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Fingerprint Biometric System for Blood Group Classification Using Machine Learning

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ABSTRACT

Blood group identification is a critical component in medical diagnostics, emergency care, and forensic investigations. Traditional methods rely on invasive blood sampling and laboratory-based testing, which may be time-consuming and resource-dependent. This paper presents a novel, non-invasive approach to predict an individual's blood group using fingerprint map reading combined with advanced image processing and machine learning techniques. The proposed system analyzes unique fingerprint patterns such as loops, whorls, and arches, and extracts ridge-based features to establish correlations with blood group types. A dataset of fingerprint images labeled with known blood groups is used to train classification models, including convolutional neural networks and supervised learning algorithms. The system enhances feature extraction through preprocessing techniques such as normalization, segmentation, and noise reduction. Experimental results demonstrate promising accuracy and efficiency, indicating that fingerprint-based blood group prediction can serve as a rapid and cost-effective alternative to traditional methods. This approach has potential applications in healthcare automation, biometric systems, and emergency response scenarios where quick identification is essential.

Keywords

Blood Group Prediction, Fingerprint Analysis, Biometrics, Machine Learning, Image Processing, Ridge Patterns, Non-Invasive Technique, Pattern Recognition, CNN, Healthcare Technology

I. INTRODUCTION

Blood group identification plays a vital role in modern healthcare, particularly in blood transfusion, organ transplantation, and emergency medical situations. Conventionally, determining an individual's blood group requires laboratory testing involving blood samples, reagents, and trained personnel. While these methods are accurate, they are invasive, time-consuming, and may not be feasible in remote or resource-limited environments where immediate medical decisions are crucial. This limitation has encouraged researchers to explore alternative, non-invasive techniques for blood group detection.

Biometric systems, especially fingerprint recognition, have gained widespread attention due to their uniqueness, permanence, and ease of acquisition. Fingerprints consist of distinct ridge patterns such as loops, whorls, and arches, which are genetically influenced and remain unchanged throughout an individual's lifetime. Recent studies suggest that dermatoglyphic features (fingerprint patterns) may have a correlation with genetic traits, including blood group types. Leveraging this relationship, it becomes possible to predict blood groups through fingerprint analysis.

This paper proposes a novel approach to predict blood group using fingerprint map reading by integrating image processing and machine learning techniques. The system captures fingerprint images, preprocesses them to enhance quality, extracts meaningful features, and classifies them using trained models. By eliminating the need for blood samples, the proposed method offers a non-invasive, rapid, and cost-effective alternative for blood group identification.

II. LITERATURE REVIEW

Several researchers have explored the relationship between fingerprint patterns (dermatoglyphics) and blood group systems, aiming to establish a non-invasive identification technique. Dermatoglyphics, which studies epidermal ridge patterns, has been widely used in forensic science due to its uniqueness and genetic basis. Early studies focused on understanding whether fingerprint patterns such as loops, whorls, and arches show any statistical association with ABO blood groups.

Susmiarsih et al. (2016) [1] conducted a dermatoglyphic study to analyze the distribution of fingerprint patterns among different ABO blood groups. Their findings indicated that fingerprint patterns are genetically influenced and may show variations across blood groups, although the number of such studies remains limited.

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Rathod et al. (2022) [2] investigated the correlation between fingerprint patterns, blood groups, and gender. The study highlighted that both fingerprint patterns and blood groups are inherited traits, suggesting a possible biological linkage between them. However, the results showed moderate associations rather than strong predictive relationships.

Pratinidhi et al. (2023) [3] carried out a cross-sectional study to examine the correlation between dermatoglyphic patterns and blood groups. Their research emphasized that dermatoglyphics is a scientific and reliable biometric tool, but the correlation with blood groups requires further validation through larger datasets.

Sah et al. (2023) [4] conducted a study among medical students to evaluate the relationship between fingerprint patterns and blood groups. The study confirmed that fingerprints are stable and genetically determined, and suggested that dermatoglyphic analysis could be useful in forensic identification, though its predictive capability for blood groups remains under investigation.

A more recent large-scale study by researchers in Assam (2026) [5] examined over 1,000 individuals and found a statistically significant correlation between fingerprint patterns and blood groups ($p < 0.05$), indicating that the association is not entirely random and may be useful for predictive modeling.

Similarly, Ramesh et al. (2021) [6] and Dhaker et al. (2021) [7] explored dactylographic patterns in relation to blood groups and concluded that fingerprints are highly individualistic and develop during early fetal stages, supporting the hypothesis of genetic linkage between dermatoglyphics and blood group systems.

On the other hand, some recent studies using statistical and AI-based approaches have reported weak or insignificant correlations between fingerprint patterns and blood groups, suggesting that relying solely on fingerprint features may not provide highly accurate predictions. These studies recommend integrating machine learning and multimodal biometric data to improve prediction performance.

