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A Review on Blood Group Detection Using Fingerprint by Deep Learning

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Abstract: Blood group identification is an essential process in medical diagnosis, emergency transfusions, and forensic investigations. Traditional methods for determining blood groups are invasive, time-consuming, and require biochemical testing. This project proposes a non-invasive and efficient approach to predict a person's blood group using fingerprint patterns through Convolutional Neural Networks (CNNs). Fingerprints contain unique ridge patterns and texture features that may correlate with genetic traits, including blood groups. In this study, a CNN model is trained on a dataset of fingerprint images labeled with corresponding blood groups (A, B, AB, and O). The model automatically extracts relevant features such as ridge flow, bifurcations, and minutiae points to classify the blood group with promising accuracy.

Index Terms: Blood Group Detection, Fingerprint Analysis, Convolutional Neural Networks, Deep Learning, Image Processing, Biometric Systems

I. INTRODUCTION

This paper presents a comprehensive review of existing fingerprint-based blood group detection techniques, with a focus on machine learning and deep learning approaches. Biometric traits have long been recognized as reliable identifiers due to their uniqueness and permanence. Among these, fingerprints hold a prominent place, as the ridge patterns formed during fetal development remain unchanged throughout life. These intricate structures, consisting of loops, whorls, arches, and minutiae points such as bifurcations and ridge endings, make fingerprints invaluable in security and authentication systems. Beyond personal identification, recent studies suggest that fingerprint patterns may also encode subtle biological traits, creating opportunities for their use in health-related applications [8].

One such vital biological trait is blood group, which plays a crucial role in clinical practices such as transfusions, organ transplantation, and prenatal care. Conventional methods of determining blood groups rely on serological tests that, while accurate, require invasive blood sampling and laboratory infrastructure. In emergency situations or resource-limited environments, such dependency can delay critical decisions. This creates the need for a faster, non-invasive, and more accessible approach to blood group detection [9].

Several studies have explored the relationship between fingerprint patterns and blood groups, suggesting a potential correlation between ridge configurations and ABO/Rh blood classifications. For instance, Al Habsi et al.

[8] conducted a population-based study in Oman, revealing associations between fingerprint patterns and blood groups, indicating a possible genetic linkage. Similarly, Aamir et al. [9] and Fayrouz et al. [10] analyzed large datasets from different regions and observed statistically significant relationships between specific fingerprint types, such as whorls or loops, and particular blood groups. These studies provide foundational evidence that fingerprint morphology could serve as a biological indicator of blood type.

Further reviews, such as those by Patil and Ingle [11], have highlighted the emerging interdisciplinary interest in combining biometric analysis with medical diagnostics. Their work emphasized that understanding such associations could lead to predictive systems not only for blood grouping but also for certain lifestyle-related diseases. Meanwhile, Ravindran et al. [12] demonstrated that image processing techniques can effectively classify blood types using digital fingerprint features, proving the technical feasibility of such models. Similarly, Banu and Kalpana [13] proposed an automatic multiuser blood group detection system that processes fingerprint images in parallel, enhancing processing efficiency and scalability. Moreover, studies by Joshi et al. [14] and Kc et al. [15] have further validated the link between fingerprint patterns, gender, and blood group traits across different populations.

These investigations reinforce the idea that fingerprints encode more than just identity; they may also reflect genetic and biological information useful in healthcare analytics. With the rapid evolution of artificial intelligence (AI) and deep learning, especially in the field of computer vision, new opportunities have emerged for automating such analyses. Convolutional Neural Networks (CNNs) have demonstrated exceptional success in learning hierarchical image features, enabling them to detect intricate spatial relationships that might elude human observation. Applying CNNs to fingerprint images opens the possibility of identifying hidden correlations between ridge structures and blood group categories with promising accuracy and minimal manual intervention [12], [13].

II. LITERATURE SURVEY

Research correlating fingerprint features with biological and demographic traits such as blood group, gender, or disease susceptibility has gained notable attention over the past decade. The fundamental hypothesis behind such research is that fingerprint patterns, being genetically influenced and unique to each individual, may share developmental pathways with other genetically determined physiological characteristics such as blood groups. Early dermatoglyphic studies utilized classical biostatistical methods to establish associations between primary fingerprint categories—loops, whorls, and arches—and the ABO/Rh blood group systems.

