniques. The study emphasizes the potential of providing quick and accessible diagnostic support during emergencies or in remote areas, thereby linking biometric identification with medical diagnostics. However, the system is highly dependent on the availability of high-quality fingerprint images and is limited by the lack of

strong medical validation regarding the correlation between fingerprint features and blood groups.

Tannmay Gupta (2023) in his work "Artificial Intelligence and Image Processing Techniques for Blood Group Prediction" surveys the application of artificial intelligence and image processing methods such as enhancement, segmentation, and feature extraction for non-invasive blood group prediction using fingerprint images. The paper highlights a notable shift in biometric systems from traditional identity verification toward healthcare diagnostics, with an emphasis on affordable and accessible solutions for emergencies and resource-constrained environments. Nevertheless, the approach faces significant challenges due to the absence of standardized datasets and limited clinical validation, which restrict its reliability and acceptance in real-world medical applications.

Santhi Chavala, Pamarthi Venkata Yaswanth Ram, Rithvik Chenna Reddy Mule, Kanulla Prathyusha, and Murapaka Likhita Sowmya (2024) in their work "Blood Group Detection using Image Processing and Fingerprint" present a non-invasive approach for predicting blood groups by analyzing fingerprint images through image processing techniques such as noise removal, grayscale conversion, and feature extraction. The study further employs machine learning algorithms to classify fingerprint patterns, with the objective of enabling rapid and contactless

blood group identification in emergency situations or rural healthcare settings. However, the method faces limitations due to the absence of medically validated correlations between fingerprint features and blood groups, alongside challenges arising from a relatively small dataset size and dependency on fingerprint image quality.

Anita Titus (2023) in her work "A Systematic Procedure to Identify Human Blood Using Image Processing Assisted Learning Principle" proposes a systematic, learning-based approach for non-invasive and automated blood group detection using image processing techniques. The study focuses on reducing human error while improving diagnostic accuracy and enhancing accessibility in remote or resource-constrained areas by eliminating the need for advanced laboratory equipment. However, the system's accuracy is highly dependent on the quality of input images and consistent environmental conditions, making it less reliable in practical scenarios where variations in lighting and fingerprint samples can affect performance.

3. PROPOSED SYSTEM

The proposed system introduces a non-invasive method for predicting blood groups using fingerprint images, eliminating the need for traditional serological testing. Fingerprint images

are first preprocessed to remove noise and enhance quality, followed by feature extraction using the Histogram of Oriented Gradients (HOG) technique. These extracted features are classified with a Support Vector Machine (SVM)model to predict the individual's ABO-Rh blood group.

The system is deployed as a web-based application where users can upload fingerprint images and obtain real-time predictions along with confidence scores. This makes the solution highly practical in emergency cases, rural healthcare, and disaster situations where laboratory facilities may not be accessible.

Key advantages include being non-invasive, user-friendly, scalable, and cost-effective, as it requires only a fingerprint scanner and basic computing resources. The system also improves continuously as more data is added, ensuring better accuracy over time. Additionally, it serves as adecision-support tool for healthcare providers while offering research value by exploring links between biometric traits and physiological characteristics like blood groups.

4. SYSTEM ARCHITECTURE
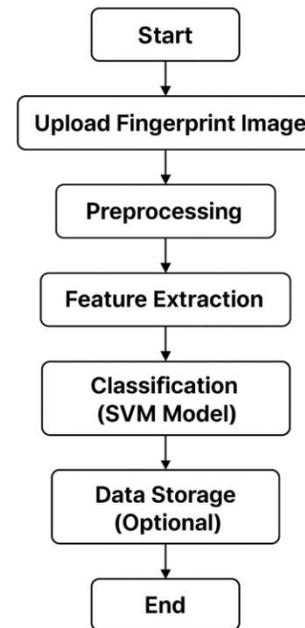
Fig 1: System Architecture for Fingerprint based Blood Group prediction

Start – Begin the blood group prediction process.

