Doctor Appointment Booking and Handwriting Recognition System

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Abstract: This research paper presents a web-based application titled "Doctor Appointment Booking and Handwriting Recognition System" designed to address two primary challenges in the healthcare sector: (1) simplifying the appointment booking process between patients and doctors, and (2) enabling the digital recognition of handwritten prescriptions. The platform is developed using the MERN stack (MongoDB, Express.js, React.js, Node.js) and integrates an OCR (Optical Character Recognition) module powered by deep learning techniques. The OCR module leverages a Convolutional Neural Network (CNN) trained on a combination of the EMNIST dataset and synthetic medical data to recognize individual characters in handwritten prescriptions. This character-level recognition is enhanced through modular development, offering a simpler yet effective solution for prescription digitization. The system supports user-friendly interaction, where patients can book appointments with doctors based on availability, and doctors have the autonomy to approve or decline requests. The admin dashboard enables global oversight of registration, approvals, and operational activities. This paper discusses the system architecture, implementation methodology, challenges faced, and potential enhancements for future scalability and accuracy.

Keywords: *MERN, Doctor Appointment, OCR, Scheduling.*

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I. INTRODUCTION

Healthcare systems around the world are increasingly adopting digital platforms to streamline their services and improve accessibility for patients. A common challenge faced by patients and healthcare providers alike is the inefficiency of manual appointment scheduling and the difficulty in interpreting handwritten medical prescriptions. To address both these issues, we have developed a comprehensive system titled "Doctor Appointment Booking and Handwriting Recognition System," which offers an integrated solution using modern web technologies and deep learning-based Optical Character Recognition (OCR).

The system has two core modules. The first module is an appointment booking system, built using the MERN stack — MongoDB, Express.js, React.js, and Node.js. This component allows patients to register, log in, and book appointments with doctors. Doctors, in turn, have the ability to accept or reject booking requests. The flexibility of location-independent doctor registration is maintained, enabling broader connectivity and accessibility. Additionally, an admin panel is integrated into the system, allowing the administrator to manage and monitor all user and doctor activity, including registration approvals and application processing.

The second module addresses the often-overlooked challenge of digitizing handwritten prescriptions. Prescriptions written by doctors are frequently difficult for patients to understand, leading to possible errors in medication usage. To solve this, we have implemented a deep learning-based Handwriting Recognition System using Convolutional Neural Networks (CNNs) for character-level feature extraction. The system is trained on the EMNIST dataset, supplemented by a synthetically generated dataset of medical terms, to recognize individual characters. The character recognition is performed at the word level by segmenting and recognizing each letter, providing a simplified yet effective approach for prescription digitization. This method reduces the model complexity while still delivering high accuracy in transcription.

II. RELATED WORK

In recent years, the digitization of healthcare services has witnessed a significant transformation, propelled by advancements in web development frameworks and artificial intelligence. The fusion of appointment management systems with intelligent Optical Character Recognition (OCR) technologies has opened new avenues for healthcare automation. Existing literature and related systems has contributed to the formulation and design of the current

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research project. Bhutada et al. introduced the "Smart Doctors Assistant," an advanced, contactless appointment booking system utilizing face recognition and voice commands. This system was particularly beneficial during the COVID-19 pandemic, as it minimized physical interactions and catered to patients with varying literacy levels [1].

Khalid et al. developed "Medicus," a mobile application that allows patients to schedule appointments with preferred doctors. It incorporates features like online chat and location-based navigation, aiming to reduce the need for physical visits, especially for senior citizens [2].

Ghosh et al. presented "HealthMate," a Python-based platform enabling patients to search for doctors based on specialization, location, and availability. It offers appointment reminders, patient profiles, and feedback mechanisms, providing a comprehensive solution for both patients and healthcare providers [3].

Ayush et al. developed "Appointify," a system leveraging the MERN stack (MongoDB, Express.js, React.js, Node.js) to facilitate real-time appointment bookings. The platform emphasizes user-friendly interfaces and incorporates features to ensure data security and privacy [4].

Handwriting recognition, particularly for medical prescriptions, poses challenges due to varied writing styles and unstructured formats.

Recent advancements in deep learning have significantly improved recognition accuracy. Jain et al. [5] combined Convolutional Neural Networks (CNNs) and Bidirectional Long Short-Term Memory (Bi-LSTM) networks with Connectionist Temporal Classification (CTC) loss to develop a system capable of recognizing complex handwritten medical prescriptions. Their model demonstrated effectiveness in reducing Character Error Rate (CER) and Word Error Rate (WER), achieving a CER of 3.59% and a WER of 9.44% on the IAM dataset.

