**Fingerprint-Based Blood Group Prediction Using Deep Learning Architectures for Non-Invasive Healthcare Applications**

Accurate and rapid blood group identification is vital in emergency medicine, transfusion safety, and healthcare. Traditional serological techniques, while dependable, are invasive, slow, and depend on laboratory infrastructure. This study explores fingerprint images as a non-invasive biometric method for blood group prediction using advanced deep learning models. The main goal is to evaluate and compare cutting-edge architectures to find the most effective and reliable model suitable for real-world use. A comprehensive fingerprint image dataset was preprocessed with augmentation, normalization, and noise reduction techniques. Several models, including CNN variants (Xception, InceptionV3, SEResNet50), lightweight architectures (MobileNetV3, EfficientNetV2-S), transformer-based models (ViT, SwinV2), and ConvNeXt variants, were trained and assessed using accuracy, precision, recall, F1-score, log-loss, and Brier score as metrics. MobileNetV3-Large achieved the highest accuracy of 98.51% with the lowest Brier score (0.0039), showing superior prediction confidence and efficiency. EfficientNetV2-S and RegNetY-032 also performed well with accuracy above 96%. The results show that fingerprint-based deep learning provides a feasible non-invasive alternative for blood group detection, with lightweight models enabling practical use in mobile or point-of-care systems. This research advances healthcare by offering a scalable, fast, and accurate method for patient identification and blood group determination, with potential use in emergency medicine, rural healthcare, and biometric health records.

**Keywords**: Fingerprint recognition, Blood group prediction, Deep Learning, MobileNetV3, Non-invasive healthcare

**Introduction**

Blood group identification is fundamental for safe transfusions, emergency care, and clinical diagnostics. Conventional serological tests, though accurate, are invasive and require laboratory facilities, which can delay critical interventions. Non-invasive alternatives, such as fingerprint-based prediction, provide a promising solution for rapid, accessible, and patient-friendly blood group determination. Fingerprints contain unique patterns that, when analyzed with advanced machine learning, may reveal correlations suitable for automated prediction. This study explores the application of deep learning architectures to achieve high-accuracy, non-invasive blood group classification.

**Objectives**

The primary aim of this study is to develop a non-invasive method for predicting human blood groups using fingerprint images. To achieve this, the research focuses on designing and implementing advanced deep learning architectures capable of accurately classifying fingerprints into their respective blood groups. The study also seeks to evaluate and compare the performance of different deep learning models using standard metrics, including accuracy, precision, recall, and F1-score. Ultimately, the goal is to propose a rapid and patient-friendly approach that can complement or even replace traditional serological testing, particularly in emergency and clinical scenarios where timely blood group determination is critical.

**Data**   
The study uses a fingerprint image dataset obtained from Kaggle. The dataset consists of **over 8,000 fingerprint images**, distributed evenly across **eight blood groups**, with approximately **1,000 images per blood group**. Each image is preprocessed and resized to suit deep learning model input requirements. Data augmentation techniques, including rotation, flipping, and scaling, are applied to enhance model generalization and improve prediction accuracy.

**Literature Review**

Recent studies have highlighted the potential of fingerprint-based biometric systems for non-invasive health applications, including blood group prediction and patient authentication. Traditional serological methods, while accurate, are invasive and require laboratory infrastructure, motivating research into rapid and accessible alternatives. Deep learning architectures, particularly Convolutional Neural Networks (CNNs) and lightweight models such as MobileNet, have demonstrated high predictive performance for classifying fingerprint images into blood groups, achieving accuracy exceeding 92% in several studies. Furthermore, advanced preprocessing techniques, including noise reduction, normalization, contrast enhancement, and data augmentation, have proven essential for improving model robustness across diverse datasets. While statistical analyses of basic fingerprint patterns often indicate weak correlations with blood group, machine learning approaches can extract complex, non-linear features that enable meaningful predictive performance, highlighting the superiority of automated models over traditional heuristic methods.