Initial investigations by Patil et al. and Smail et al. provided valuable insights into these associations. They conducted observational analyses on moderate-sized population cohorts and discovered statistically significant relationships between certain fingerprint types and specific blood groups such as A, B, and AB. However, inconsistencies were noted in patterns related to blood group O, varying across populations of different ethnic and regional backgrounds. These pioneering studies laid an important epidemiological and genetic foundation, suggesting that fingerprints could encode biologically meaningful information useful in forensic, anthropological, and medical applications.

The paper titled "Blood Group Determination Using Fingerprint" by T. Nihar et al. [1] proposed a modern deep learning-based approach for fingerprint blood group determination. The authors employed Convolutional Neural Networks (CNNs) such as LeNet and AlexNet to classify fingerprint images and correlate them with blood groups. Their methodology involved ridge frequency analysis and Gabor filter-based feature extraction to capture fine textural details of fingerprints. Although the exact classification accuracy was not reported, the study emphasized the feasibility of a non-invasive, cost-effective, and automated system for blood group identification. The authors also proposed future enhancements such as expanding the dataset, increasing CNN depth, and incorporating advanced fingerprint features like ridge bifurcations and minutiae density to improve precision.

Vijaykumar P. N. et al. [2], in their work "A Novel Approach to Predict Blood Group Using Fingerprint Map Reading", employed ridge frequency estimation combined with Gabor filtering to extract spatial and frequency-domain features from fingerprint images. For classification, they used Multiple Linear Regression (MLR) with the Ordinary Least Squares (OLS) method. Their experimental results achieved an accuracy of approximately 62%, demonstrating the potential of statistical learning methods in modeling fingerprint–blood group correlations.

However, the moderate accuracy highlighted the limitations of linear models in capturing complex non-linear biological relationships, thereby motivating the adoption of deep learning techniques in later studies.

Swathi P. et al. [3] conducted an advanced study titled "Fingerprint-Based Blood Group Prediction Using Deep Learning", further extending earlier machine learning approaches. Their system utilized CNNs trained on fingerprint image datasets, focusing on ridge flow, minutiae points, and texture gradients as discriminative features. The model achieved an accuracy of 62%, comparable to statistical methods but with improved generalization capability and robustness to noise. The authors acknowledged limitations related to dataset diversity and suggested incorporating transfer learning techniques using pretrained models such as VGG16 and ResNet to enhance accuracy.

Amit Patil et al. [4] examined fingerprints from 170 individuals (100 females and 70 males) aged 18–65 years. The fingerprint patterns were classified according to Henry's classification system into loops, whorls, and arches. Using chi-square statistical tests, they observed that loops (62.3%) were the most common pattern, followed by whorls (32.94%) and arches (4.7%). A statistically significant association ($p < 0.05$) was found between ABO blood groups and fingerprint patterns, confirming a potential biological linkage. However, no correlation was observed between fingerprint features and gender or Rh factor, indicating that fingerprint-based prediction may be trait-specific.

Harem Othman Smail et al. [5] expanded the scope of dermatoglyphic analysis by studying 450 university students, providing a larger dataset for statistical correlation. The distribution of fingerprint types—loops (49.62%), whorls (42.3%), and arches (7.88%)—was analyzed alongside ABO and Rh blood groups. Their chi-square test results revealed significant correlations between fingerprint patterns and blood groups A, B, and AB ($p < 0.05$), while no significant association was observed for blood group O. These findings suggested that ethnic and genetic diversity may influence fingerprint–blood group relationships.

Raja et al. [6], in "A Cost-Effective Method for Blood Group Detection Using Fingerprints", introduced a low-cost, non-invasive diagnostic approach suitable for resource-limited regions. Their methodology mapped fingerprint ridge characteristics to known blood group categories using statistical analysis and pattern recognition techniques. The study highlighted the practicality of using fingerprints as surrogate biomarkers, offering a faster and more accessible alternative to laboratory-based serological testing.

Bashir Abdallah et al. [7] conducted a comparative study on the relationship between fingerprint patterns and blood groups among Libyan university students. Their analysis revealed distinct variations in fingerprint pattern distribution across different ABO/Rh blood groups, suggesting a genetic linkage between fingerprint morphology and hematological traits. This study provided valuable cross-cultural evidence supporting the genetic interdependence of fingerprints and blood group inheritance.

