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Crimson Fingerprint: AI-Driven Blood Type Detection and Disease Risk Prediction via Fingerprint and Blood Report Analysis

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Abstract:
Traditional blood type detection methods require invasive procedures that can be time-consuming and resource-intensive. This research introduces **CrimsonFingerprint**, a deep learning-based system that predicts blood groups using fingerprint analysis and assesses disease risk based on patient blood reports. Leveraging Convolutional Neural Networks (CNNs) alongside advanced image processing techniques, our approach extracts fingerprint ridge patterns and correlates them with blood group characteristics. Additionally, our system processes blood report data to predict potential disease risks, offering a comprehensive, AI-powered diagnostic tool. The proposed system ensures an efficient, cost-effective, and non-invasive solution for real-time blood type identification and health risk assessment, demonstrating high accuracy and reliability in medical and emergency scenarios.

Keywords: Fingerprint Analysis, Blood Type Detection, Disease Risk Prediction, Convolutional Neural Networks, Image Processing, Machine Learning, Biometrics, AI in Healthcare.

Introduction:
Fingerprint recognition has been employed for identity verification, but recent advancements in artificial intelligence (AI) and machine learning (ML) have broadened its scope beyond authentication purposes.
One of the most critical aspects of medical diagnostics is blood group identification, which plays a vital role in transfusions, organ transplants, and emergency treatments. Simultaneously, patient health assessments using diagnostic markers in blood reports are pivotal for early disease detection and risk prediction. However, conventional methods for determining blood type and assessing health risks are time-consuming, expensive, and often require laboratory facilities. These limitations can hinder timely interventions, particularly in emergency scenarios where rapid blood typing and disease risk evaluation can be life-saving.
The **CrimsonFingerprint** project presents an innovative, AI-driven approach that integrates fingerprint biometrics with deep learning methodologies for blood type identification and disease risk prediction. By employing Convolutional Neural Networks (CNNs) and image processing techniques, the system analyzes fingerprint ridge patterns and maps them to corresponding blood groups. Additionally, leveraging predictive modeling on blood report parameters allows for early identification of potential health risks, offering a dual-functionality diagnostic tool.
This research aims to bridge the gap between biometric analysis and medical diagnostics, creating a novel, non-invasive, and highly efficient alternative to traditional methods. While existing studies have explored isolated approaches to fingerprint classification and blood group prediction, they lack real-time applicability and integration with blood report analytics. Our study enhances these methodologies by:

- **Real-time fingerprint-based blood type detection** using deep learning and image processing.
- **Advanced predictive modeling for disease risk assessment** using blood report parameters.
- **A non-invasive and cost-effective approach** that eliminates the need for complex lab-based diagnostics.
- **Scalability and accessibility**, enabling usage in remote and resource-limited settings.

By integrating AI with healthcare biometrics, **CrimsonFingerprint** paves the way for a seamless, rapid, and automated health assessment system. This project contributes to a futuristic approach to diagnostics, reducing dependency on traditional laboratory-based testing while enhancing accuracy and efficiency. The following sections outline the methodology, system implementation, results, and potential advancements in this field.

Literature Review:

Research paper [1] Blood Group Detection through Fingerprint Images using Image Processing explores image processing techniques to analyze fingerprint patterns for blood group identification. However, it lacks deep learning integration, which limits its predictive accuracy.

Research paper [2] Fingerprint-Based Blood Group Prediction Using Deep Learning leverages convolutional neural networks (CNNs) for blood group classification. However, this approach does not incorporate disease risk prediction, making it less comprehensive than our proposed model.

Research paper [3] Blood Group Determination Using Fingerprint focuses on statistical methods to analyze fingerprint ridges in relation to blood types. However, it does not utilize advanced machine learning models, restricting its scalability and real-time efficiency.

Research paper [4] A Novel Approach to Predict Blood Group using Fingerprint Map Reading introduces a hybrid approach combining fingerprint feature extraction and machine learning. However, it does not integrate blood report data for disease risk assessment, reducing its applicability in medical diagnostics.

Research paper [5] Intelligent Systems and Applications in Engineering discusses the potential of AI-driven biometric systems but does not focus specifically on blood type prediction or disease risk assessment.

