Vikira AI – AI-Assisted Chest X-ray Interpretation for India

Problem Statement

India faces a critical healthcare challenge with delays in chest X-ray interpretation, leading to significant morbidity and mortality, particularly from respiratory infections like pneumonia. This crisis is characterized by:

- **High Mortality:** Over 127,000 child deaths annually from respiratory infections, with India bearing the highest global burden.
- **Frequent Fatalities:** India sees 1 child's death every 4 minutes, making it the leading cause of mortality for children under five.
- **Overwhelmed Diagnostics:** 300 million chest X-rays yearly create massive backlogs.
- **Radiologist Shortage:** Critical scarcity, especially in rural areas, causes interpretation bottlenecks.
- **Slow Turnaround:** Manual X-ray reports take 8 to 72 hours, unacceptable for acute conditions.
- **Deadly Consequence:** Delays in diagnosis and reporting lead to missed or late treatment and preventable deaths.

Target Audience & Context

The primary target audience for VikiraAI is primary care physicians and healthcare professionals across India. Specifically, it targets those:

- In rural and underserved areas with limited access to specialist radiologists.
- On the front lines, managing high patient volumes and urgent diagnostic needs for respiratory conditions.

The current context involves:

- Overwhelmed diagnostic systems.
- A critical scarcity of expert interpretation.
- Leading to delayed patient care and suboptimal outcomes. VikiraAI aims to empower these medical professionals by providing rapid, accurate diagnostic support where it is needed most.

Relevance of Problem

The problem's relevance is underscored by its direct impact on patient outcomes and the public health system in India. Key aspects include:

- **Direct Impact on Lives:** Pneumonia is the leading cause of mortality for children under five in India, with devastating consequences.
- **Treatment Delays:** Delays in diagnosis directly translate to missed or late treatment.
- **Increased Risk:** This increases the risk of preventable deaths. By addressing the bottlenecks in chest X-ray interpretation, VikiraAI tackles a fundamental barrier to timely and effective care, particularly for acute respiratory conditions. Empowering clinicians with faster, smarter diagnostic tools is crucial for improving health equity and reducing the burden of respiratory diseases across the nation.

Gen-AI Use Case

Generative AI, specifically Google Gemini 1.5 Flash, is central to VikiraAI's solution. Its roles include:

- **Structured Report Generation:** Creating comprehensive, structured diagnostic reports.
- **Intelligent Q&A:** Powering an intelligent clinical Q&A assistant.

After the Vision Transformer (ViT) model analyzes an X-ray for pneumonia:

- Gemini 1.5 Flash integrates findings with privacy-filtered patient metadata.
- It generates an immediate, ICMR-protocol-aligned medical report. This dramatically reduces manual reporting time (hours to seconds).
- Working within a Retrieval Augmented Generation (RAG) architecture (with a ChromaDB knowledge base of ICMR guidelines), Gemini provides factual, context-aware responses to doctors' queries.

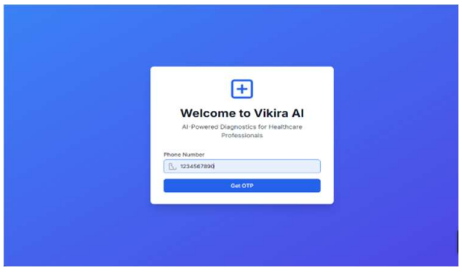
This application of Gen-AI is suitable because it:

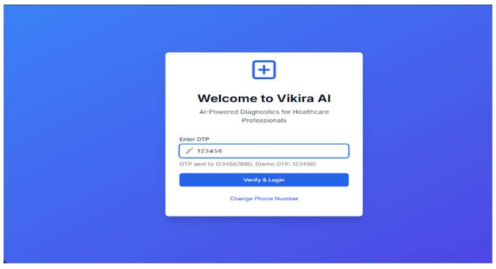
- Automates complex report generation.
- Provides intelligent, grounded insights.
- Scales to meet high demand.
- Mitigates hallucinations through RAG prioritization.

Solution Framework or Workflow

VikiraAI functions as an AI assistant for chest X-ray interpretation, designed with a "human-in-the-loop" approach, enhancing diagnostic precision without replacing clinical judgment. The streamlined workflow includes:

1. **User Authentication & Profile Management:**
    - Medical professionals securely log in via Firebase Phone Authentication.
    - Mock profiles are used for hackathon demonstration.
2. **Secure X-ray Upload & Privacy-Preserving Data Handling:**
    - Clinicians seamlessly upload digital chest X-ray images (JPEG/PNG) via a web interface.
    - Essential, non-identifying patient metadata (e.g., age, gender, relevant symptoms) is included.
    - An automated mechanism ensures removal of Personal Health Information (PHI) to safeguard sensitive details.