Ali et al. [6] proposed a hybrid model integrating Mask R-CNN for image segmentation and Transformer-based Optical Character Recognition (TrOCR) with Multi-Head Attention. This model accurately extracted medicine names from handwritten prescriptions and achieved a CER of 1.4%, showcasing the potential for automating prescription digitization.

Maiti [7] explored an RNN-based system for deciphering handwritten prescriptions. By minimizing the CTC loss function, this system enhanced the clarity of medication names and prescription details, significantly improving the recognition accuracy for doctors' handwriting.

Firmani et al. [8] undertook the "In Codice Ratio" project, which aimed to digitize handwritten Latin documents from the Vatican Apostolic Archive. Using deep convolutional networks, they achieved a 96% accuracy rate in interpreting medieval handwriting, demonstrating the versatility of deep learning techniques in recognizing diverse writing styles.

III. PROPOSED SYSTEM

The proposed system integrates a Doctor Appointment Booking Platform and a Handwriting Recognition System (OCR) into a unified MERN-based web application. The architecture follows a modular approach to separate concerns between backend (Node.js/Express.js), frontend (React.js), and the OCR module which uses deep learning for optical character recognition. The core modules of the system—appointment management and OCR for handwritten prescriptions—are outlined below.

➤ *System Architecture Overview*

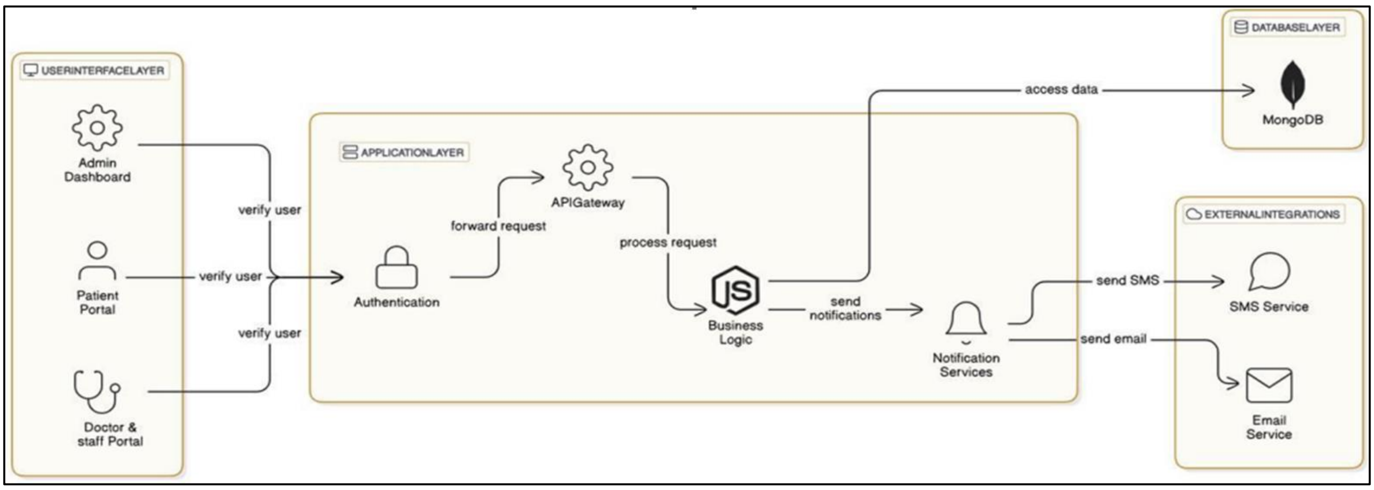

Fig 1 This Figure Describes the System Architecture of the Appointment Management System

The figure illustrates the architecture of the proposed system, emphasizing a modular and layered design for effective operation management and data flow. At the core of the User Interface Layer, there are three distinct portals: an Admin Dashboard for managing system users and overseeing activity logs, a Patient Portal that allows users to register, log in, and book appointments, and a Doctor & Staff Portal designed for viewing appointments, managing consultations, and updating prescriptions.

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Each portal is connected to a secure Authentication Module that verifies user credentials and ensures appropriate access permissions. Post-authentication, all incoming requests are routed via the API Gateway, which directs the operations to the Business Logic component within the Application Layer. This logic layer, built using Node.js, handles key functions such as scheduling, data validation, and internal communication between system components. It acts as the brain of the platform, ensuring seamless coordination between users and backend services.

For data persistence, the platform relies on MongoDB, which serves as the Database Layer. This NoSQL database stores structured data such as appointment records, user details, and consultation history in a scalable and secure format.

