Blood Group Determination Using Fingerprint Image Processing: A Review

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Abstract-Blood group determination is essential in medical emergencies, transfusions, organ donations, and forensic investigations. Traditional serological testing methods are accurate but invasive and time-consuming. With the increasing integration of biometrics and artificial intelligence, recent research has explored the feasibility of non-invasive blood group prediction using fingerprint image processing. This review summarizes the progress, methodologies, and findings of studies conducted in this area. It highlights the correlation between dermatoglyphics and blood group traits and examines machine learning and deep learning approaches applied to fingerprint images. The review also discusses applications, limitations, and future research directions.

INTRODUCTION

The determination of blood group is a foundational task in healthcare and forensics. The conventional methods require a blood sample, which may not always be feasible in emergencies or mass casualty situations. Consequently, researchers are exploring non-invasive methods, and fingerprint image processing has emerged as a potential solution. Dermatoglyphics, the scientific study of fingerprints, has long been hypothesized to correlate with genetic traits, including blood groups. This paper reviews existing literature to evaluate the efficacy and scope of using fingerprint images to determine an individual's blood group.

BLOOD GROUP SYSTEMS AND FINGERPRINT PATTERNS

ABO and Rh Systems: The ABO system classifies blood into four types—A, B, AB, and O—based on the presence or absence of specific antigens. The Rh system further categorizes blood as positive or negative, depending on the presence of the Rh factor.

Fingerprint Patterns: Fingerprints consist of ridge patterns categorized into loops, whorls, and arches. These patterns and their minutiae points (ridge endings and bifurcations) are unique and can be extracted using image processing algorithms.

Correlation Hypothesis: Studies such as those by [5] and [6] have statistically demonstrated correlations between specific fingerprint patterns and blood groups. Though not causally linked, these correlations provide a probabilistic basis for machine learning models to predict blood types.

METHODOLOGIES AND APPROACHES

Data Acquisition and Preprocessing: Most studies collect fingerprint images using optical scanners. Preprocessing steps include grayscale conversion, filtering (Gaussian, median), and contrast enhancement (histogram equalization).

Feature Extraction

- Minutiae-based: Ridge endings, bifurcations [3]
- Texture-based: GLCM, wavelet transforms [1]
- Topological features: Loop, whorl, and arch types

Classification Models

- Machine Learning: SVM, k-NN, Decision Trees [7]
- Deep Learning: CNNs and hybrid models [2]

Performance Metrics
Key performance indicators include accuracy, sensitivity, specificity, and confusion matrices. [4] achieved 91.2% accuracy using a CNN-PCA model.

Comparative Analysis

Study	Dataset Size	Methodology	Accuracy (%)	Classification
Sharma et al. (2020)	500	SVM + Gabor Filters	82.4	ABO + Rh
Patil & Deshmukh (2021)	800	CNN	88.9	ABO
Khan et al. (2019)	300	k-NN + Minutiae	76.5	ABO
Gupta et al. (2022)	1000	Deep CNN + PCA	91.2	ABO + Rh
Al-Zubaidy & Mohammed (2020)	700	Decision Tree, ML	85.5	ABO

Applications

- Emergency healthcare: Rapid identification
- Military: Field-ready diagnosis
- Forensics: Non-invasive personal data acquisition
- National ID systems: Integration with health records

Challenges and Limitations

- Biological complexity: No direct causal mechanism
- Data variability: Poor fingerprint quality affects accuracy
- Model generalization: Limited cross-population datasets
- Ethical concerns: Privacy of biometric and medical data

Future Research Directions

- Integration of multimodal biometrics
- Development of global, diverse datasets
- Explainable AI to improve trust and transparency
- Deployment via mobile platforms for real-time use

CONCLUSION

Fingerprint image processing offers a promising, non-invasive approach to blood group determination. While current research shows encouraging accuracy, the technique remains in the developmental phase. With further advancements in AI, data collection, and cross-disciplinary collaboration, this method could significantly impact healthcare and forensic domains.

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