A Comprehensive Review of AI Applications in Smart Healthcare Systems

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***Abstract*— This study explores current developments in the use of artificial intelligence (AI) for healthcare applications, with particular emphasis on predicting cardiovascular conditions, identifying blood groups, scheduling clinical appointments, and optimizing emergency ambulance services. Techniques involving deep learning—such as Convolutional Neural Networks (CNN), EfficientNet, InceptionV3, and MobileNetV2—are commonly used for processing images like retinal and fingerprint scans. The reviewed literature showcases how these approaches support early diagnosis, enable contactless blood group determination, and assist in continuous patient tracking. The literature highlights emerging challenges including model explainability, dataset limitations, integration with hospital infrastructure, and the need for scalable, secure, and patient-centered solutions.**

***Index Terms*— Artificial Intelligence, CNN, Retinal Images, Blood Group Detection, Fingerprint, Smart Ambulance, OPD Booking, Healthcare**

I. INTRODUCTION

The healthcare sector worldwide has been rapidly growing due to the increasing need for timely, cost-effective, and patient-focused services. Conventional medical practices, which typically rely on manual workflows and outdated infrastructure, are now being augmented by digital technologies to improve service delivery, are increasingly being supplemented or replaced by intelligent, automated solutions that enhance diagnosis, patient management, and emergency response. The combination of both information and communication technologies (ICT) in healthcare—collectively known as e-health—has opened new ways for improving patient care, reducing costs, and enabling remote services.

One of the most promising developments in this domain is the application of artificial intelligence (AI) and image processing in clinical diagnostics and hospital management. Deep learning algorithms such as Convolutional Neural Networks (CNNs) have shown high accuracy in detecting complex medical conditions from imaging data, including retinal scans and fingerprint patterns. These non-invasive techniques offer faster diagnosis and better resource utilization compared to conventional methods. Additionally, biometric systems, smart ambulance frameworks, and online appointment platforms contribute to the growing ecosystem of smart healthcare solutions. As healthcare becomes more patient-centric and data-driven, these innovations play a vital role in expanding access, improving outcomes, and enhancing operational efficiency across urban and rural settings alike.

II. LITERATURE SURVEY

In this section, various authors have presented various face recognition and detection techniques.

S. Shaikh et.al[1] developed a model where it presents a hybrid artificial intelligence model designed for the early detection of heart conditions through the analysis of retinal scans. The approach integrates U-Net for precise identification of blood vessel structures and combines its output with convolutional neural networks and other algorithms for diagnostic classification. Image quality and feature detail are improved through techniques like CLAHE and gamma enhancement. The researchers utilized the DRIVE dataset for training, achieving a segmentation accuracy of 96.54%. Although the method yields accurate results and relies on a non-invasive approach.

U. Gawande et.al[2] developed a model where it introduces a real-time prediction framework for cardiovascular conditions using convolutional neural networks on retinal fundus imagery. The model incorporates several advanced architectures, including VGG, ResNet, and EfficientNet, and also features a specialized HDP-CNN utilizing focal loss to address class imbalance issues. To enhance clarity in image features, CLAHE preprocessing is applied. The proposed system is deployed as an online health assessment platform that supports browser-based access, achieving a validation accuracy of 84%. Its lightweight design makes it suitable for integration into digital healthcare interfaces, although interpretability and handling of atypical cases remain areas for further improvement.

T. Vineetha et.al[3] developed a model where it presents a specialized convolutional neural network designed to categorize retinal images for cardiovascular analysis. Unlike conventional methods like ECG, this approach relies on fundus image interpretation. The model achieved high accuracy, reporting 97% during training and 96% in testing. These results support the potential of using retinal scans as a non-invasive tool for heart disease screening. However, the CNN's internal operations remain opaque, leading to ongoing concerns about the explainability and clinical reliability of its predictions

B. Rose et.al[4] developed a model where it introduces a deep learning method to evaluate heart disease risk non-invasively using colored fundus images. The authors leverage the InceptionV3 a deep learning framework based on CNN architecture to process over 6,000 retinal images annotated with clinical features such as blood pressure, hemoglobin, and BMI. The images undergo preprocessing steps including resizing to 299x299 pixels, normalization, and JPEG decoding before being passed to the CNN. The model achieves a high training accuracy of 97% and a testing accuracy of 96%, reflecting its robustness in detecting subtle indicators such as microaneurysms and vessel thickness variations. These retinal features are critical in identifying early signs of hypertension, diabetes, and other heart-related conditions. A key advantage of the model is its capability to autonomously detect layered image characteristics without needing human input. However, the authors note that the dataset's demographic homogeneity and the lack of explainable AI mechanisms limit the generalizability and clinical interpretability of the system. They propose enhancing the dataset with broader diversity and incorporating explainability techniques to build trust in real-world applications, particularly in medical diagnostics.