To enhance user experience and keep stakeholders informed, a Notification Service is incorporated, capable of sending updates in real-time. Notifications—such as booking confirmations, reminders, or status changes—are dispatched through external integrations like SMS services and email gateways. This architecture provides a robust and adaptable backbone for the appointment booking and OCR-enabled prescription recognition system, ensuring secure, efficient, and real-time interactions between users and services.

The OCR module is designed to recognize handwritten characters from prescriptions using a CNN-based architecture. The process is broken down as follows:

- *Data Segmentation:*

Handwritten prescriptions are preprocessed by segmenting the text into individual characters. This segmentation step ensures that the model can focus on recognizing individual symbols, which simplifies the recognition process.

- *CNN for Feature Extraction:*

The model uses Convolutional Neural Networks (CNNs) for feature extraction. CNNs excel at recognizing patterns in images, which is critical for deciphering the shapes of handwritten characters. The CNN layers are trained on both the EMNIST dataset (general character recognition) and a synthetically generated medical dataset, which simulates common medical symbols, terms, and numbers found in prescriptions. The strength of CNNs lies in their ability to learn feature hierarchies directly from training data, without the need for manual feature engineering, making them particularly effective for tasks such as image classification and handwriting recognition.

$$F_{i,j}^{(k)} = \sigma\left(\sum_{m}\sum_{n} W_{m,n}^{(k)} \cdot X_{i+m,j+n} + b^{(k)}\right)$$

Fig 2 Formula I

- *Training Methodology:*

The model is trained with the combination of EMNIST and synthetic medical data, enabling the system to generalize better to medical handwriting styles. Synthetic data is generated specifically for medical terms, ensuring the model is capable of handling variations found in prescriptions. Data augmentation techniques like rotation, scaling, and translation are employed to make the model more robust.

- *Character-Level Recognition:*

The CNN processes each individual character in the prescription and outputs the corresponding recognized symbol. This method is more modular than full-text OCR systems, allowing for faster training and easier implementation.

- *Evaluation:*

The model is evaluated based on character-level accuracy, using both EMNIST and synthetic medical datasets to assess how well the system performs in recognizing medical terms and handwritten symbols. The training accuracy and performance are also validated through rigorous testing using a separate validation set.

IV. RESULTS AND DISCUSSION

➢ *Appointment Booking System*

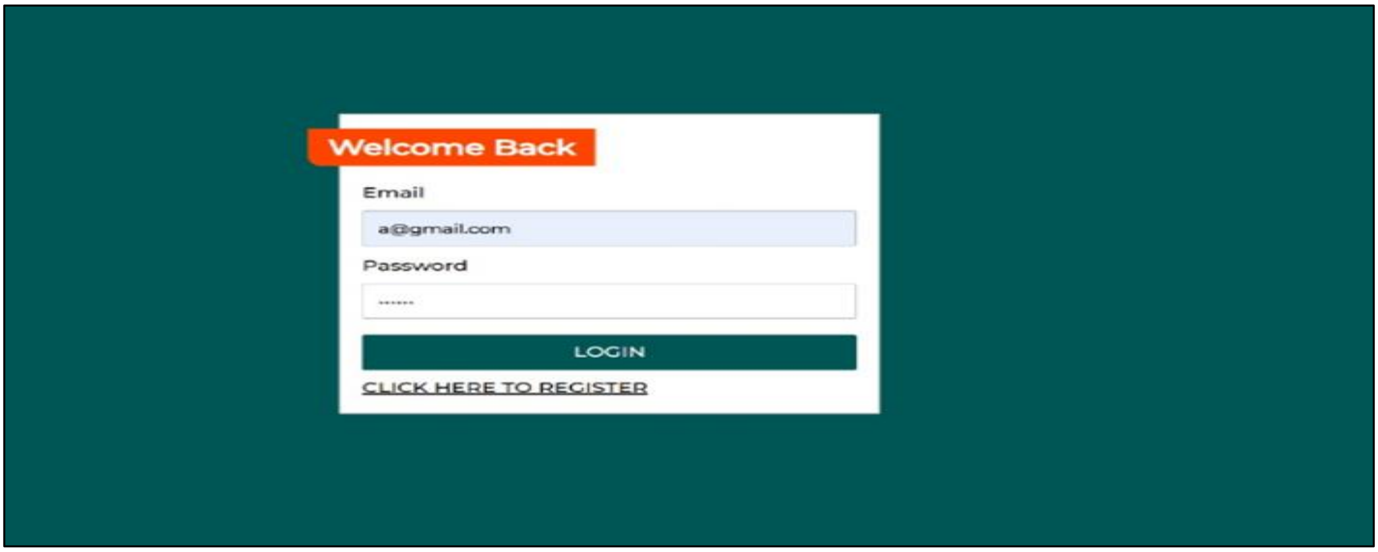

Fig 3 Login Page

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The Figure 3 shows the Login page where returning users can securely sign into their accounts by entering their registered email address and password. The interface includes a hyperlink provided for users who have not yet registered, allowing them to navigate to the registration page easily.