Upload Fingerprint Image – User uploads a fingerprint image to the system.

Preprocessing – Image undergoes grayscale conversion and noise removal.

Feature Extraction – Key fingerprint features like minutiae and ridge patterns are identified.

Classification (SVM Model) – Extracted features are classified into a blood group using SVM.

Data Storage (Optional) – Prediction results may be stored in a database or file.

End – The process completes with blood group prediction output.

5. MODULES

The **Web Interface Module** is responsible for handling user interactions through a web application. It manages templates, static files, and routing to ensure smooth communication between the user and the system.

The **Image Processing and Feature Extraction Module** preprocesses and cleans the fingerprint images before analysis. It extracts essential features, such as Histogram of Oriented Gradients (HOG), which serve as input for the machine learning model.

The **Machine Learning Module** focuses on training and evaluating models for accurate blood group prediction. It also manages and updates saved models for future use.

The **Dataset and Feedback Module** stores and updates fingerprint datasets that are used for model training and testing. Additionally, it integrates user feedback to continuously improve the system's performance and accuracy.

6. ALGORITHMS

Dataset Preprocessing: The fingerprint dataset consists of 570 images covering eight blood groups (A+, A-, B+, B-, AB+, AB-, O+, O-). Each image was resized to a fixed resolution of 256×256 pixels to ensure consistency. Noise removal filters were applied, and contrast enhancement techniques were used to improve ridge visibility. To address class imbalance, oversampling and augmentation methods (such as rotation and flipping) were applied. The dataset was then divided into training (80%) and testing (20%) subsets to evaluate performance reliably.

Histogram of Oriented Gradients (HOG): It is a feature extraction method widely used in image processing.It begins by calculating the gradient of each pixel**,** measuring intensity changes in horizontal and vertical directions. This step highlights the fingerprint's ridges, edges, and fine structures. The fingerprint image is then divided into cells Within each cell, a histogram of gradient directions is created to capture local texture. Next, several neighboring cells are grouped into blocksfor normalization. Block normalization makes the system resistant to lighting or contrast changes. Finally, all block histograms are combined to form a feature vector. This vector numerically represents the fingerprint's unique ridge patterns.

Support Vector Machine (SVM): It is then applied to classify these feature vectors.SVM works by finding an optimal hyperplane that separates different blood group classes.It maximizes the margin between classes for better accuracy and generalization.Since blood group detection involves eight classes, SVM uses multi-class strategies like One-vs-Rest or One-vs-One.Each fingerprint is

classified into one of the eight groups (A+, A-, B+, B-, AB+, AB-, O+, O-).SVM also calculates confidence scores, indicating the reliability of the prediction.This makes the system more trustworthy in critical medical applications.The combination of HOG and SVM is efficient because HOG extracts strong fingerprint features, while SVM provides accurate classification even with limited training data.Thus, the integrated approach ensures a non-invasive, reliable, and scalable method of blood group detection.This workflow bridges biometric analysis with healthcare applications effectively.
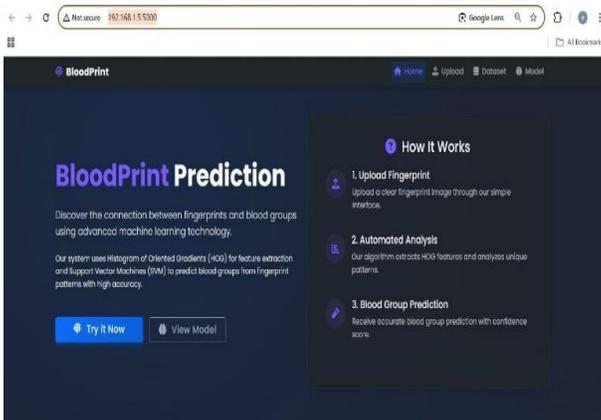
7. RESULTS