J. P. Li et.al[5] developed a model where it introduces a an integrated framework utilizing both feature selection strategies and classical classification models to determine contributing factors to heart disease by leveraging organized clinical data. The authors propose a unique technique for selecting key features known as FCMIM (Fast Conditional Mutual Information Maximization), which aims to isolate the most valuable and distinct data points ahead of model classification. These features will be the input into different ML algorithms such as SVM, logistic regression, K-Nearest Neighbors (KNN), Decision Trees, Naive Bayes, and Artificial Neural Networks (ANN). Among all the models, the FCMIM-SVM combination yielded the highest accuracy of 92.37%, reflecting a strong synergy between data-driven feature extraction and robust classification. The system is designed to work with digital medical records, enhancing its usability across online healthcare systems. However, challenges remain in aligning the model with diverse clinical data sources, especially due to inconsistencies in metadata and varying patient profiles. The study also notes limitations in generalizing results beyond the scope of the dataset used. To enhance applicability, the authors suggest integrating real-time clinical decision support, improving cross-domain data harmonization, and incorporating explainable AI components for transparent diagnostics.

S. Natarajan et.al[6] developed a model where it introduces an enhanced AlexNet-based CNN tailored for classifying blood groups from fingerprint data. The model achieved a prediction accuracy of 95.27% and was benchmarked against LeNet-5 and ZFNet, showing superior results. The system is efficient for real-time use, though it only supports ABO and Rh group classifications and may not generalize well to unseen data without a larger and more diverse dataset.

S. Pankaj et.al[7] developed a model where it presents a CNN-based approach to identify ABO and Rh blood groups from fingerprint images. The method uses sweat-based antigen pattern analysis which is combined with image processing to detect blood type, offering a non-invasive, needle-free alternative to traditional blood sampling. This technique is particularly useful in emergencies and for patients averse to needles. However, the model was developed using a limited dataset and covers only basic blood group systems, requiring expansion for broader use.

S. Bensbih et.al[8] developed a model where an image-based approach is proposed where the ridge lines in fingerprint images are segmented and equalized via histogram techniques prior to CNN-based analysis. Feature extraction is performed using Gabor filters, and the model is trained and tested using statistical validation methods like the Chi-square test. This approach is cost-effective and fast but still in early research stages, lacking real-world testing and clinical validation.

V. Akshay et.al[9] developed a model where it presents a dual-method system that classifies blood groups using both blood smear and fingerprint images via the MobileNetV2 architecture. The blood smear model, trained on a dataset of 750 images, achieved 100% accuracy, while the fingerprint-based model trained on 10,477 images yielded 94% training and 90% validation accuracy. The system is implemented using a Python-based backend (Flask) and a responsive web frontend using HTML, CSS, and JavaScript, enabling real-time predictions in clinical or remote environments. The authors highlight the advantage of MobileNetV2's lightweight architecture for deployment on mobile devices and low-resource settings. This system supports two modes: traditional blood image-based and fingerprint-based, providing flexibility for different use cases. However, the the fingerprint model performed somewhat worse, likely because of inconsistent image quality and the absence of uniform data collection procedures. The paper emphasizes the need for dataset expansion and refinement of the fingerprint model to reach parity with smear-based methods. Future directions include enhancing mobile compatibility, linking with digital health systems (EHR), and extending the system to multilingual and multi-format platforms for wider adoption.

Ruchit, P et.al[10] developed a model where it introduces a web-based framework employing deep CNNs to classify blood groups using fingerprint-based visuals. The architecture features a multi-step pipeline that includes image acquisition, grayscale conversion, contrast enhancement, Gaussian filtering for noise reduction, and subsequent classification using CNN layers. The model is deployed through a Flask application, enabling users to upload fingerprints and receive real-time blood group predictions. The system supports all eight major blood types and reports classification accuracy up to 98%, indicating strong potential for deployment in hospitals, emergency response systems, and rural clinics. A major innovation is the system's real-time response capability, which allows it to be used for rapid triaging or pre-transfusion blood typing. However, its performance is highly dependent on the quality and diversity of the fingerprint dataset, with variations in age, skin condition, or scanner resolution potentially affecting results. The authors suggest improvements in fingerprint acquisition methods, training on broader datasets, and eventual integration with mobile platforms or biometric health cards to enhance usability and reach in remote or underserved areas.