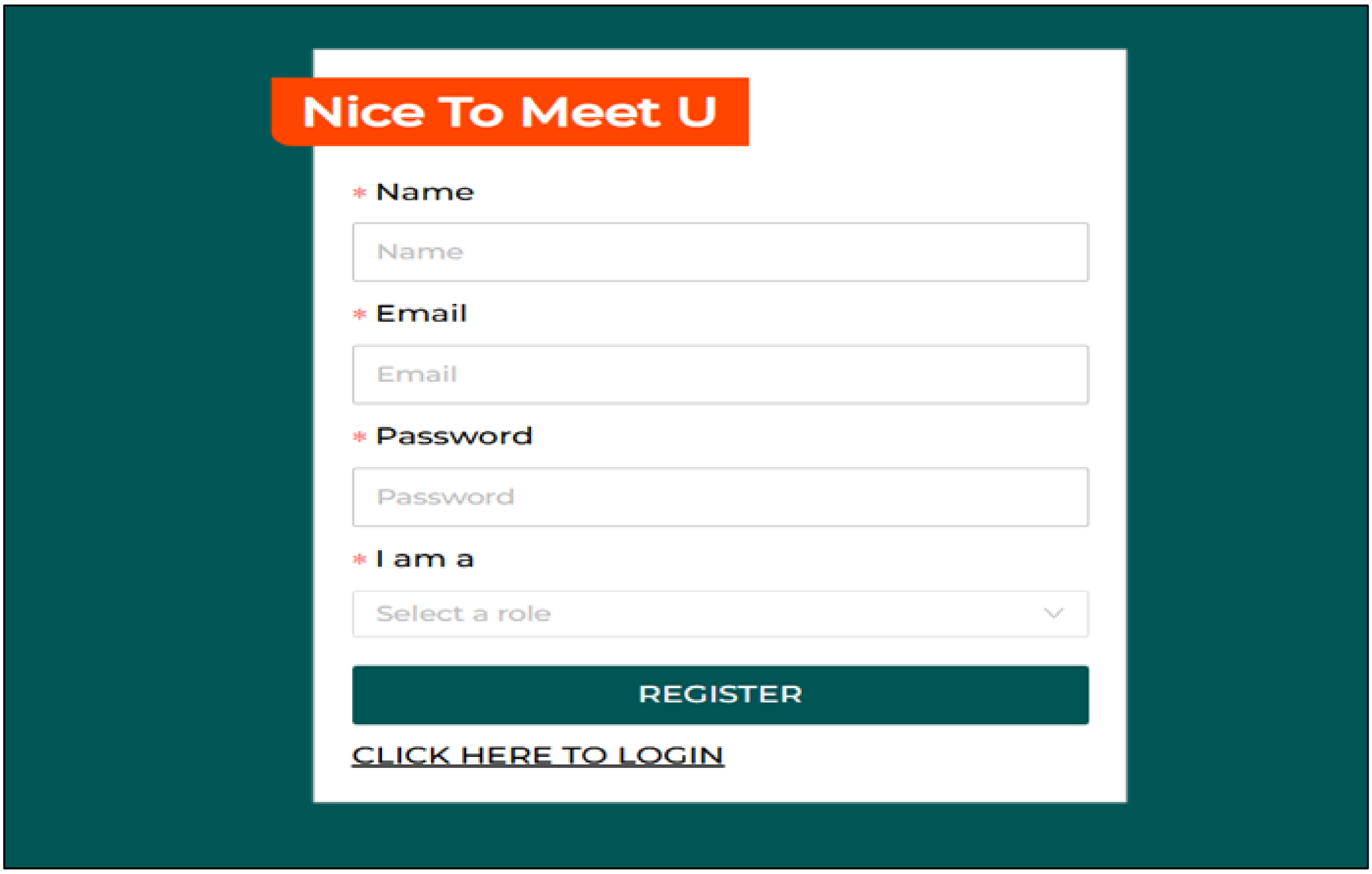

Fig 4 Registration Page

The Figure 4 presents the Registration page where new users can create an account by submitting their name, email, and password, also identifying their role as a user or a doctor. This page includes a link for already registered users to switch back to the login page. These forms are essential for enabling secure access, forming the entry point for patients, doctors, and reception staff.