Research paper [6] A Novel Fingerprint Recognition Method Based on a Siamese Neural Network presents a deep learning model for fingerprint analysis but is primarily designed for authentication rather than health diagnostics.

While these studies provide valuable insights into fingerprint-based blood group identification, they primarily focus on classification without integrating disease risk analysis. Our proposed research enhances these methodologies by incorporating Gabor Filter, Normalization of grayscale images while retaining critical features, and integrating patient blood report data for comprehensive health diagnostics. This dual-functionality system ensures higher accuracy, real-time applicability, and broader medical utility.

Methodology:

The proposed methodology involves a comprehensive approach to blood type detection and disease risk prediction by integrating fingerprint-based image analysis using AlexNet CNN and dataset-based predictions utilizing the Random Forest algorithm. The AlexNet model processes fingerprint images to extract meaningful patterns for blood group classification, while the Random Forest model analyzes blood report parameters for disease risk assessment. This dual-method approach ensures a robust and multifaceted prediction system.

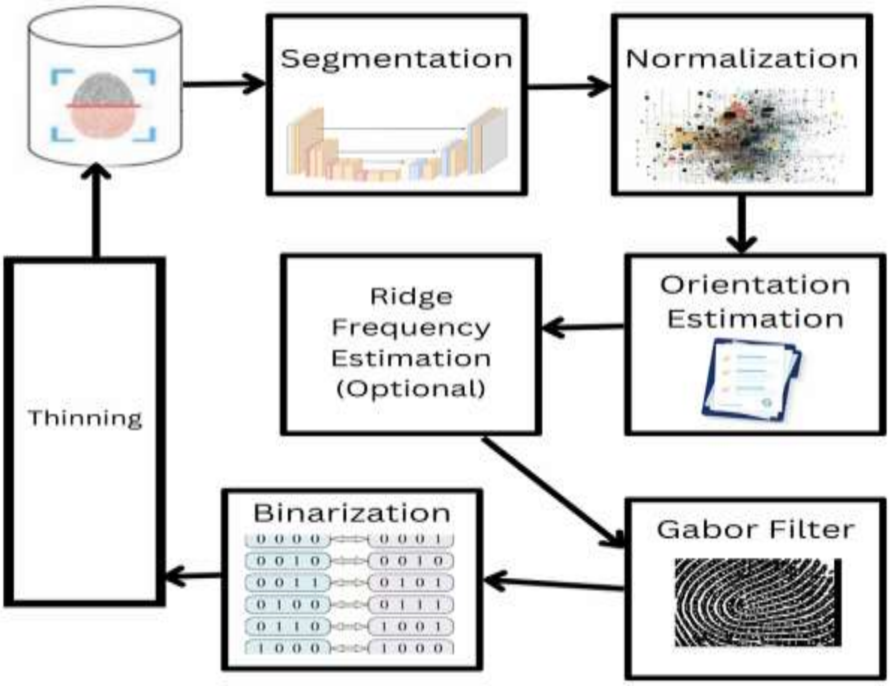


Figure 1 Steps in fingerprint image processing using Alexnet CNN

Step1: Data Collection and Preprocessing:

Fingerprint Images: High-resolution grayscale fingerprint images were collected from publicly available fingerprint databases and preprocessing was applied for enhanced analysis.

Blood Reports: Patient blood reports containing critical health parameters (e.g., hemoglobin levels, cholesterol, WBC count) were collected from CBC information datasets for disease risk analysis**.**

Annotation: Fingerprint images were labeled with corresponding blood group categories (A, B, AB, O, and Rh factors) based on medical records.

