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Thorax AI: Chest X Ray Disease Detection+Medical Chatbot

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Abstract

Thorax AI is an innovative final-year project utilizing deep learning and AI for automated chest disease diagnosis. It features a chest X-ray image classifier, powered by EfficientNet B0, to detect common thoracic diseases, such as pneumonia, Tuberculosis, and Cardiomegaly, with speed and precision. Complementing this, an integrated medical chatbot, backed by the Gemini API, provides users with medically accurate responses to health-related queries. The platform offers a user-friendly web interface for seamless interaction, secure image upload and analysis, and real-time diagnostic feedback.ThoraxAI aims to assist healthcare professionals in early disease detection, support resource-constrained settings, and offer instant, AI-driven medical responses to patients. This project showcases the powerful potential of combining advanced technology and healthcare to improve societal well-being.

Index Terms: Deep Learning, Artificial Intelligence, Chest X-ray, Medical Diagnosis, Healthcare Technology, Chatbot, Efficient Net B0, Gemini API.

1. INTRODUCTION

The burgeoning role of artificial intelligence in healthcare has demonstrably enhanced diagnostic precision and operational efficiency in recent years [5]. This is particularly crucial when addressing thoracic diseases, such as pneumonia, tuberculosis, and lung cancer, which tragically remain major global mortality contributors [8]. Prompt and accurate identification of these conditions is paramount, offering the potential to save countless lives and alleviate the immense strain on healthcare infrastructures worldwide [7]. In this transformative landscape, Thorax AI emerges as a pioneering deep learning-based system specifically engineered to automate the intricate process of chest X-ray analysis. At its core, Thorax AI harnesses the robust capabilities of the EfficientNet-B0 architecture, renowned for its balance of computational efficiency and high 6accuracy in image recognition tasks [10].To further elevate its utility, Thorax AI seamlessly integrates a sophisticated medical chatbot, powered by the advanced Gemini API. This strategic combination transforms Thorax AI into a truly dual-purpose platform [9]. It not only delivers precise disease predictions based on thorough X-ray analysis but also provides users with intelligent and reliable medical consultations, bridging the gap between complex diagnostic data and easily understandable health information [2]. This holistic approach ensures comprehensive support for both healthcare professionals and patients.

1.1 EXISTING SYSTEM

The conventional approach to diagnosing thoracic diseases relies heavily on manual interpretation of chest X-ray images by trained radiologists [20]. In this process, patients are required to visit a healthcare facility, undergo an X-ray scan, and then wait for the results to be analyzed and reported by medical professionals [12]. While effective in clinical settings, this method is often time-consuming and constrained by the availability of radiologists, especially in rural or underserved regions. Furthermore, manual diagnosis can be subjective, with varying interpretations depending on the experience and workload of the radiologist. In response to these challenges, AI-based diagnostic systems such as CheXNet, Qure.ai, and Lunit INSIGHT CXR have been developed. These systems apply deep learning models to automatically detect thoracic abnormalities from X-ray images. However, despite their high accuracy, most of these tools are limited to static image classification and lack interactive features. They do not provide users with personalized medical explanations or contextual understanding of the diagnosis [2]. Moreover, many of these systems are designed for clinical use and are not directly accessible to patients or general users [10]. The absence of real-time interaction, explainability, and accessibility in existing solutions highlights the need for a more comprehensive and user-friendly diagnostic platform.

1.1.1 CHALLENGES

Compatibility between deep learning models and web interfaces: This required multiple layers of conversion and validation, as image processing libraries (like PyTorch and OpenCV) operate differently from web frameworks (like Flask) [15].

Integrating the Gemini API chatbot with image-based results: The chatbot needed to interpret context from diagnostic outputs and generate relevant responses, which involved careful prompt engineering and validation [20].

Managing performance on local machines: Handling large X-ray images, especially on low-resource systems, posed a constraint. Optimizations like lazy loading of the model and utilizing GPU acceleration were implemented to address this [1].