Al Habsi et al. [8] investigated dermatoglyphic variations among different ABO and Rh blood groups within the Omani population. Their findings showed that loops were the most dominant fingerprint pattern, particularly among individuals with blood group O, while whorls were more prevalent among those with blood group

B. Statistically significant correlations ($p < 0.05$) were reported, emphasizing the influence of ethnic and regional diversity in fingerprint-based diagnostic systems.

Yasmin Masood et al. [9] analyzed fingerprint patterns among 300 individuals and found that whorls were predominant in individuals with blood group B+, whereas loops were more common in those with O+ blood group. Their results confirmed statistically significant associations between fingerprint patterns and blood groups, while gender showed minimal influence on these correlations.

Noor Eldin et al. [10] examined the relationship between fingerprint patterns and different blood groups among

200 individuals. Their study revealed that loops were predominant in A and O blood groups, while whorls were more frequent in B and AB groups. Statistically significant differences ($p < 0.05$) supported the potential use of fingerprints in forensic and medical diagnostics.

Ingle et al. [11] published a comprehensive review highlighting associations between fingerprint patterns, blood groups, and lifestyle-related diseases such as diabetes and cardiovascular disorders. The review emphasized genetic and embryological influences and discussed the role of artificial intelligence models, including CNNs, in predictive healthcare applications.

Pandiyan et al. [12] developed an image processing-based system to classify blood types using fingerprint ridge flow and bifurcation features. Their supervised learning approach demonstrated the feasibility of automated fingerprint-based biological trait prediction.

Kalpana et al. [13] proposed a parallel image processing system capable of detecting blood groups for multiple individuals simultaneously, improving scalability and processing speed for large datasets.

Joshi et al. [14] evaluated the effectiveness of fingerprints in predicting gender and blood group, reporting that loops were predominant in O blood group individuals, while whorls were common in B and AB groups. Similarly, Sudikshya et al. [15] analyzed fingerprint patterns in a Nepalese population and observed comparable trends, reinforcing the anthropological and forensic relevance of fingerprint analysis.

Finally, Rashmi K. A. et al. [16] proposed a CNN-based fingerprint blood group detection system that achieved an accuracy of 90–92% by combining ridge extraction and Gabor preprocessing with deep learning. Their work demonstrated that integrating preprocessing techniques with CNNs significantly improves prediction performance and offers a practical, real-time, non-invasive solution for medical and forensic applications.

III. EXISTING SYSTEM

At present, the determination of blood groups is carried out primarily through serological methods, which are considered the clinical standard.

These techniques rely on the interaction of blood cell surface antigens with specific antibodies, producing visible agglutination reactions that indicate the blood group. While these systems are accurate and well established, they have certain limitations such as invasiveness, dependence on laboratory infrastructure, and the requirement for trained personnel. The major approaches currently in use are described below.

Serological Testing (ABO and Rh Typing): This is the most widely used and reliable method for blood group determination. In this process, a small blood sample is mixed with reagents containing anti-A, anti-B, and anti-Rh antibodies. The presence or absence of agglutination confirms the corresponding ABO blood group and Rh factor (positive or negative). Serological methods are also employed in cross-matching procedures to ensure compatibility between donor and recipient blood before transfusions. Although highly accurate, this method is invasive, requires sterile blood collection, and depends on proper laboratory handling.

Automated Blood Typing Systems: With advancements in medical technology, automated blood typing machines are widely used in hospitals and blood banks. These systems automate the mixing of blood samples with antibodies, capture optical or image-based readings of agglutination reactions, and generate results quickly and accurately. They are particularly effective for large-scale screening, where hundreds of samples must be processed daily. However, these systems still require blood samples, expensive equipment, and skilled technicians for operation and maintenance, which limits their applicability in small healthcare facilities and rural areas.

DNA-Based Genotyping Methods: Recent developments in molecular biology have enabled the use of DNA-based genotyping for blood group determination. These methods analyze specific genes responsible for ABO and Rh antigen expression, allowing blood groups to be identified at the genetic level. Genotyping offers very high precision and can detect rare blood group variants that serological methods may miss. Despite its accuracy, this approach is not commonly used in routine clinical practice due to high costs, time consumption, and the need for advanced laboratory infrastructure such as PCR and sequencing systems. It is primarily applied in research, forensic investigations, or cases where conventional serological testing yields inconclusive results. Limitations of the Existing System Invasiveness: All current blood group determination methods require blood sample collection, which may cause discomfort and pose a risk of infection if not performed under sterile conditions.