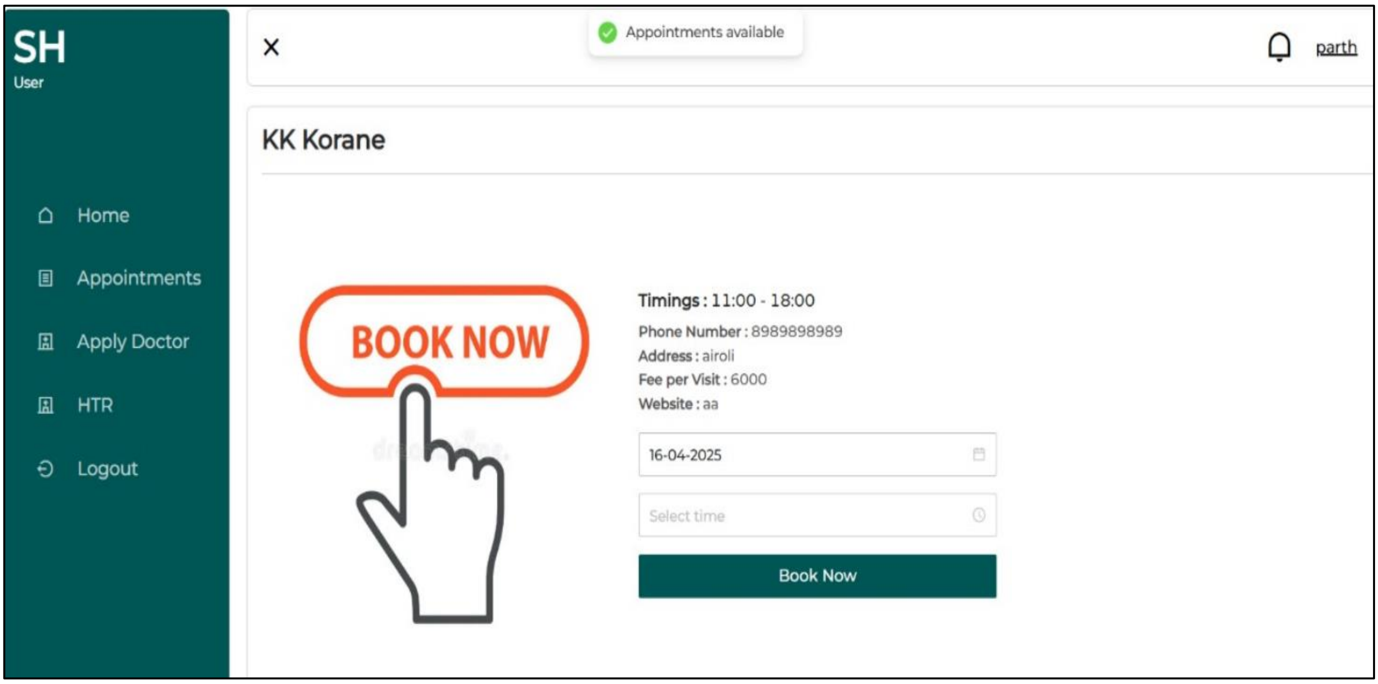

Fig 5 Book an Appointment

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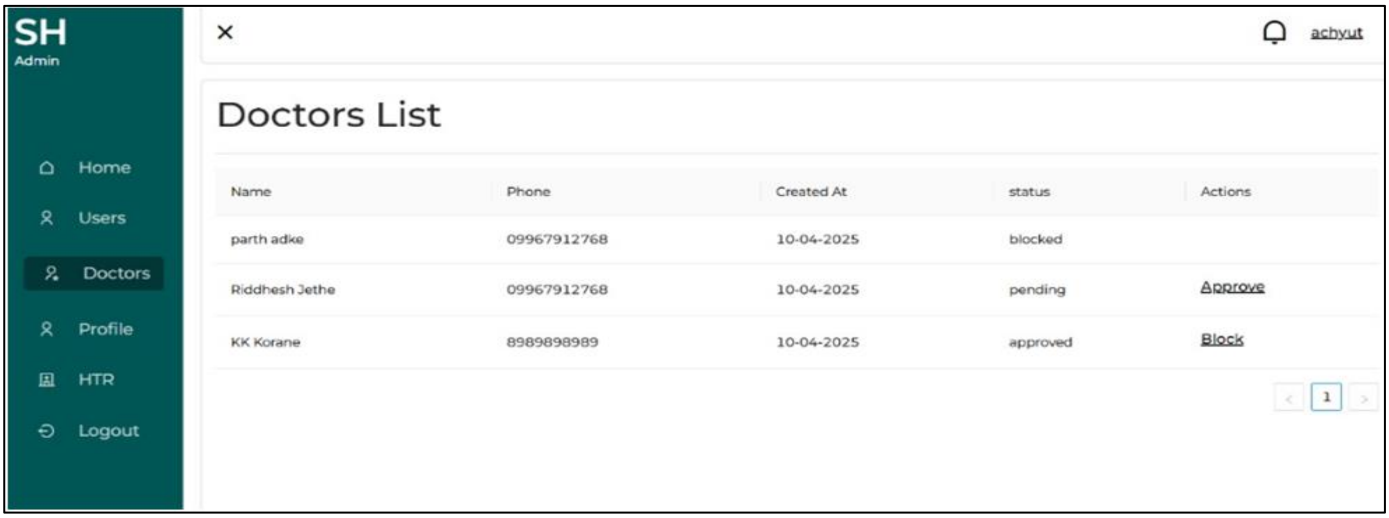