Despite these advancements, challenges remain in dataset diversity, class imbalance, and generalizability. Rare blood groups often show lower prediction performance, and models trained on specific populations or devices may underperform when deployed elsewhere. Emerging solutions include synthetic data generation, multimodal biometric integration, and lightweight, mobile-compatible deep learning architectures for real-time deployment. Studies also suggest that explainable AI techniques could improve model transparency and trust in clinical applications. Collectively, these findings establish a foundation for the current research, which aims to leverage deep learning models to develop a non-invasive, efficient, and accurate fingerprint-based blood group prediction system suitable for practical healthcare and point-of-care use.

**Methodology**A diagram of a model training

AI-generated content may be incorrect.

**Results and Discussion**

In fingerprint-based blood group prediction, the results demonstrate that MobileNetV3-Large achieved the best overall performance, reaching the highest accuracy of 98.51%, precision of 98.52%, and F1-score of 98.51%, along with the lowest Brier score (0.0039) and log loss (0.0763), making it the most reliable and generalizable model. This was closely followed by EfficientNetV2-S (accuracy 97.79%) and RegNetY-032 (accuracy 96.94%), both of which also demonstrated strong predictive capabilities with low error rates, suggesting that advanced convolutional architectures are highly effective in capturing fingerprint patterns for non-invasive blood group classification. ConvNeXtV2-Tiny (accuracy 96.34%) and SwinV2-Tiny (accuracy 94.89%) also performed competitively, indicating the robustness of transformer-based and next-generation convolutional models. On the other hand, traditional architectures such as InceptionV3 (86.00%) and MobileNetV3-Small (82.00%) showed weaker performance with higher log loss and Brier scores, reflecting their limited generalization ability compared to modern deep learning architectures. Interestingly, Xception (92.00%) and ViT-Base-Patch16-224 (90.02%) maintained good accuracy, though not at par with MobileNetV3-Large or EfficientNetV2-S. Overall, the findings highlight that **lightweight yet advanced architectures like MobileNetV3-Large and EfficientNetV2-S outperform older models**, establishing deep learning as a powerful tool for non-invasive, rapid, and patient-friendly blood group prediction using fingerprint images.

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| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Model | Accuracy | Precision | F1-Score | Brier Score | Log Loss | | ConvNeXtV2-Tiny | 0.9634 | 0.9648 | 0.9635 | 0.0073 | 0.1112 | | ConvNeXtV2-Small | 0.8742 | 0.8788 | 0.8738 | 0.0224 | 0.3310 | | SwinV2-Tiny | 0.9489 | 0.9504 | 0.9489 | 0.0096 | 0.1419 | | EfficientNetV2-S | 0.9779 | 0.9793 | 0.9778 | 0.0047 | 0.0810 | | MobileNetV3-Large | 0.9851 | 0.9852 | 0.9851 | 0.0039 | 0.0763 | | MobileNetV3-Small | 0.8200 | 0.8400 | 0.8200 | 0.2686 | 0.4956 | | InceptionV3 | 0.8600 | 0.8700 | 0.8600 | 0.2318 | 0.4149 | | Xception | 0.9200 | 0.9200 | 0.9200 | 0.0878 | 0.1765 | | ViT | 0.9002 | 0.9141 | 0.9014 | 0.0179 | 0.2605 | | RegNetY-032 | 0.9694 | 0.9701 | 0.9690 | 0.0065 | 0.1092 | | SEResNet50 | 0.9370 | 0.9395 | 0.9373 | 0.0131 | 0.2152 | |

**Implications/Conclusions**

The findings of this study demonstrate that fingerprint-based deep learning models provide a **reliable, rapid, and non-invasive method** for blood group prediction, with lightweight architectures like MobileNetV3-Large and EfficientNetV2-S achieving the highest accuracy, precision, and F1-scores while maintaining low Brier scores and log loss. These results highlight the potential of such models for **practical deployment in emergency care, rural healthcare, and point-of-care settings**, where traditional serological testing may be time-consuming or inaccessible. Moreover, the successful integration of advanced CNNs and transformer-based models underscores the effectiveness of deep learning in capturing intricate fingerprint patterns for biometric-based healthcare applications. Overall, this research establishes a scalable framework for non-invasive blood group determination, offering **patient-friendly, fast, and accurate alternatives** that can complement or even replace conventional laboratory methods in clinical and real-world scenarios.

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