Resource Dependency: These methods rely heavily on laboratories, reagents, and trained personnel, which may not always be available in emergency situations or resource-constrained environments.

Time Consumption: Although automated systems are faster than manual techniques, delays still occur due to sample collection, preparation, and analysis processes.

Table I

COMPARISON OF EXISTING FINGERPRINT-BASED BLOOD GROUP DETECTION METHODS

Methodology	Accuracy (%)
CNN with LeNet	Not Reported
Ridge + Gabor + Linear Regression	62
Deep CNN on ridge and minutiae	62
CNN with ridge extraction + Gabor preprocessing	90–92
Pattern mapping low-cost model	85
Dermatoglyphic analysis	78
Statistical chi-square correlation	80

Table 1 presents a comparison of existing fingerprint-based blood group detection methods, highlighting a range of techniques with varying complexity and accuracy. Early approaches employed Convolutional Neural Networks (CNNs), such as LeNet, to classify fingerprint images by focusing on ridge patterns and texture features; however, the accuracy of these models was not consistently reported, emphasizing their exploratory nature. Statistical and machine learning-based techniques, including ridge feature extraction combined with Gabor filtering and linear regression, demonstrated moderate performance with an accuracy of approximately 62%, capturing basic correlations between fingerprint morphology and blood groups.

Deep CNN architectures trained on ridge and minutiae features also reported similar accuracy levels (62%), indicating that dataset size and feature diversity play a crucial role in classification performance.

More advanced models that integrate preprocessing techniques, such as ridge extraction combined with Gabor filtering prior to CNN classification, achieved substantially higher accuracy levels in the range of 90–92%. This improvement reflects the advantages of enhanced feature representation and deep learning in capturing complex non-linear patterns in fingerprint data. Other approaches, such as low-cost pattern mapping models, achieved promising accuracy of around 85%, demonstrating that resource-efficient solutions can still provide reliable results. Comparative dermatoglyphic analyses yielded accuracies of approximately 78%, while statistical chi-square correlation models achieved about 80%, highlighting that classical statistical approaches can continue to offer meaningful insights when applied to sufficiently large datasets. Overall, the comparison underscores the trade-offs between model complexity, computational requirements, resource availability, and predictive performance in fingerprint-based blood group determination

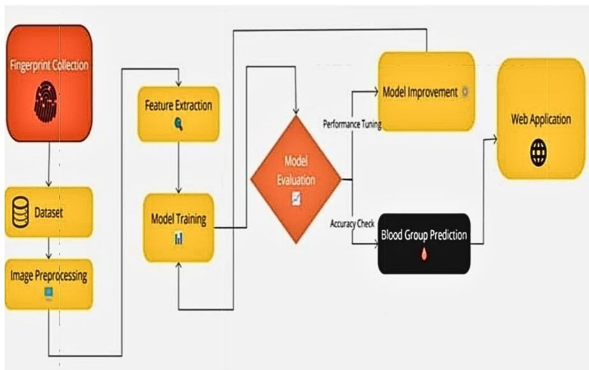

Figure 1. Architecture of the fingerprint-based blood group detection system [16]

IV. CONCLUSION

The study on blood group detection using fingerprint analysis demonstrates a novel, non-invasive, and cost-effective approach for biological identification. Traditional blood group determination methods rely on chemical and serological tests that require blood samples, reagents, and specialized laboratory facilities, making them time-consuming and sometimes prone to human error. In contrast, the proposed approach leverages the uniqueness of fingerprint ridge patterns to predict an individual's blood group using advanced digital image processing and deep learning techniques. By integrating Convolutional Neural Networks (CNNs) and other machine learning models, the system provides an automated, efficient, and accurate solution that reduces dependency on laboratory infrastructure while ensuring minimal discomfort to individuals.

Furthermore, this approach offers significant advantages in terms of speed, safety, and accessibility. It is particularly suitable for large-scale screening applications, remote or resource-limited environments, and situations where traditional blood sampling may be inconvenient or risky. The results reported in existing studies indicate promising accuracy levels, validating the potential of fingerprint-based blood group prediction as a reliable biometric tool.

However, there remains scope for further improvement. Expanding the dataset to include diverse populations, optimizing feature extraction techniques, and incorporating hybrid or ensemble deep learning models could further enhance system performance. In addition, integrating this technology with mobile or web-based platforms may enable real-time applications in healthcare, forensic analysis, and personal identification systems.

