

Vitadetect : Vitamin Deficiency Detection

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Abstract - Vitamin deficiencies continue to affect millions of individuals worldwide and often remain undetected until severe symptoms emerge. Conventional diagnostic approaches rely heavily on laboratory testing and specialist consultation, which may be expensive, time-consuming, and inaccessible in rural or resource-constrained regions. This paper presents VitaDetect, an intelligent AI-powered web platform designed for early-stage vitamin deficiency screening using image-based medical analysis.

The proposed system utilizes Convolutional Neural Network (CNN) architectures trained on curated dermatological and clinical datasets to classify deficiency-related conditions from images of nails, tongue, and skin. Three specialized deep learning models were developed for body-part-specific analysis. The nail model identifies conditions such as Bluish Nail and Alopecia Areata corresponding to Iodine and Vitamin D deficiencies. The tongue model detects Pale Tongue and Diabetes-related indicators associated with Iron and Vitamin B12 deficiencies. The skin model identifies Acne and Carcinoma patterns associated with Vitamin D and Vitamin A deficiencies.

The system follows a modern full-stack architecture consisting of a React + Vite frontend, a FastAPI backend, and TensorFlow/Keras-based inference services. Additional intelligent healthcare support features include personalized 7-day diet plan generation, confidence visualization using interactive charts, downloadable health recommendations, nearby doctor discovery using geolocation services, and privacy-preserving in-memory image processing.

Keywords: Vitamin Deficiency Detection, Deep Learning, CNN, TensorFlow, Medical Image Analysis, FastAPI, React, OpenCV, Nutritional Screening, Healthcare AI, Computer Vision, Diet Recommendation System.

1. INTRODUCTION

Vitamin deficiencies are among the most common yet underdiagnosed health conditions globally. Deficiencies in essential nutrients such as Vitamin D, Vitamin B12, Iron, Iodine, and Vitamin A can lead to severe complications including fatigue, weakened immunity, skin disorders, neurological abnormalities, anemia, hair loss, and impaired metabolism. Despite their prevalence, early-stage deficiencies are frequently ignored due to limited awareness and the lack of affordable screening methods.

Traditional diagnosis primarily depends on blood tests, laboratory investigations, and specialist consultation. While clinically reliable, these approaches require healthcare infrastructure, repeated appointments, and financial resources that may not be accessible to large sections of the population. In developing countries and rural regions, delayed diagnosis often results in disease progression before treatment begins.

Interestingly, many nutritional deficiencies manifest visible symptoms on external body regions including nails, tongue, and skin. Bluish or brittle nails, pale tongue appearance, acne, skin lesions, and discoloration patterns often provide important visual indicators of internal nutritional imbalance. Advances in artificial intelligence and deep learning now make it possible to analyze such visual symptoms automatically through image classification systems.

Recent developments in Convolutional Neural Networks (CNNs) have demonstrated remarkable success in medical image analysis tasks including skin cancer detection, retinal disease analysis, tongue diagnosis, and dermatological screening. Motivated by these advancements, this work proposes **VitaDetect**, a comprehensive AI-powered vitamin deficiency detection platform capable of performing multi-body-part analysis using CNN-based image classification.

Unlike conventional research prototypes, the proposed system provides a complete real-time healthcare assistance platform integrating:

- Image-based deficiency detection
- Confidence-based prediction visualization
- Personalized 7-day diet planning
- Nearby doctor and hospital recommendations

- Downloadable health reports
- Interactive responsive user interface
- Privacy-preserving local image processing

The system architecture separates frontend interaction from backend inference services, improving scalability, maintainability, and deployment flexibility. By combining medical image analysis with actionable dietary recommendations and healthcare accessibility support, VitaDetect aims to provide an affordable, accessible, and practical preventive healthcare solution.

2. LITERATURE SURVEY

The application of artificial intelligence in healthcare has expanded significantly in recent years, particularly in the domain of medical image analysis. Deep learning models, especially Convolutional Neural Networks (CNNs), have achieved high accuracy in detecting visual abnormalities from medical images.

Esteva et al. demonstrated dermatologist-level skin cancer classification using deep neural networks, establishing a strong foundation for AI-based dermatological diagnosis. Similar studies in tongue diagnosis have shown that tongue texture, coating, and color patterns can be analyzed using CNNs to identify nutritional deficiencies and metabolic disorders.

Transfer learning techniques using architectures such as ResNet, MobileNetV2, EfficientNet, and VGG have become increasingly popular in medical image classification tasks. These pre-trained models significantly reduce training time and improve performance when datasets are limited.

Several studies have also focused on skin disease classification using CNN-based systems. Most of these systems achieved high accuracy under controlled conditions but lacked real-world deployment capability and practical healthcare integration.