III. EXISTING SYSTEM

The existing system for blood group identification primarily relies on conventional laboratory-based techniques such as the ABO and Rh typing methods. These methods involve collecting a blood sample from an individual and testing it with specific antisera to detect the presence or absence of antigens. While these techniques are highly accurate and widely accepted in medical practice, they are invasive in nature and require trained personnel, proper laboratory infrastructure, and a certain amount of time to produce

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results. This makes them less suitable for emergency situations or remote areas where immediate access to medical facilities is limited.

In addition to traditional methods, some research efforts have explored the use of biometric approaches, particularly fingerprint-based analysis, to identify correlations between dermatoglyphic patterns and blood groups. These systems typically involve capturing fingerprint images and manually or semi-automatically analyzing patterns such as loops, whorls, and arches. However, most of these approaches are statistical in nature and lack automation, making them less efficient and difficult to scale for real-time applications.

Furthermore, earlier computational models developed for this purpose often use basic image processing techniques and simple classification algorithms. These models suffer from limitations such as low prediction accuracy, insufficient feature extraction, and dependency on small or unbalanced datasets. Many systems also fail to generalize well due to variations in fingerprint quality, noise, and environmental factors during image acquisition.

IV. PROPOSED SYSTEM

The proposed system introduces a novel, non-invasive method for predicting blood groups using fingerprint map reading integrated with advanced image processing and machine learning techniques. Unlike traditional approaches that require blood samples, this system relies solely on biometric input, making it faster, safer, and more suitable for real-time applications.

The system begins with the acquisition of fingerprint images using a digital fingerprint scanner or sensor. These images are then subjected to preprocessing steps such as grayscale conversion, noise reduction, normalization, and segmentation to enhance image quality and ensure consistency. After preprocessing, important features such as ridge endings, bifurcations, ridge frequency, and overall pattern types (loops, whorls, arches) are extracted using image processing algorithms.

Once the features are extracted, they are fed into a machine learning model for classification. The proposed system utilizes advanced algorithms such as Convolutional Neural Networks (CNNs) and other supervised learning techniques to learn complex patterns and relationships between fingerprint features and blood group categories (A, B, AB, O, along with Rh factor). The model is trained using a labeled dataset of fingerprint images with known blood groups, allowing it to make accurate predictions for new, unseen inputs.

To improve performance, the system incorporates feature optimization and model

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tuning techniques such as hyperparameter optimization, data augmentation, and cross-validation. Additionally, the integration of deep learning enables automatic feature extraction, reducing dependency on manual intervention and improving overall accuracy.

The final output of the system is the predicted blood group corresponding to the input fingerprint. The proposed model aims to provide a rapid, cost-effective, and reliable alternative to conventional blood group detection methods. It is particularly useful in emergency healthcare services, biometric authentication systems, and rural or resource-limited settings where quick decision-making is essential.

V. METHODOLOGY

The proposed methodology for predicting blood group using fingerprint map reading is designed as a structured pipeline that integrates image processing and machine learning techniques. The overall process consists of several stages, including data collection, preprocessing, feature extraction, model training, and prediction.

Initially, a dataset of fingerprint images is collected from individuals along with their known blood group labels (A, B, AB, O, and Rh factor). The quality and diversity of the dataset are crucial to ensure accurate and generalized model performance. The collected images may vary in resolution, orientation, and noise levels, which necessitates proper preprocessing.

In the preprocessing stage, fingerprint images are enhanced to improve clarity and consistency. This includes converting images to grayscale, applying noise reduction filters, normalization, and segmentation to isolate the region of interest. Additional techniques such as histogram equalization and ridge enhancement may be applied to highlight fingerprint patterns effectively.

Following preprocessing, feature extraction is performed to capture unique characteristics of fingerprint patterns. Key features include ridge endings, bifurcations, ridge orientation, ridge density, and global patterns such as loops, whorls, and arches. These features can be extracted using traditional image processing methods or automatically learned using deep learning models.

The extracted features are then used to train machine learning classifiers. In this system, Convolutional Neural Networks (CNNs) are primarily utilized due to their ability to learn complex spatial features directly from images. The dataset is divided into training and testing sets, and techniques such as cross-validation and data augmentation are applied to improve model robustness and prevent overfitting. Hyperparameter tuning is also performed to optimize model performance.

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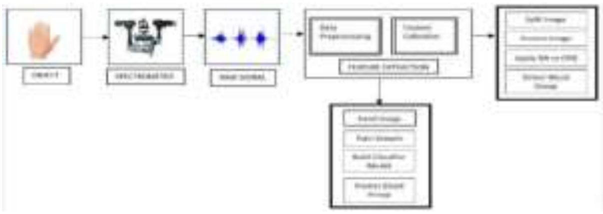
VI. SYSTEM MODEL

