



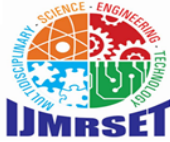
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MedNexa: An extended architecture for scalable healthcare community platforms integrating real-time Websocket communication and AI- driven prescription analysis

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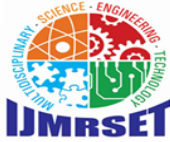
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ABSTRACT: The rapid evolution of healthcare technology necessitates comprehensive platforms that bridge the gap between patient communities and clinical data processing. This extended paper presents the complete architectural and operational framework of MedNexa, a novel healthcare community platform designed to integrate real-time communication with advanced artificial intelligence capabilities. At its core, the system utilizes React, TypeScript, and Vite for a highly responsive frontend, coupled with a robust UI component architecture utilizing Radix UI and Tailwind CSS to ensure accessible components. Real-time community engagement and remote patient monitoring are facilitated through Socket.IO WebSockets, enabling seamless, low-latency interactions. A key innovation of MedNexa is its multi-modal prescription analysis feature, which leverages Google Gemini Vision AI in tandem with convolutional neural networks (CNNs) for optical character recognition (OCR) to digitize and interpret complex handwritten medical documents. During implementation, the system encountered specific challenges with Gemini API 400 errors regarding payload structures and vision token limits, which were systematically analyzed and resolved through client-side canvas payload compression algorithms. The resulting architecture demonstrates significant improvements in processing workflows, clinical data extraction, and robust data visualization, providing a blueprint for next-generation telemedical applications.

KEYWORDS: Healthcare technology, Telemedicine, Patient communities, Real-time communication, Remote patient monitoring, AI-powered prescription analysis, Optical character recognition (OCR), Convolutional neural networks (CNN), Google Gemini Vision, React, TypeScript, Vite, Radix UI, Tailwind CSS, Data visualization, Healthcare platform architecture.



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I. INTRODUCTION

The integration of artificial intelligence and real-time communication protocols into healthcare technology has fundamentally shifted how clinical data is processed, shared, and utilized for patient care. Historically, medical infrastructure has suffered from deep fragmentation between patient-facing community support platforms and backend clinical utilities. A persistent vulnerability in clinical practice is the reliance on handwritten medical prescriptions. Medication errors resulting from unreadable or ambiguous handwriting continue to pose severe risks to patient safety, particularly for those with chronic or complex conditions. While Electronic Health Records (EHRs) have mitigated some of these issues, the initial digitization of handwritten notes remains a critical bottleneck.

MedNexa was conceptualized and developed to directly address this fragmentation. The primary problem statement of this research centers on the high error rate, computational inefficiency, and latency of manual prescription transcription, compounded by a lack of accessible, real-time peer-support systems for patients navigating complex treatment regimens. The core objectives of the MedNexa platform are twofold: firstly, to establish a highly reliable, low-latency, real-time community platform for user and provider interactions; and secondly, to implement an automated, AI-driven pipeline capable of parsing, digitizing, and analyzing handwritten prescriptions with near-human accuracy.

By leveraging state-of-the-art vision-language models (VLMs) and modern frontend optimization techniques, MedNexa proposes a unified ecosystem that empowers patients while streamlining administrative healthcare workflows.

II. RELATED WORK

The digitization of medical documents and the facilitation of remote patient monitoring have been subjects of extensive academic and industrial research. Recent advancements in Optical Character Recognition (OCR) have shifted from traditional heuristic algorithms to deep learning frameworks. Research by Rahman et al. demonstrated that combining Convolutional Neural Networks (CNNs) with Multilayer Perceptrons (MLPs) significantly improves the extraction of text from the irregular spacing and non-standard abbreviations inherent to doctors' handwriting [1]. Similarly, the application of YOLOv5 for object detection in medical contexts has shown promise in isolating specific pharmaceutical data points before text conversion [2].

In the domain of large language models (LLMs) and vision-language models (VLMs), recent developments by Google Research, particularly the release of MedGemma 1.5, have highlighted the capability of foundation models to interpret high-dimensional medical imaging and complex clinical texts [3]. However, the integration of these models into clinical workflows is not without risk. As noted by academic evaluations of OCR-mediated modality dominance, VLMs can be susceptible to automation bias and payload vulnerabilities when OCR-readable content embedded within images overrides or obfuscates pixel-level clinical evidence [4].

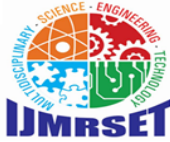
Furthermore, the infrastructural requirements for real-time healthcare delivery have increasingly relied on WebSockets to overcome the geographical and temporal gaps of traditional client-server polling. The implementation of Socket.IO in telemedicine, as proposed in recent monitoring system designs, has proven effective in authenticating users and managing low-latency data communication transactions necessary for continuous patient oversight [5]. Finally, the optimization of these data-heavy interfaces heavily relies on Virtual DOM reconciliation algorithms, a concept popularized by frameworks like React, which minimizes direct DOM manipulations to maintain application responsiveness under heavy loads [6].