Fig 6 Admin Dashboard Depicting Doctors List and Users List

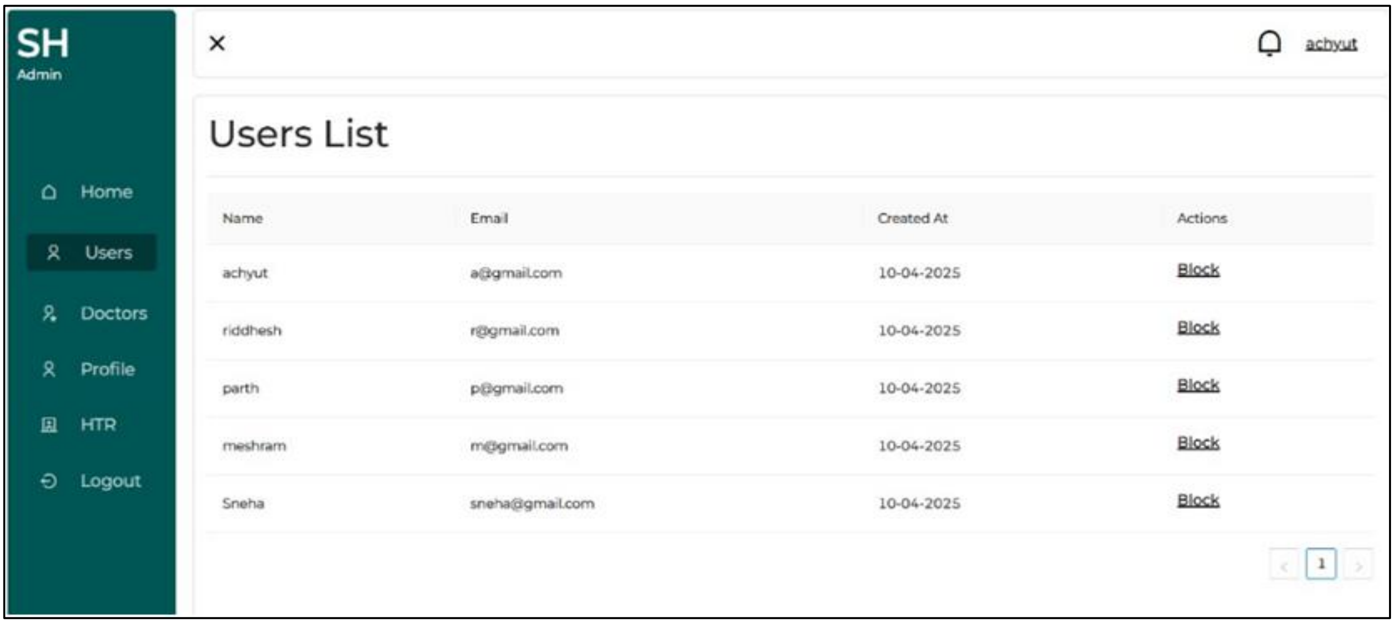

Fig 7 Admin Dashboard Depicting Doctors List and Users List

The two Figures above depicts the Admin Dashboard which serves as the control center of the Doctor Appointment Booking and Handwriting Recognition System, enabling administrators to manage both users and doctors efficiently.