Fig 2: Web application Home page interface for Blood Group Detection system
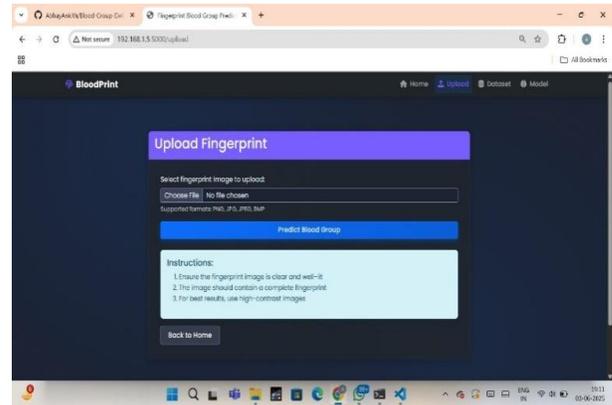

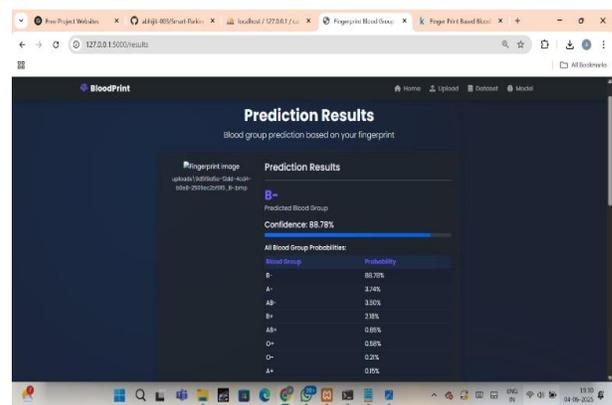*Figure 3: Fingerprint upload page in the web application*

Figure 4: Sample prediction result page showing detected Blood Group

8. CONCLUSIONS

The proposed project introduces a non-invasive approach for predicting human blood groups using fingerprint image processing, making it a safer and quicker alternative to traditional blood sampling. It makes use of advanced image processing techniques such as Histogram of Oriented Gradients (HOG) for extracting unique fingerprint features and employs machine learning models like Support Vector Machines (SVM) for accurate

classification. This integration of biometric recognition with medical diagnostics highlights the innovative nature of the system.

The solution is particularly valuable in emergency medical situations and in rural or under-resourced healthcare environments where laboratory facilities are not readily available. By providing real-time predictions through a simple web interface, it ensures accessibility and ease of use for both medical professionals and patients. The system is also scalable and cost-effective since it only requires a fingerprint scanner and basic computational resources. Despite its potential, the project faces challenges due to the need for larger, standardized datasets and strong medical validation to prove the correlation between fingerprint patterns and blood groups.

Nevertheless, the results achieved so far indicate that this technique can evolve into a reliable decision-support tool for healthcare. Overall, it represents a significant step toward combining biometrics and healthcare, offering a quick, affordable, and innovative solution to blood group detection.

9. FUTURE SCOPE

In the future, the system can be further enhanced by improving model accuracy through training on larger and more diverse datasets. This will help the model generalize better and handle variations in fingerprint patterns across different populations.

Another important direction is the integration of deep learning techniques, which can automatically learn more complex and robust fingerprint features compared to traditional methods like HOG.

Additionally, medical validation studies must be conducted to establish a stronger scientific correlation between fingerprint patterns and blood groups. Such validation will make the system more acceptable in clinical and healthcare environments.

The development of a mobile application can also extend the usability of this technology, allowing real-time blood group detection in remote areas or during emergencies without requiring a computer system.

Furthermore, the system can be made more user-friendly by incorporating real-time feedback mechanisms and providing multilingual support, ensuring accessibility for users from different regions and backgrounds.

These improvements will not only make the system more reliable but also increase its adoption in both healthcare and emergency response scenarios.

Ultimately, such advancements will help transition the project from a research prototype to a practical healthcare solution.

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