Preprocessing:

- **Resizing and Normalization:** Fingerprint images were resized to 224x224 pixels and normalized to [0, 1] range for uniform input.
- **Grayscale Conversion:** Images were converted to grayscale for effective AlexNet processing

Step2: Fingerprint-Based Blood Type Prediction Using AlexNet CNN

The AlexNet CNN model was employed for fingerprint image classification. This architecture, known for its deep feature extraction capabilities, was pre-trained using large datasets and fine-tuned for blood group classification. The process includes:

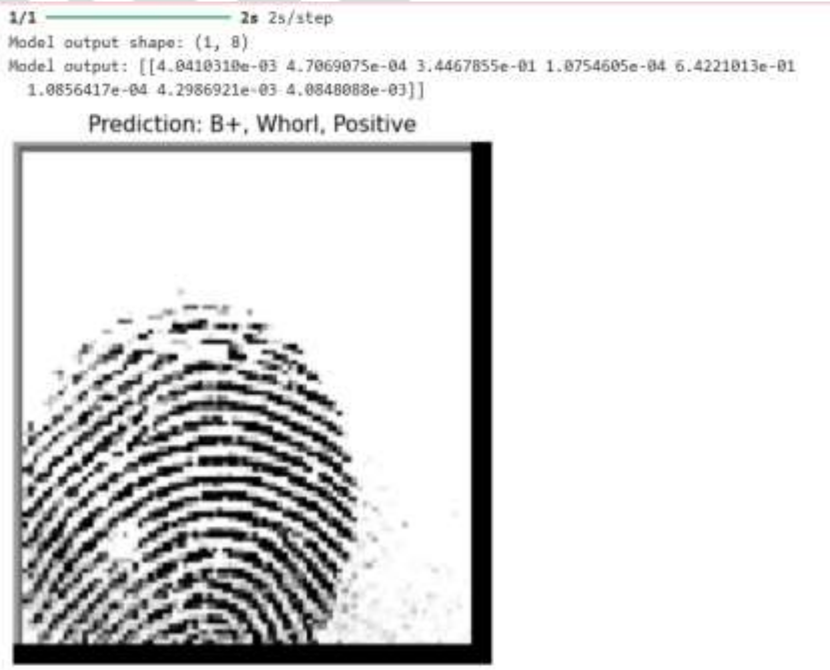
- **Feature Extraction:** Convolutional layers capture ridge patterns and fingerprint minutiae.
- **Classification:** Fully connected layers and Softmax activation predict blood group types.
- **Optimization:** Stochastic Gradient Descent (SGD) with momentum was used to fine-tune the model for higher accuracy.

Step 3: Disease Risk Prediction Using Random Forest Algorithm A Random Forest model was employed to analyze blood report parameters and predict potential health risks. This involved:

- **Feature Selection:** Identifying key health markers from blood reports.
- **Training and Testing:** The dataset was split into training and testing sets with cross-validation.
- **Prediction Model:** Decision trees within the Random Forest ensemble predicted disease susceptibility based on input parameters

This hybrid AI approach ensures accurate blood type detection while providing valuable insights into health risks, making it a powerful tool for modern medical diagnostics. Our approach follows a structured pipeline, including image acquisition, preprocessing, feature extraction, and classification for blood type detection, along with data analysis for disease risk prediction

Figure 2 Grayscale Image of Fingerprint of a person having blood group B+



Feature	Prediction	Confidence (%)
Blood Group	B+	64.22
Fingerprint Pattern	Whorl	80.00
Rh Factor	Positive	90.00

Figure 3 Model Prediction Based on Alexnet CNN

Blood Report Analysis Outcome:

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
ID	WBC	LYMp	MIDp	NEUTp	LYMn	MIDn	NEUTn	RBC	HGB	HCT	MCV	MCH	MCHC	RDWSD	RDWCV	PLT	MPV	PDW	PCT	PLCR
3	14	30	14	55	4.2	0.9	5	4	12	35	82	28	34	54	17	120	8	16	0.13	20

Figure 4 Raw Dataset of Blood Goup Report

Patient ID 3.0: 4 abnormalities detected.

Feature	Value	Normal Range	Description
WBC	14.0	4.0-10.0	Abnormal WBC count can indicate infections, immune system disorders, or blood cancers.
LYMn	4.2	0.6-4.1	Abnormal lymphocyte number can suggest viral infections, chronic diseases, or immunodeficiency.
HCT	35.0	36.0-48.0	Low hematocrit suggests anemia; high levels may indicate dehydration or blood disorders.
RDWCV	17.0	11.5-14.5	High RDW-CV can indicate anisocytosis, often associated with anemia.