Dynamic Grad-CAM visualization: Generating heatmaps dynamically for different diseases added complexity in terms of memory management and frontend rendering [13].

Ensuring overall system functionality without latency or crashes: This necessitated rigorous testing, logging, and error handling to ensure the entire system operated smoothly as a single web application [9].

1.2 PROPOSED SYSTEM

Thorax AI proposes an AI-powered system combining deep learning-based chest X-ray disease detection with a medical chatbot for real-time user interaction [22]. It utilizes the EfficientNet-B0 model for accurate multi-label classification of thoracic diseases and a Grad-CAM module for interpretable heatmaps. An integrated medical chatbot, powered by the Gemini API, allows users to ask health-related questions and receive medically accurate guidance [23]. This system, built with Python and Flask, delivers fast, reliable diagnoses and empowers users with contextual understanding, particularly in settings where medical professionals are not readily accessible [18].

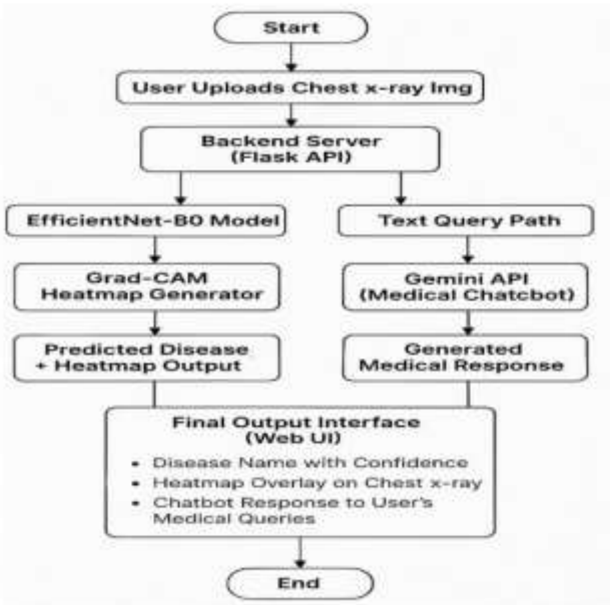

Fig. 1 Flowchart of the Proposed System

1.2.1 ADVANTAGES

- **Automated, Accurate, and Accessible Diagnosis:** Thorax AI addresses the global burden of respiratory diseases by providing an automated, accurate, and accessible diagnostic tool.
- **Fast and Precise Predictions:** By leveraging the Efficient Net B0 architecture, known for its accuracy and computational efficiency, the system ensures fast and precise predictions, even on low-resource systems.
- **Intelligent Medical Assistant:** The integration of the Gemini conversational AI API transforms the platform into an intelligent medical assistant.
- **Medically Accurate and Validated Information:** The chatbot is programmed to respond exclusively with medically accurate and validated information, enhancing trustworthiness and usability.
- **Assists Healthcare Professionals:** The project's significance lies in its ability to assist healthcare professionals in early disease detection.
- **Real-time Diagnostic Feedback and Conversation:** The platform provides real-time diagnostic feedback and conversation.
- **Low Hallucination Score:** Thorax AI achieves a remarkably low hallucination score (0.0201), outperforming several popular vision and language models in reliability and medical accuracy. This is attributed to its hybrid architecture tightly coupling image-based diagnosis with structured chatbot prompts, minimizing incorrect or irrelevant responses.

2. LITERATURE REVIEW

Thorax AI is a deep learning-based system that combines EfficientNet-B0 for accurate chest X-ray disease detection with a Gemini API-powered medical chatbot for real-time user interaction and medically accurate information [17]. This innovative platform provides rapid diagnoses and contextual medical guidance, bridging the gap between advanced AI diagnostics and patient-centered care.