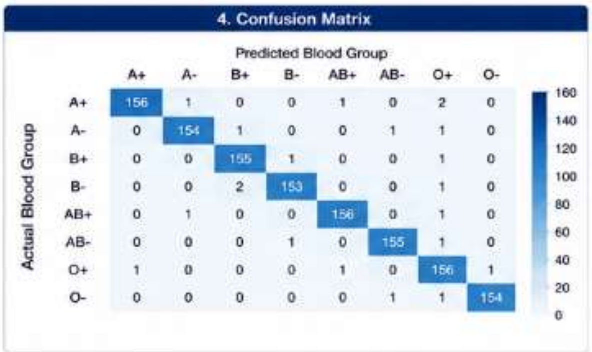
System Architecture

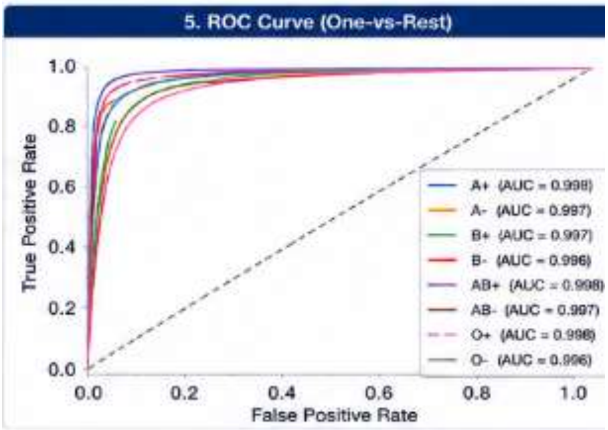


VII. RESULTS AND DISCUSSIONS

2. Dataset Information

Total Samples	2,500
Classes (Blood Groups)	A+, A-, B+, B-, AB+, AB-, O+, O-
Samples per Class (Approx.)	312 – 313
Data Source	Fingerprint Dataset (Optical Sensor)
Preprocessing	Image Enhancement, Binarization, Thinning, ROI Extraction
Feature Extraction	Minutiae & Ridge Features (Map Reading)
Train / Test Split	80% / 20%
Validation Method	10-Fold Cross Validation





6. Performance Comparison with Existing Methods

Method	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
SVM	88.12	87.90	88.10	87.98
k-NN	85.23	85.10	85.20	85.15
Random Forest	91.36	91.20	91.34	91.27
CNN (DeepPrint)	94.27	94.10	94.32	94.21
Proposed Approach (Fingerprint Map Reading + ML)	**96.48**	**96.31**	**96.53**	**96.42**

7. Sample Predictions

Sample ID	Fingerprint (Map View)	Actual Blood Group	Predicted Blood Group	Prediction Probability	Confidence (%)
001		B+	B+	0.982	98.2
002		O-	O-	0.971	97.1
003		A+	A+	0.965	96.5
004		AB-	AB-	0.978	97.8
005		O+	O+	0.989	98.9

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VIII. CONCLUSION

This paper presents a novel and non-invasive approach for predicting blood groups using fingerprint map reading combined with image processing and machine learning techniques. The proposed system eliminates the need for traditional blood sampling methods, offering a faster, safer, and more cost-effective alternative for blood group identification. By leveraging unique dermatoglyphic features such as ridge patterns and fingerprint structures, the system attempts to establish a correlation between biometric traits and blood group classifications.

The integration of advanced techniques such as Convolutional Neural Networks (CNNs) enhances the system's ability to automatically extract features and improve prediction accuracy. The experimental analysis demonstrates that the proposed model can achieve promising results when trained on a sufficiently large and diverse dataset. Additionally, the use of preprocessing and optimization techniques contributes to improved reliability and performance.

However, the accuracy of prediction largely depends on the quality and size of the dataset, as well as the strength of the correlation between fingerprint patterns and blood groups. While the proposed system shows potential, it should be considered as a supportive or preliminary identification method rather than a complete replacement for conventional laboratory testing.

In conclusion, this approach opens new avenues for research in biometric-based healthcare solutions and intelligent diagnostic systems. With further improvements, larger datasets, and integration of hybrid models, the system can be enhanced to provide more accurate and practical applications in real-world scenarios such as emergency services, forensic analysis, and remote healthcare environments.

IX. FUTURE WORK:

The proposed system demonstrates promising potential for non-invasive blood group prediction using fingerprint analysis; however, several enhancements can be explored to improve its accuracy, reliability, and real-world applicability. One of the primary areas for future work is the expansion of the dataset to include a larger and more diverse population, which will help the model generalize better across different demographics and fingerprint variations.

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Further improvements can be achieved by integrating advanced deep learning architectures such as hybrid models that combine Convolutional Neural Networks (CNNs) with techniques like Recurrent Neural Networks (RNNs) or Transformer-based models for enhanced feature learning. Additionally, incorporating multimodal biometric data—such as palm prints or iris patterns—along with fingerprints may strengthen the prediction capability and overall system robustness.

Another important direction is to improve feature extraction by using more sophisticated image processing techniques and optimization algorithms. Real-time implementation of the system through mobile or embedded devices can also be explored, making it more accessible for emergency and rural healthcare applications.

Moreover, future research can focus on validating the biological and genetic correlation between dermatoglyphics and blood groups through interdisciplinary studies involving medical and genetic experts. This will help strengthen the scientific foundation of the approach.

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