C. Thaijiam et.al[11] developed a model where it presents a web-based application for hospital appointment scheduling. It includes modules for patients and administrators, allowing appointment booking, cancellation, and payment through a secure interface. Admins can manage doctor availability, review feedback, and access historical records in real time. This system improves patient flow and reduces congestion in outpatient departments. Despite offering real-time access from any device, the system lacks support for emergency appointments and relies heavily on uninterrupted internet connectivity.

M. A. R. Abdeen et.al[12] developed a model where it presents a case study on the design and implementation of a web-based appointment booking system aimed at replacing traditional manual processes in hospitals. The system uses PHP and MySQL as the backend technologies and includes distinct login portals for patients, doctors, and administrators. The design process is informed by data flow diagrams (DFDs), class diagrams, and entity-relationship (ER) diagrams that define system logic and database relationships. Patients can search for doctors available for them, book appointments with them, and receive confirmation via SMS or email, while doctors can view and manage their schedules. Administrators maintain control over registrations, user access, and report generation. The system also integrates features like QR code generation for appointments and data security measures for protected access. Although effective in reducing appointment delays and improving workflow, the system can't not support mobile platforms or telemedicine consultations. Moreover, it does not combine with existing hospital information systems, which limits its utility in larger or more complex hospital environments. The authors highlight the need for future enhancements including mobile app deployment, Aadhaar-based login for Indian users, real-time video consultations, and secure cloud-based hosting for scalability and performance

Sanjana et.al[13] developed a model where the authors explore the implementation of online appointment systems (OAS) in Moroccan public hospitals and evaluate their impact on healthcare access and patient satisfaction. Using a qualitative methodology, the study collects data from structured interviews, field observations, and official documents across four hospitals over a four-month period. The analysis reveals that OAS platforms significantly reduce waiting times, improve transparency in scheduling, and enhance patient trust in healthcare services. The model supports email notifications and is seen as a critical component in shifting from provider-centered to patient-centered care. However, several challenges are identified, including digital illiteracy among patients, equipment shortages, staff overload, and infrastructural limitations, especially in rural hospitals. The paper argues that these issues hamper system adoption and reduce potential benefits. To overcome these barriers, the authors recommend integrating OAS with electronic health records, introducing mobile health (mHealth) tools, and providing digital literacy training for users. The study positions OAS as a vital tool for improving operational efficiency and patient experience, particularly when integrated into broader national health digitization efforts.

P. Thirumoorthi et.al[14] developed a model where it details the creation of a modular, web-based application that facilitates real-time appointment booking and schedule management. The system uses HTML, CSS, PHP, and MySQL for the front-end, server-side logic, and database layers, respectively. It is divided into user and administrator modules, with features including user registration, appointment browsing and booking, slot availability management, and administrative control over time slots and service offerings. The development follows an iterative approach, ensuring that each module is independently tested before final integration. BOOKAZOR ensures real-time updates to prevent double-booking and provides automated notifications to users about their appointments. While functionally sound, the platform lacks integration with mobile devices, external calendar systems (e.g., Google Calendar), or payment gateways. Furthermore, its security infrastructure is relatively basic, relying on minimal encryption and session control, which could raise concerns about data privacy and integrity in real-world deployments. The authors recommend future improvements including responsive mobile design, advanced authentication mechanisms, calendar synchronization, and a feedback system to collect user satisfaction data for continual service improvement.

V. N. Patil et.al[15] developed a model where a comprehensive appointment booking portal is proposed using the Django MVT framework. The system includes hospital comparison, online medical record access, and unique patient IDs to streamline health record management. Dijkstra's algorithm is used to find the nearest hospitals based on distance and availability, enhancing decision-making for users. The system reduces paperwork and simplifies booking, but concerns about data privacy, internet dependency, and integration with hospital EHRs are highlighted.

T. Nihar et.al[16] developed a model where it proposes an ambulance system that uses wearable sensors, smart glasses, and GPS to monitor patient conditions in real-time. A decision tree algorithm processes the urgency of the condition, traffic status, and hospital capabilities to select the most appropriate hospital. Medical data is transmitted to the hospital before patient arrival, which significantly improves preparedness and reduces treatment delays. However, implementing such a system requires expensive hardware and trained personnel, which may not be available in all regions.

Prasad, M et.al[17] developed a model where the authors present an advanced smart ambulance management framework aimed at minimizing response time and optimizing hospital selection in real-time. The system incorporates real-time data on traffic conditions, hospital workloads, and ambulance locations to support intelligent routing and dispatching decisions. Mathematical modeling is conducted using queuing theory (specifically Erlang-C) to simulate various EMS scenarios, while simulation results are used to validate system performance under different patient arrival rates and hospital capacities. The framework supports decision-making algorithms for ambulance assignment, dynamic route planning, and hospital destination selection based on estimated door-to-needle times. The case study conducted in Madinah, Saudi Arabia demonstrates significant improvements in reducing ambulance delays and patient wait times. By modeling spatial and temporal variations in traffic and hospital availability, the system adapts to real-world conditions and supports load balancing across hospitals. However, implementation depends heavily on the availability of high-speed internet, real-time data feeds, and modern infrastructure such as 5G networks, which may be limited in developing regions. The authors propose integrating smart diagnostic models to pre-process patient conditions en route and expanding the model to consider patient triage severity in future iterations.