2.1 ARCHITECTURE

The Thorax AI system architecture comprises a user interface that handles X-ray image uploads and chat interactions [7]. This interface communicates with a Flask API backend, which serves as the central hub for processing. The backend directs the uploaded images to a

Disease Detection module, powered by EfficientNet-B0 and associated preprocessing steps [11]. This module is responsible for analyzing the chest X-rays and predicting diseases.

Concurrently, user queries are routed to a

Medical Chatbot module, which leverages the Gemini API. After disease detection.

Grad-CAM (Heatmap) module generates visual explanations by highlighting affected regions on the X-ray [1]. Finally, the user receives the diagnosis, along with the chatbot's explanation, all displayed through a unified output interface which includes the predicted disease, a heatmap overlay, and the chat reply.

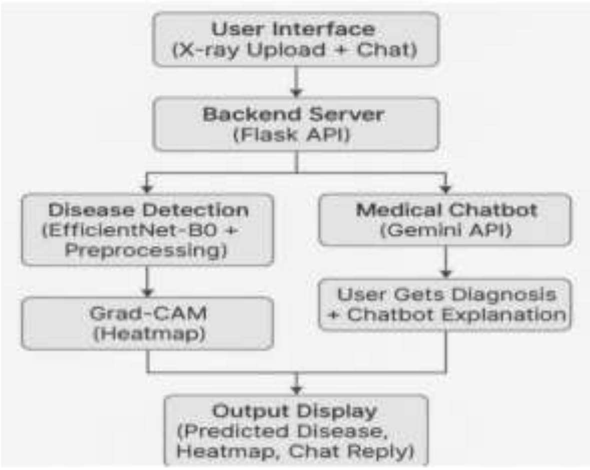

Fig. 2 system architecture

2.2 ALGORITHM

The Thorax AI system employs a two-pronged algorithmic approach, fusing deep learning for image analysis and generative AI for conversational interaction [1].

For Chest X-ray Disease Detection:

1. **Data Preprocessing:** Input X-ray images are converted to RGB (if needed), resized to 224×224 pixels, and normalized using specific mean and standard deviation values. Finally, they are transformed into a tensor format suitable for PyTorch processing [12].

2. **Model Inference:** The preprocessed image is fed into the EfficientNet-B0 model. This convolutional neural network, pre-trained on ImageNet and fine-tuned for thoracic disease detection, generates raw logits [11].

3. **Prediction and Interpretation:** The logits are converted into class probabilities using the softmax function. The class with the highest probability is identified as the predicted diagnosis. A Grad-CAM module generates heatmaps, highlighting the regions of the X-ray most influential in the classification decision, thereby enhancing interpretability.

2.3 TECHNIQUES

Thorax AI aims to revolutionize chest disease detection through deep learning and AI, integrating an Efficient Net B0-powered chest X-ray classifier and a Gemini API-backed medical chatbot. The system processes user-uploaded X-ray images to detect common thoracic diseases like Pneumonia, Tuberculosis, and Cardiomegaly, ensuring fast and precise predictions. Users receive X-ray analysis results and can interact with the AI chatbot for medically accurate and validated health-related information [8]. This platform assists healthcare professionals in early disease detection, supports resource-constrained settings, and offers instant, AI-driven medical responses to patients. It bridges the gap between patients and medical knowledge by delivering understandable, AI-curated responses in real-time [20]. The project showcases proficiency in deep learning, web development, and AI integration, demonstrating technology's potential for societal betterment in healthcare.