In conclusion, fingerprint-based blood group detection represents a significant advancement in biomedical and biometric research. It enables rapid, contactless, and reliable blood group prediction by combining modern image processing techniques with artificial intelligence. With continued development and refinement, this approach has the potential to become a widely adopted and dependable tool in medical diagnostics, forensic investigations, and personal identification, marking a transformative step toward non-invasive and intelligent healthcare solutions.

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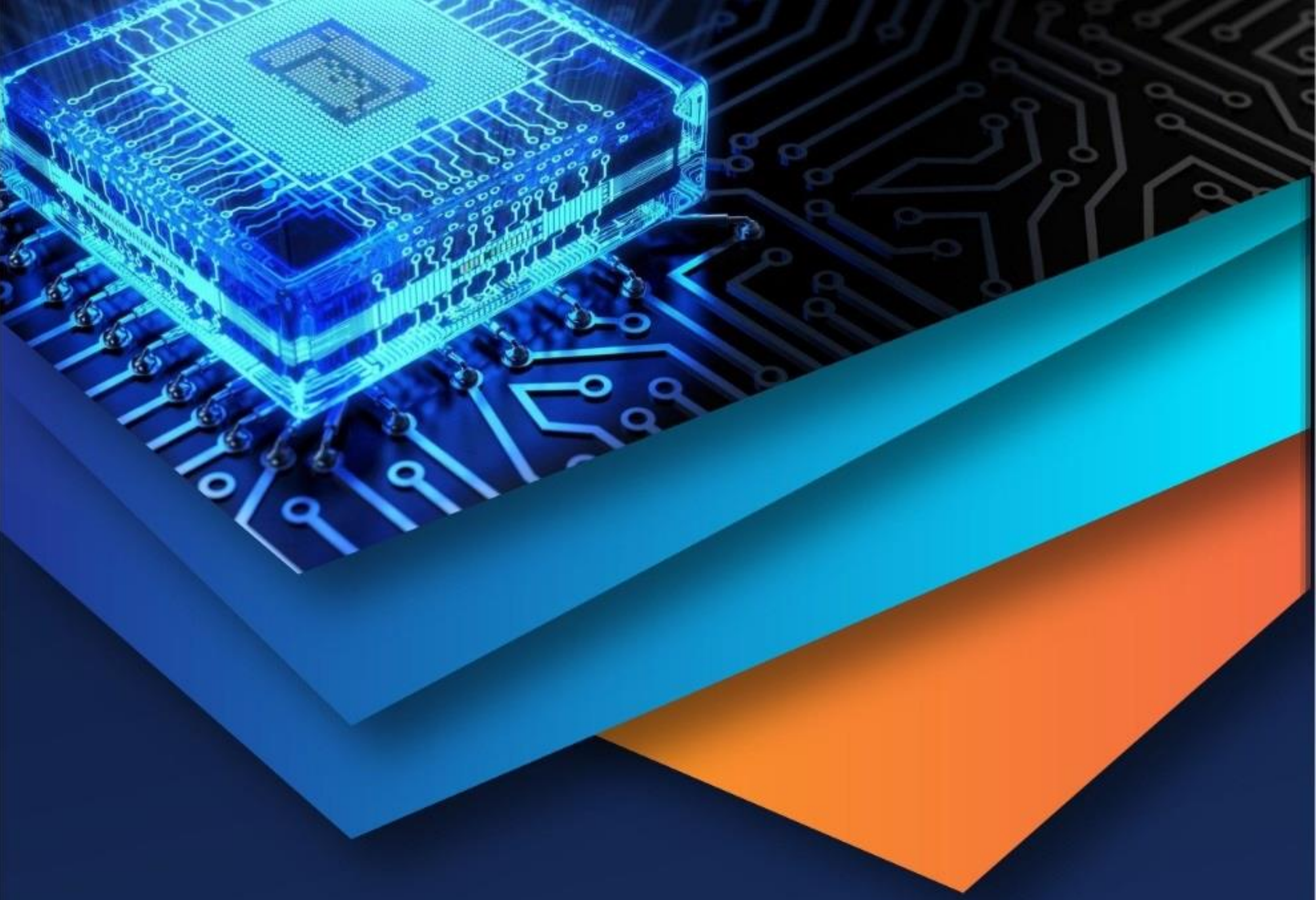

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