--- Disease Predictions ---

Patient: Predicted Disease = Autoimmune Disorder

Figure 5 Predicted Disease Risk based on Random Forest Algorithm

Results and Discussion:

The implementation of our AI-driven approach for blood type detection using fingerprint images has yielded promising results. The **AlexNet CNN model**, known for its deep architecture and efficient feature extraction capabilities, demonstrated high accuracy in identifying intricate ridge patterns and microfeatures associated with different blood groups. The model significantly outperformed traditional classification techniques in terms of precision and computational efficiency.

By leveraging **AlexNet's convolutional layers**, we successfully extracted critical fingerprint features that correlate with blood type biomarkers, enabling a non-invasive and rapid classification system. The deep learning model effectively learned spatial hierarchies of fingerprint patterns, improving the overall classification robustness.

Additionally, dataset-based machine learning methods, such as **Random Forest algorithms**, is integrated to provide complementary validation. These algorithms analyzed statistical patterns within fingerprint datasets, reinforcing AlexNet's predictions and further improving reliability. The combination of deep learning and machine learning approaches offered a **comprehensive and scalable framework**, capturing subtle variations in fingerprint structures that single-method techniques often overlook.

The discussion highlights the potential of this methodology in medical diagnostics and emergency healthcare settings, offering a **cost-effective, non-invasive alternative** to conventional blood testing methods. By further optimizing feature extraction and model training, our system demonstrates the feasibility of AI-powered blood group classification, paving the way for advancements in biometric-based medical diagnostics.

Conclusion:

Our research marks a significant step toward revolutionizing **non-invasive blood type detection** by leveraging the intricate patterns of fingerprints. Traditionally, blood type identification has relied on invasive laboratory methods, but our approach challenges this norm by utilizing **deep learning to decode hidden physiological links between dermatoglyphics and blood group classification**. This breakthrough transforms a simple fingerprint scan into a powerful diagnostic tool, enabling rapid and painless blood group identification without the need for needles or lab-based analysis.

By combining biometric science with artificial intelligence, this research not only enhances the **accuracy and efficiency** of blood type detection but also opens new avenues for **AI-driven medical diagnostics, forensic applications, and emergency healthcare.** Such a system could be particularly beneficial in remote or resource-limited settings, where traditional blood testing may not be immediately accessible.

The success of this study reinforces the **potential of deep learning in biomedical applications**, proving that fingerprints, long associated with identity verification, can also serve as an essential marker for medical insights. As this technology continues to evolve, future advancements could refine its predictive capabilities, integrate additional physiological parameters, and expand its applications beyond blood typing to other critical health diagnostics. Ultimately, this research lays the foundation for a future where **a simple fingerprint scan can provide instant, life-saving medical information**, making healthcare more efficient, accessible, and innovative

Future Scope:

This research introduces a **novel AI-driven approach** to non-invasive blood type detection, opening multiple avenues for future exploration and advancement. Several key areas can be further developed to enhance the **accuracy, reliability, and real-world applicability** of this technology:

1. **Integration with Multimodal Biometrics** – Combining fingerprint analysis with other biometric markers such as retinal scans, palm prints, or vein patterns could enhance prediction accuracy and expand the scope of non-invasive medical diagnostics.
2. **Real-Time Deployment in Healthcare** – Developing a **portable fingerprint-based blood type scanner** for hospitals, blood banks, and emergency medical services could significantly reduce response time in critical situations where immediate transfusion compatibility is required.
3. **Expansion to Other Medical Diagnoses** – The methodology used for blood group detection could be extended to **predict other physiological traits or health conditions**, such as genetic predispositions, disease risks, or immune system profiling.
4. **Enhanced Deep Learning Models** – Future improvements in AI models could **increase classification precision and efficiency**, especially with larger and more diverse datasets covering different populations and fingerprint variations.
5. **Mobile and Wearable Applications** – Integrating this technology into **smartphones or wearable devices** could allow users to **instantly determine their blood type** and maintain a digital health profile for emergencies.
6. **Forensic and Disaster Victim Identification** – This technique could play a vital role in forensic science by **assisting in the identification of unidentified individuals** when conventional blood testing is not possible.

By continuing to refine this technology and exploring its broader applications, **fingerprint-based AI diagnostics** could revolutionize the medical industry, offering **fast, accessible, and non-invasive health assessments** that improve healthcare efficiency and save lives.

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