M. A. R. Abdeen et.al[18] developed a model it investigates how the geographic placement of ambulance stations can affect EMS efficiency, using Stockholm, Sweden as a case study. The research analyzes real ambulance dispatch data in combination with Geographic Information System (GIS) simulations to evaluate how relocating a single ambulance station impacts response times and coverage areas. The findings show that even minimal relocations can significantly enhance emergency service efficiency, particularly in high-density urban areas. The authors use a quantitative, data-driven methodology, comparing current station placements with hypothetical optimized configurations based on historical travel times and demand concentration. The model assumes static variables such as crew availability and road conditions, which are held constant to isolate the effects of spatial placement. Although the results are highly accurate within the studied urban context, the model does not account for dynamic real-time conditions such as weather, ongoing traffic incidents, or varying patient severity levels. The study suggests that EMS planning should incorporate regular spatial audits and GIS-based optimization strategies, and that future work should explore multi-station configurations and adaptive deployment policies across different city types and health infrastructure system.

Tannmy Gupta et.al[19] developed a model where it introduces a biometric-based emergency system where patient fingerprints are scanned in the ambulance to retrieve their medical history. If the fingerprint matches a known patient, their data is automatically sent via email using SMTP to the nearest hospital based on GPS location. If not, predefined emergency messages are sent to alert the hospital. This system enhances early intervention but depends on prior fingerprint registration and network reliability for successful data transfer..

Gupta, D et.al[20] developed a model where the author develops a lightweight, AI-based blood group prediction system that supports both traditional blood smear imaging and non-invasive fingerprint analysis. The system uses the MobileNetV2 CNN architecture to classify input images into ABO and Rh blood groups, offering rapid results via a web interface. The blood smear component of the system, trained on 750 images, achieves 100% accuracy, while the fingerprint-based component, trained on a much larger dataset of 10,477 images, records 94% training accuracy and 90% validation accuracy. The system is implemented using Python, Flask, HTML, CSS, and JavaScript, and is optimized for use on low-resource devices, making it suitable for clinics, field hospitals, and mobile healthcare units. While the blood smear model is highly accurate, the fingerprint model faces minor accuracy challenges due to variability in input quality and user interaction. The study notes that this multi-modal approach enhances flexibility in clinical workflows, allowing for context-specific application. To improve the fingerprint model's performance, the paper suggests training on more diverse and high-quality datasets and improving preprocessing techniques. Future expansion includes embedding the system in handheld diagnostic devices, integrating it with EHR platforms, and enabling multilingual support for wider accessibility.

III. SUMMARY

The survey presents an AI-integrated smart healthcare system that addresses critical needs in cardiovascular disease prediction, blood group identification, OPD appointment scheduling, and emergency response through smart ambulances. Leveraging convolutional neural networks (CNNs), the system can non-invasively analyze retinal images to predict heart disease with high accuracy, thus enabling early intervention and better prognosis. Additionally, fingerprint-based blood group detection modules provide a rapid and contactless method for identifying ABO and Rh types, reducing delays in emergency transfusion scenarios.Multiple studies on hospital appointment systems show the effectiveness of web platforms for managing patient bookings, doctor schedules, and administrative workflows. These systems typically use backend technologies such as PHP, MySQL, or Django, and support features like QR-based verification, SMS/email notifications, and hospital comparisons. However, limitations remain in terms of integration with electronic health records (EHRs), lack of support for emergency appointments, and absence of telemedicine modules. Similarly, research on smart ambulance systems demonstrates the potential of GPS, biometric sensing, and decision-making algorithms to enhance rescue efficiency. Systems incorporating data transmission, real-time hospital selection, and wearable monitoring devices show promise, but face challenges related to infrastructure, cost, and data privacy. Overall, the literature reflects significant progress toward intelligent, responsive healthcare environments, while emphasizing the need for broader data diversity, real-time interoperability, and expanded mobile accessibility.

Overall, it demonstrates a cohesive and practical application of artificial intelligence in healthcare, combining automation, accessibility, and accuracy to enhance medical outcomes. It bridges gaps in traditional systems by offering a unified, real-time solution for preventive care, diagnostics, and emergency readiness, with the potential to improve healthcare delivery in both urban and underserved rural regions.

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