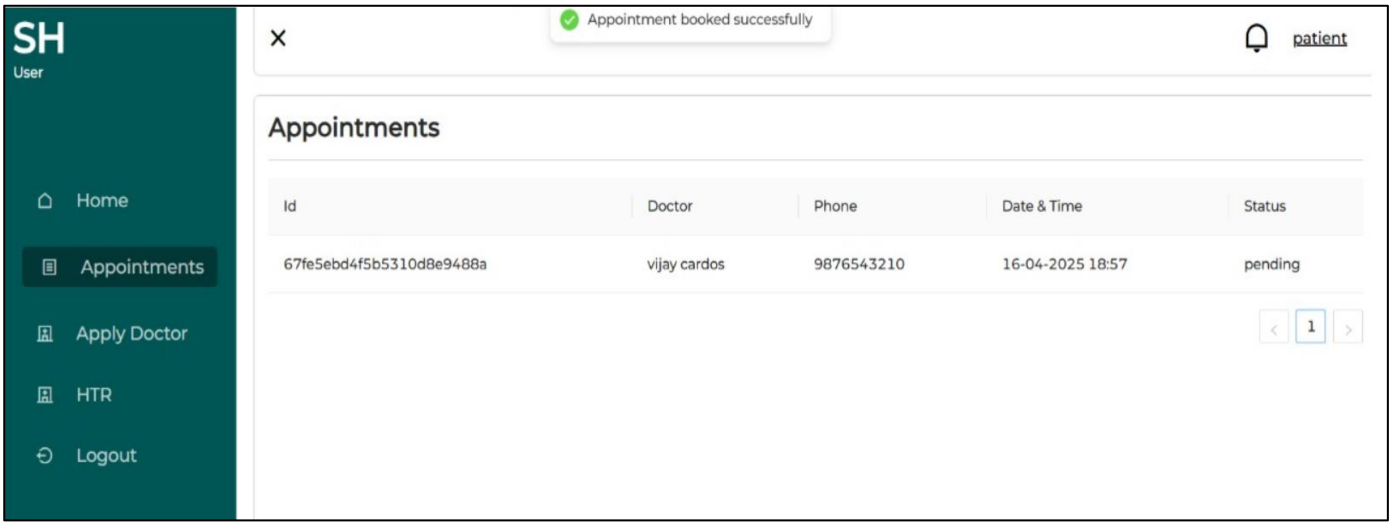

Fig 8 Shows Upcoming Appointments

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➢ *OCR Module*

Fig 9 Results of the Model Applied on an Image from the Dataset

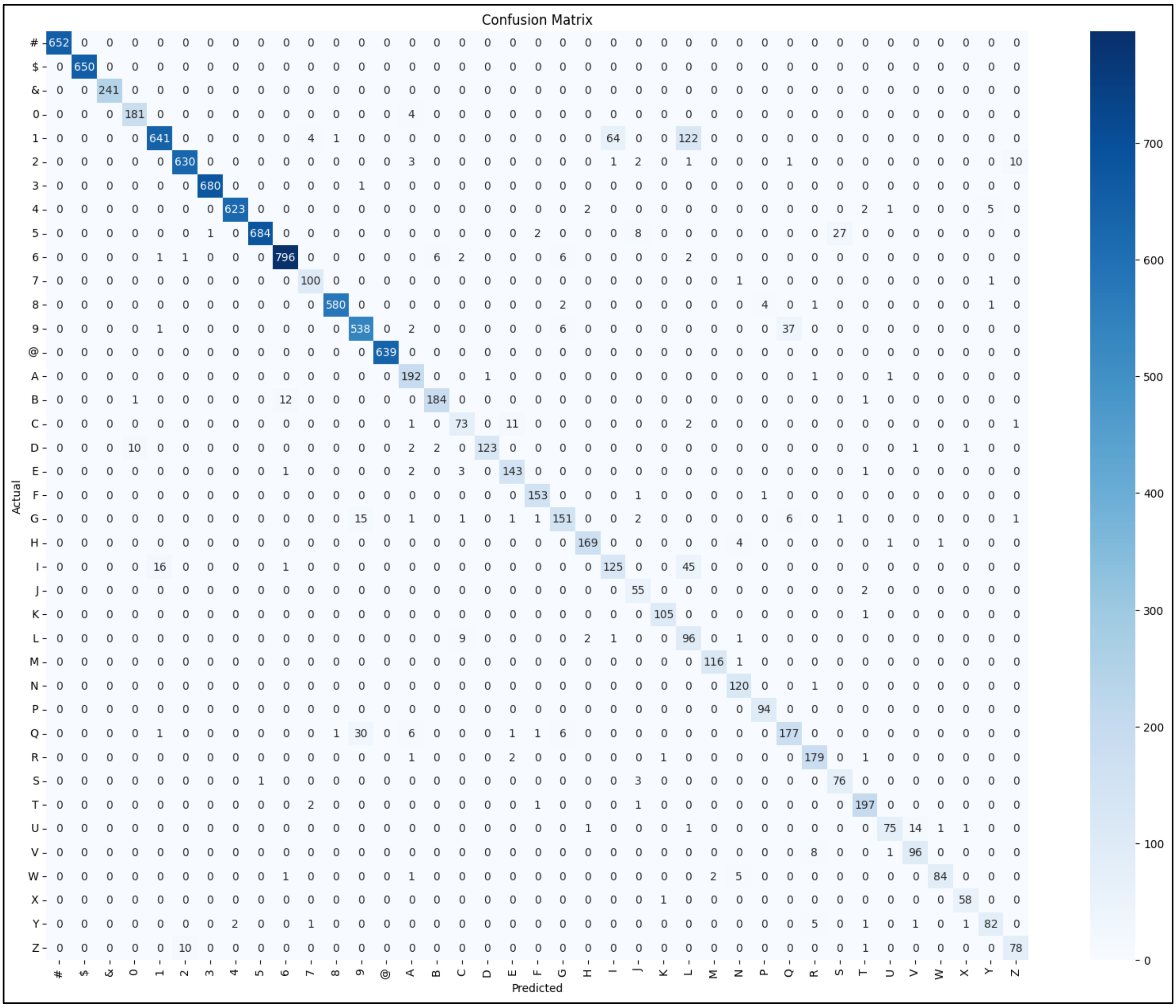

Fig 10 Confusion Matrix

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The confusion matrix shown above illustrates the classification performance of the Convolutional Neural Network (CNN) model trained on EMNIST and synthetic handwritten medical data. The diagonal elements indicate correctly classified characters, while the off-diagonal values represent misclassifications. The following insights are drawn from the matrix:

- *High Classification Accuracy:*
  A large concentration of values lies along the diagonal, indicating that the model accurately predicted the majority of character classes.

- *Minimal Misclassification:*
  Only a few misclassifications are observed, primarily among visually similar characters such as ‘I’ and ‘L’, or ‘S’ and ‘5’, reflecting common ambiguities in handwritten text.

- *Consistent Performance Across Labels:*
  The model demonstrates strong recognition consistency across a wide range of characters including digits, uppercase letters, and symbols, validating its robustness for prescription digitization tasks.

The following metrics were used to evaluate the model’s effectiveness:

- *Accuracy:*
  The model achieved an overall accuracy of approximately 94.4%, reflecting its strong capability in recognizing handwritten characters from diverse sources.

- *Precision:*
  High precision was observed across most classes, especially for symbols and digits, indicating that the model made very few false-positive predictions.

- *Recall:*
  The recall values were consistently strong, with the model accurately identifying the majority of characters, though some confusion was noted in visually similar letters like ‘I’, ‘L’, and ‘S’.

- *F1-Score:*
  The F1-score, which balances both precision and recall, remained above 0.90 for the majority of characters, confirming that the model maintains reliable and consistent performance across different classes.

V. CONCLUSION AND FUTURE WORK

This doctor appointment system presents a strong foundation for streamlining healthcare bookings and can be extended in several meaningful ways to meet real-world demands more effectively.