2.4 TOOLS

The Thorax AI project utilizes a variety of tools across its development and implementation phases:

- **Deep Learning Frameworks & Libraries:**
  - PyTorch
  - TorchVision (for EfficientNet-B0 model and transforms)
  - Google Colab (for model training)
  - TensorFlow (mentioned for potential future enhancements/flexibility)
- **Image Processing & Visualization:**
  - OpenCV
  - Matplotlib
  - PIL (Pillow - Python Imaging Library)
- **AI/Generative AI:**
  - Gemini API (Google Generative AI)
  - google.generativeai library
- **Web Development:**
  - Python
  - Flask (backend framework)
  - HTML
  - CSS
  - JavaScript
  - Bootstrap (for frontend)
- **Development Environment & Utilities:**
  - Visual Studio Code (primary development environment)
  - python-dotenv (for API key management)
  - torch.nn (for model customization)
  - torch.nn.functional (for softmax)
  - torch.topk (for retrieving top predictions)

2.5 METHODS

Thorax AI integrates an EfficientNet-B0 powered chest X-ray classifier with a Gemini API-backed medical chatbot to provide automated, accurate, and accessible chest disease detection. This dual-purpose platform offers real-time diagnostic predictions and interactive medical consultations, enhancing early detection and patient understanding, especially in resource-constrained settings [15].

3. METHODOLOGY

3.1 INPUT

Thorax AI is a final year project designed to revolutionize chest disease detection using deep learning and artificial intelligence [9]. This innovative platform integrates a chest X-ray image classifier powered by Efficient Net B0 and a medical chatbot backed by the Gemini API. The system's primary function is to process and analyse chest X-ray images, detecting common thoracic diseases such as Pneumonia, Tuberculosis, and Cardiomegaly with speed and precision [14]. Users receive X-ray analysis results and can interact with the AI chatbot to ask health-related questions, receiving medically accurate and validated information. The project aims to assist healthcare professionals in early disease detection, provide support in resource-constrained settings, and offer instant, AI-driven medical responses [20]. It bridges the gap between patients and medical knowledge by delivering understandable, AI-curated responses in real-time.