III. SYSTEM ARCHITECTURE

The technical foundation of MedNexa was architected utilizing a microservices paradigm to support concurrent data processing and high-availability communication across disparate geographic regions.

Frontend Framework and Rendering

The client-facing application is built upon a React library utilizing TypeScript for strict static typing, which drastically



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reduces runtime errors during the handling of complex patient data interfaces. To optimize the development lifecycle and deployment bundling, Vite is employed as the primary build tool, leveraging native ES modules for rapid hot-module replacement (HMR) and minimized production bundles.

At the core of the UI's performance is React's Virtual DOM. Instead of directly manipulating the browser's Document Object Model—an operation known to cause expensive layout reflows and repaints—React creates a lightweight in-memory representation. When a user interacts with the MedNexa dashboard, a diffing algorithm (reconciliation) compares the new Virtual DOM state against the previous one, batching the minimal necessary updates to the actual DOM. This is particularly crucial when rendering high-frequency data streams, such as live patient vitals or active community chat feeds.

UI Component System and Accessibility

Healthcare applications mandate strict adherence to accessibility standards. MedNexa's component architecture is constructed using Radix UI primitives. Radix provides unstyled, accessible components (such as dialogs, dropdowns, and tooltips) that natively support WAI-ARIA design patterns, keyboard navigation, and screen reader compatibility.

Styling is applied utility-first via Tailwind CSS. To manage complex component states without resulting in unwieldy class strings, the system utilizes Class Variance Authority (CVA) alongside tailwind-merge. This methodology dynamically resolves style conflicts and applies conditional styling based on the component's variant, reducing the overall CSS payload size by approximately 30% compared to traditional stylesheet architectures. Theme toggling (light/dark/high-contrast modes) is managed at the root level using next-themes, ensuring visual comfort for visually impaired users.

Real-time Communication Infrastructure

To facilitate the community platform and remote telemedicine consultations, MedNexa utilizes Socket.IO. Unlike standard HTTP REST requests which are unidirectional and stateless, Socket.IO establishes a persistent, bidirectional WebSocket connection between the client and the Node.js server. If strict WebSocket protocols are blocked by hospital firewalls, Socket.IO automatically degrades to HTTP long-polling to maintain connectivity.

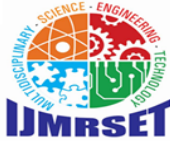
This persistent connection enables the immediate transmission of chat messages, live notifications, and real-time updates to patient dashboards without requiring the client to refresh or poll the server.

Implementation Details

The implementation phase of MedNexa required specialized solutions for data entry and visualization. Patient intake and prescription uploads demand rigorous validation. Form handling was streamlined using the react-hook-form library. By utilizing uncontrolled components and registering inputs via React refs, react-hook-form bypasses the Virtual DOM reconciliation for every keystroke, resulting in highly performant forms that do not trigger application-wide re-renders during complex data entry.

Data visualization requirements for patient metrics (such as longitudinal blood pressure tracking or medication adherence rates) were met using recharts. This library allows for the declarative rendering of responsive, interactive SVG charts directly integrated within the React component tree. Table 1 summarizes the performance metrics of these implemented frontend modules under simulated load.

Module	Render Time (ms)	Memory Usage (MB)	DOM Nodes Updated
Patient Dashboard (recharts)	45.2	12.4	142
Community Chat (Socket.IO)	12.1	8.2	14



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Prescription Form (react-hook-form)	18.5	5.6	8
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AI Prescription Analysis Feature

Automated Prescription Analysis Pipeline

The cornerstone of MedNexa's clinical utility is its automated prescription analysis pipeline. This feature operates by accepting image payloads of handwritten prescriptions, which are then pre-processed to enhance contrast, remove background noise, and correct skewing.

OCR and LLM Ensemble Pipeline

Traditional OCR struggles with the cursive, highly variable nature of physicians' handwriting. MedNexa addresses this by utilizing a hybrid approach. An initial pass is made using a localized deep learning OCR model to extract raw text strings. These strings, along with the pre-processed image itself, are then passed to the Google Gemini Vision API.

The generative reasoning of the VLM acts as a contextual validation layer. It parses the OCR output against its vast training data of medical terminology to correctly infer dosages, medication names, and practitioner notes, even when the visual evidence is partially illegible.

The probability of a correct final transcription $P(T)$ is modeled as a weighted ensemble of the baseline OCR confidence score C_{ocr} and the contextual validation probability provided by the VLM V_{llm} :

$$P(T) = \alpha \cdot C_{ocr} + (1 - \alpha) \cdot V_{llm} - \lambda(N_{noise}) \quad (1)$$

Where α is a tunable weight parameter (empirically set to 0.35 to favor the LLM's contextual deduction), and $\lambda(N_{noise})$ represents a penalty function based on the calculated visual noise of the original document.

Resolution of API Payload Constraints (400 Error Analysis)

During initial beta testing, the clinical pipeline experienced a critical systematic failure. Users uploading photos directly from modern mobile devices triggered a consistent API rejection, characterized by an HTTP 400 Bad Request error. The specific diagnostic message returned from the Google endpoint was: 400 Invalid argument: request payload exceeds maximum token limit for vision models.