In the future, the platform can incorporate artificial intelligence to provide personalized recommendations, such as suggesting optimal appointment times based on availability patterns or recommending doctors based on patient history and medical specialties. [10]The integration of a real-time video consultation module using WebRTC or third-party APIs can facilitate remote diagnosis, making the platform more inclusive, especially in rural and underserved regions. Additionally, the incorporation of a secure and seamless payment gateway will allow patients to complete transactions online, enabling a more complete digital experience.

Another promising enhancement is the development of mobile applications using React Native, which would make the service more accessible on smartphones and widen user reach. From an administrative perspective, adding a comprehensive analytics dashboard can provide insights into appointment trends, doctor availability, patient engagement, and revenue generation. Role-based access control can also be improved to ensure granular security between patients, doctors, and admins.

To increase reliability and trust, automated appointment reminders via email or SMS can be implemented to reduce no-shows. Moreover, the inclusion of features such as e-prescriptions, digital health records, feedback systems, and multilingual support will bring the system closer to becoming a fully functional digital healthcare assistant. On the OCR part, shifting towards word-level OCR models, possibly using transformer-based architectures[9], could reduce segmentation errors and streamline the pipeline. Incorporating a larger and more diverse dataset of real medical prescriptions will significantly boost model robustness and generalization across different doctors' handwriting styles. Using dynamic image preprocessing, including skew correction, denoising, and character bounding box prediction, can improve input quality for better recognition.

With the right scaling strategies and continuous improvements, this system has the potential to evolve into an enterprise-grade solution catering to hospitals, clinics, and telemedicine platforms.

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