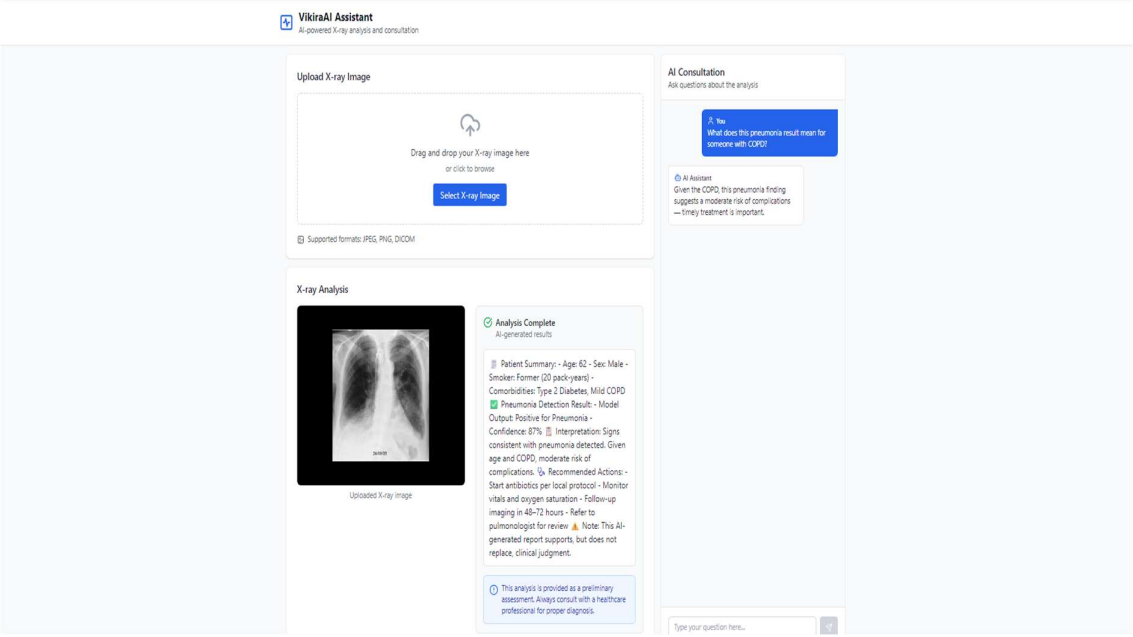




3. **AI-Powered Analysis: Vision Transformer (ViT) Inference Engine:**
    - Leverages a pre-trained and fine-tuned Vision Transformer model (dima806/chest_xray_pneumonia_detection).
    - Processes the privacy-filtered X-ray image in under 10 seconds.
    - Classifies the X-ray as "Pneumonia Detected" or "Not Detected."
    - Provides a high-confidence score (e.g., 96.08% accuracy on its test dataset). This rapid analysis is crucial for acute conditions.
4. **Structured Report Generation with Google Gemini 1.5 Flash:**
    - ViT model's results and patient metadata are fed to Google Gemini 1.5 Flash.
    - Gemini immediately generates a comprehensive, structured medical report.

    - Report aligns with Indian Council of Medical Research (ICMR) protocols, including findings and clinical recommendations.
5. **Intelligent Clinical Q&A Assistant (Retrieval Augmented Generation - RAG):**
    - Powered by Gemini 1.5 Flash and a ChromaDB vector database.
    - Allows doctors to ask context-aware clinical questions.
    - RAG system prioritizes factual information from a curated knowledge base of ICMR guidelines.
    - Ensures responses are factual, source-aware, and minimize "hallucinations."

This entire framework ensures clinicians retain full diagnostic authority while being empowered with actionable AI insights and visual heatmaps.



Feasibility & Execution

VikiraAI's practical implementation is highly feasible, supported by:

- **Robust Authentication:** Firebase Phone Authentication for secure user login.
- **Model Availability:** Core AI model (fine-tuned Vision Transformer) is available on Hugging Face for rapid deployment.
- **Prototype Optimization:** Computational demands managed through model quantization and free cloud-based inference environments (Google Colab, Kaggle Kernels, Hugging Face Spaces) for cost-effective demonstration.
- **Scalable Deployment:** Future vision includes commercial cloud platforms (AWS, GCP, Azure) to ensure high availability and capacity for millions of X-rays, demonstrating a clear path from prototype to production.

Scalability & Impact

VikiraAI is poised for significant impact by:

- **Accelerating Detection:** Critical pneumonia detection, vital for rural clinics.
- **Empowering Clinicians:** Providing rapid insights and visual heatmaps while ensuring human oversight.
- **Addressing Challenges:** An accurate, affordable, and deployable AI solution for India's unique healthcare challenges.

The system is designed to be modular and scalable, with a roadmap including:

- Detection of other critical respiratory conditions (TB, COVID-19).
- Severity grading and lung-zone overlays.
- Seamless integration with India's ABHA ID system and hospital PACS/HMIS. This evolution ensures VikiraAI can adapt to the growing needs of patients, providers, and national healthcare systems, fostering equitable and efficient healthcare across India.

Conclusion / Summary & Bonus Minimum Lovable Product

VikiraAI represents a vital step towards empowering precision diagnostics across India, offering faster, smarter chest X-ray interpretation. Its unique blend of a Vision Transformer for rapid analysis and Gemini 1.5 Flash for intelligent report generation and clinical support directly addresses critical diagnostic delays. As a Minimum Lovable Product, VikiraAI provides immediate, accurate pneumonia detection, making it a viable business that saves lives by ensuring timely treatment, especially in underserved regions, and lays the foundation for a scalable, integrated national health solution.