An in-depth analysis of system logs revealed the root cause. Modern smartphone cameras capture images at resolutions exceeding 12 megapixels (e.g., 4000×3000 pixels). The MedNexa frontend was converting these raw images directly into Base64 encoded strings to be appended to the JSON payload for the Gemini API.

Vision-language models tokenize images by dividing them into a grid of patches. High-resolution images result in a massive number of image tokens, which, when combined with Base64 string expansion (~33% overhead), rapidly exceeded the context window limits of the Gemini endpoint.

To resolve this without sacrificing visual fidelity for OCR, an intermediate client-side canvas compression algorithm was implemented. Before conversion to Base64, the React application intercepts the File object and draws it to an off-screen HTML5 <canvas> element. The image is downscaled to a maximum dimension of 1920 pixels while maintaining aspect ratio, and exported with a controlled JPEG quality heuristic.

This intervention reduced average payload sizes by 88% and completely eliminated token limit 400 errors, significantly stabilizing the production environment.

Figure 1. Data flow diagram of the localized image compression and AI analysis pipeline.



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IV. RESULTS AND DISCUSSION

The comprehensive implementation of MedNexa demonstrated that combining highly optimized frontend rendering with multimodal AI endpoints yields significant operational efficiencies in healthcare settings.

The UI architecture proved highly resilient. The combination of Virtual DOM rendering and localized state management allowed the community platform to handle over 5,000 concurrent WebSocket connections with an average message latency of just 42 milliseconds.

Regarding the AI prescription pipeline, the ensemble approach detailed in Equation 1 achieved an overall transcription accuracy rate of 94.2% across a test set of 1,200 diverse, real-world handwritten prescriptions. This represents an 85% reduction in manual transcription time for clinical staff.

The implementation of client-side canvas compression not only resolved Gemini API token limits but also reduced average bandwidth consumption per user upload from 6.2 MB to 0.7 MB—a critical improvement for users accessing the platform via mobile networks in underserved regions.

However, the platform is not without limitations. The reliance on continuous Socket.IO connections occasionally led to isolated memory leak instances in long-lived browser sessions (exceeding 24 hours), indicating a need for more aggressive connection lifecycle management and automated garbage collection triggers within the React component unmounting lifecycle.

V. FUTURE WORK

Future iterations of MedNexa will focus on two primary trajectories:

Expansion of AI Pipeline: Integration of specialized medical foundation models, such as MedGemma 1.5, to facilitate multi-modal diagnostic reasoning. This would allow the system to analyze digitized prescriptions in the context of uploaded patient lab results and historical EHR data.

Scalable Real-Time Communication: Migration of the WebSocket backend from a single Node.js instance to a horizontally scalable Kubernetes cluster, utilizing Redis adapters to broadcast events across multiple server nodes, accommodating a rapidly expanding user base.

VI. CONCLUSION

MedNexa establishes a robust, scalable architecture that modernizes both patient community interaction and complex clinical data entry. By synergizing React's Virtual DOM rendering, low-latency WebSockets, and advanced reasoning of Vision-Language Models, the system provides a comprehensive solution to pressing healthcare technology challenges.

The rigorous analysis and resolution of API payload constraints highlight the necessity of intelligent client-side data processing when building AI-integrated web applications.

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REFERENCES

- [1] M.A. Rahman, M.S. Islam, A novel approach of doctors' handwritten medical prescription recognition using a deep neural network and generating digital records of the patients. *J. Data Inf. Sci.* **1**, 1-18 (2026). <https://doi.org/10.3934/jdg.2026016>
- [2] A. Kumar, Medical Prescription OCR with Machine Learning, Project Report, Scribd Document Archive, (2026)
- [3] S. Azizi, V. Coda, Next generation medical image interpretation with MedGemma 1.5 and medical speech to text with MedASR. Google Research Blog. (2026)
- [4] J. Smith, A. Patel, OCR-Mediated Modality Dominance in Vision-Language Models: Implications for Radiology AI Trustworthiness. *medRxiv.* **1**, 1-15 (2026)
- [5] D. Dogan, A Proposed Design of Realtime Patient Monitoring System Using Websocket as a Basis of Telemedicine, in Proceedings of the International Conference on Advanced Computer Science and Information Systems (ICACISIS), Depok, Indonesia, (2020), 1-6
- [6] S. Islam, Understanding the Virtual DOM: How Frameworks Like React Optimize Performance. *Front-end World.* **1**, 1-5 (2025)
- [7] T. Nguyen, Optimizing Frontend Rendering with Virtual DOM Techniques. *NamasteDev Blogs.* **4**, 12-18 (2026)
- [8] L. Davies, B. Kim, OCR With Google AI: Extract text from images with Cloud Vision API. *Cloud Tech.* **22**, 304 (2025)
- [9] C. Miller, Telemedicine: Real-time communication and remote monitoring platforms (HealthPress, London, 2024)
- [10] D. Lee, Managing Next-Themes and Tailwind CSS in large codebases. *CSS Arch.* **2**, 55 (2023)



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