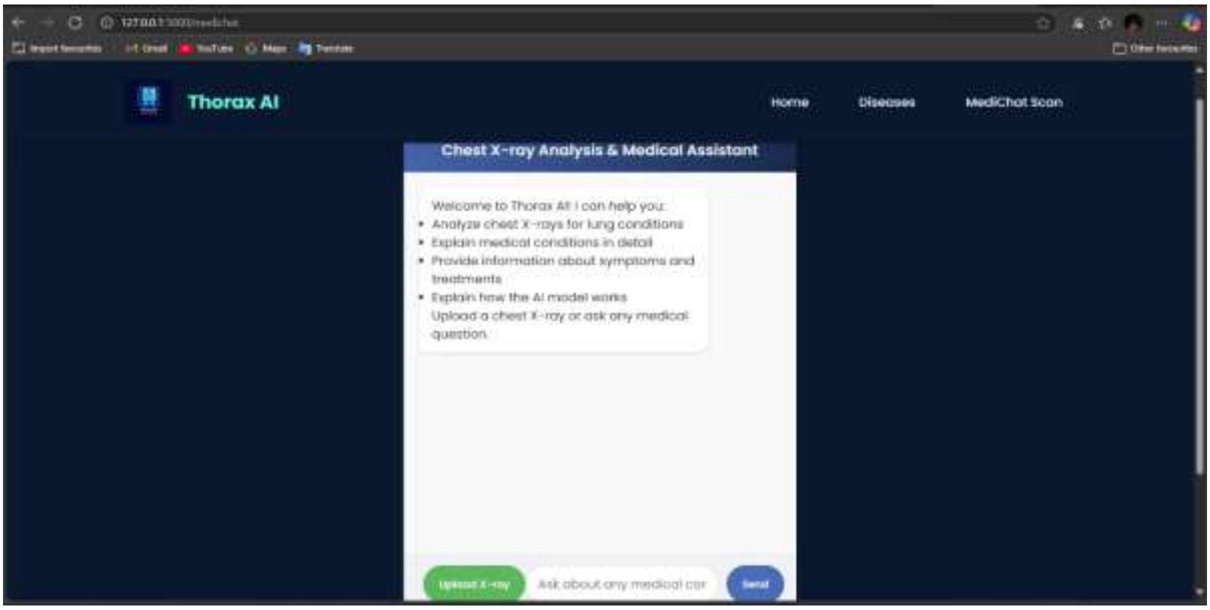

Fig. 3 Upload a chest x-ray or ask any medical question

3.2 METHOD OF PROCESS

The Thorax AI system processes chest X-ray images through a deep learning pipeline and handles medical queries via a generative AI chatbot. Images are first pre-processed, involving resizing, normalization, and conversion to tensor format [22]. These prepared images are then fed into the EfficientNet-B0 model for multi-label thoracic disease classification, yielding diagnostic predictions and probability scores. For interpretability, a Grad-CAM module generates heatmaps highlighting relevant areas of the X-ray [1]. Simultaneously, user medical queries are processed by the Gemini API-powered chatbot, which generates contextually informed and medically accurate responses, with input validation ensuring relevance [5]. All these processes are seamlessly integrated within a Python and Flask-based web interface, providing real-time feedback.

3.3 OUTPUT

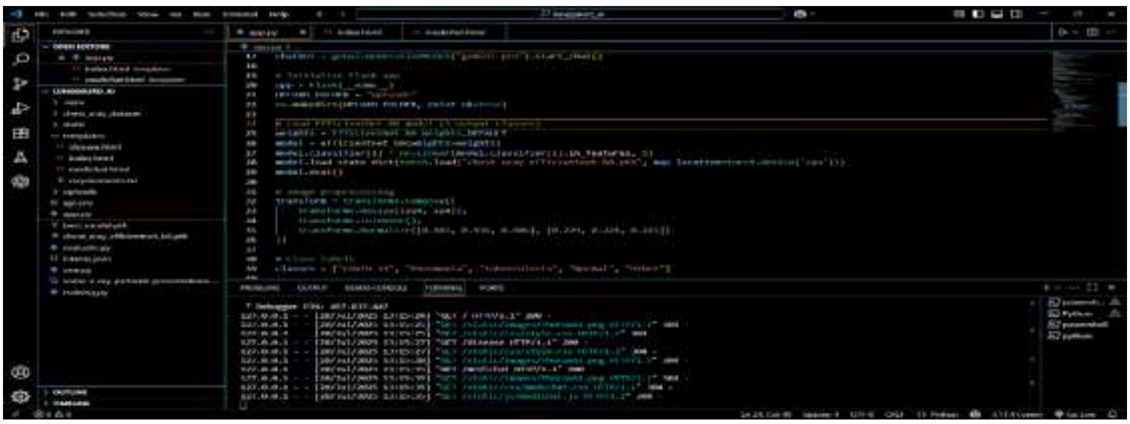

Fig. 4 Preprocess data

The Thorax AI project integrates deep learning and AI to revolutionize chest disease detection [5]. It utilizes an Efficient Net B0-powered chest X-ray classifier for fast and precise diagnosis of conditions like Pneumonia and Tuberculosis. Complementing this, a medical chatbot, backed by the Gemini API, provides users with medically accurate responses to health-related questions. This platform aims to assist healthcare professionals in early detection and offer instant, AI-driven medical responses, bridging the gap between patients and medical knowledge [12].

Fig. 5 home page

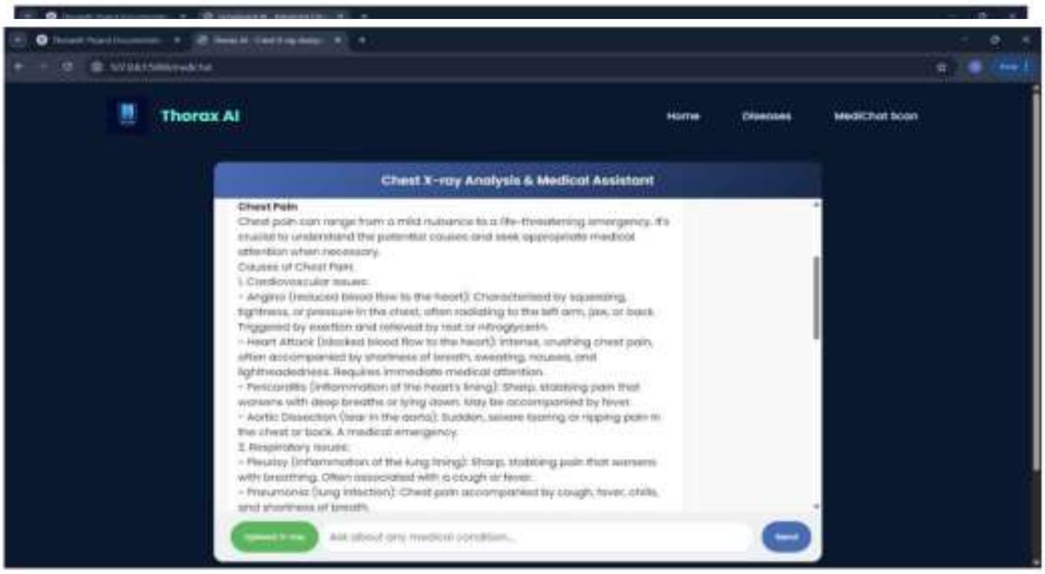

Fig. 6 Gemini ai chatbot

Fig. 7 chest x ray in chatbot

4. RESULTS

Thorax AI is a final year project that revolutionizes chest disease detection by integrating a deep learning-based chest X-ray image classifier (EfficientNet B0) and a medical chatbot (Gemini API). It processes X-ray images to accurately detect common thoracic diseases and offers real-time, medically validated responses to user queries. This innovative platform aims to assist healthcare professionals in early disease detection and empower patients with accessible, AI-driven medical insights.

5. DISCUSSIONS

The discussion around Thorax AI centers on its novel integration of an EfficientNet-B0 image classifier with a Gemini API-powered medical chatbot, addressing the limitations of existing standalone diagnostic tools and non-contextual chatbots. This combined approach aims to deliver accurate, interpretable chest X-ray diagnoses alongside real-time, medically validated explanations, crucial for both healthcare professionals and patients, especially in underserved areas. A key point of discussion is its significantly lower

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hallucination score compared to other AI models, demonstrating improved reliability in medical contexts due to its multi-modal, integrated design.

6. CONCLUSION

Thorax AI significantly advances medical diagnostics by integrating an EfficientNet-B0 deep learning model for chest X-ray classification with a Gemini API-powered medical chatbot. This system provides accurate, interpretable diagnoses with visual heatmaps, along with interactive, medically validated responses to user queries, achieving a remarkably low hallucination score. Ultimately, Thorax AI improves diagnostic efficiency and empowers users by delivering accessible, automated medical knowledge, especially valuable in resource-constrained settings.

7. FUTURE SCOPE

The future scope of Thorax AI involves expanding its disease coverage to include more thoracic conditions and other imaging types like CT scans and MRIs. Enhancements could also include integrating the system into mobile or cloud-based platforms for remote access, and evolving the chatbot into a full-fledged virtual health assistant with voice input, multilingual capabilities, and integration with wearable health devices. Continuous model improvement through active learning and integration with Electronic Health Records (EHR) can further refine predictions and personalize responses.

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Bamsuganti Balakrishna is pursuing his final semester MCA in Sanketika Vidya Parishad Engineering College, accredited with A grade by NAAC, affiliated by Andhra University and approved by AICTE. With interest in Machine learning M Tomouli has taken up her PG project on THORAX AI: CHEST X RAY DISEASE DETECTION+ MEDICAL CHATBOT and published the paper in connection to the project under the guidance of Pinnamraju T S Priya, Assistant Professor, Head of the department, SVPEC.

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