From the reviewed literature, the following observations were identified:

- CNN-based systems outperform traditional machine learning approaches such as Support Vector Machines and Random Forests in image classification tasks.
- Transfer learning improves classification performance for limited medical datasets.
- Most existing systems focus on a single body part instead of multi-region analysis.
- Many research models remain limited to notebook implementations and lack deployable full-stack architecture.
- Existing healthcare screening systems rarely provide actionable dietary guidance after prediction.
- Few systems combine AI diagnosis with geolocation-based healthcare accessibility support.

The proposed VitaDetect system addresses these limitations by integrating:

- Multi-body-part image analysis
- Real-time AI inference
- Personalized diet recommendations
- Nearby doctor discovery
- Interactive confidence visualization
- Privacy-preserving architecture
- Lightweight CPU-based deployment

This integration transforms the system from a simple classifier into a practical preventive healthcare assistant.

3. PROPOSED SYSTEM

The proposed system, VitaDetect, is a full-stack AI-powered healthcare platform designed for real-time vitamin deficiency detection and nutritional guidance.

The system architecture consists of three major layers:

1. Frontend Layer (React + Vite)
2. Backend Layer (FastAPI)
3. AI Inference Layer (TensorFlow/Keras CNN Models)

Users upload images of nails, tongue, or skin through the frontend interface. The image is transferred to the FastAPI backend using REST API communication. The backend preprocesses the image using OpenCV and forwards it to the corresponding CNN model for prediction.

The system returns:

- Detected disease condition
- Associated vitamin deficiency
- Confidence score
- Probability breakdown visualization
- Personalized diet recommendations
- Nearby doctors and hospitals

The system additionally supports:

- Drag-and-drop image uploads
- Dark and light themes
- Downloadable diet plans
- Interactive confidence charts
- Geolocation-enabled healthcare discovery
- Real-time low-latency inference

Figure 1: System Architecture Diagram

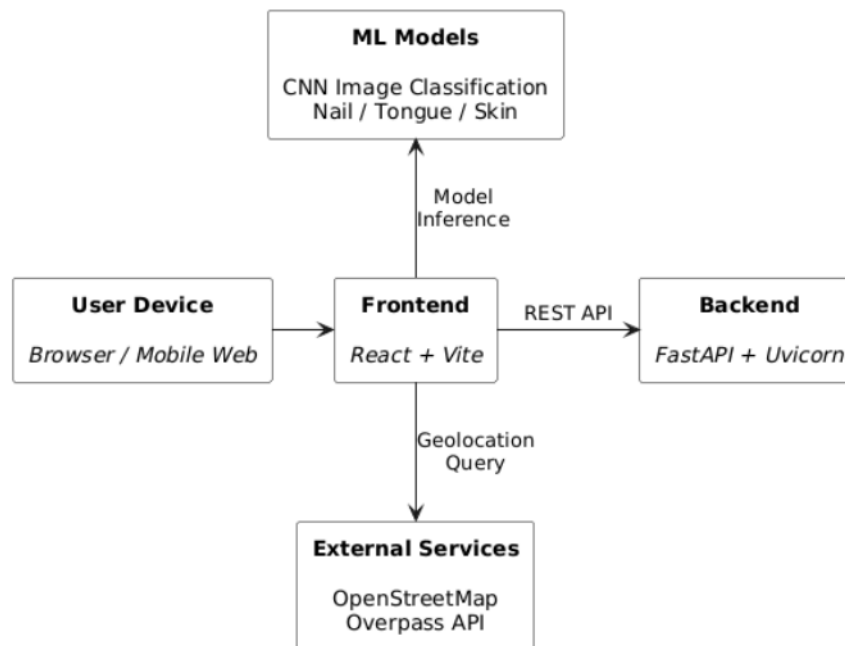


Figure-1.1 : Architecture Diagram

4. METHODOLOGY

The implementation methodology of VitaDetect consists of multiple stages including dataset preparation, preprocessing, model training, backend integration, frontend development, and healthcare recommendation generation.

4.1 Dataset Preparation

The dataset was organized into three body-part categories: Nail, Tongue, and Skin.

Body Part	Condition	Deficiency Mapping
Nail	Bluish Nail	Iodine Deficiency
Nail	Alopecia Areata	Vitamin D Deficiency
Tongue	Pale Tongue	Iron Deficiency
Tongue	Diabetes Indicators	Vitamin B12 Deficiency
Skin	Acne	Vitamin D Deficiency
Skin	Carcinoma	Vitamin A Deficiency

The dataset was split into training, validation, and testing sets to ensure balanced model evaluation.

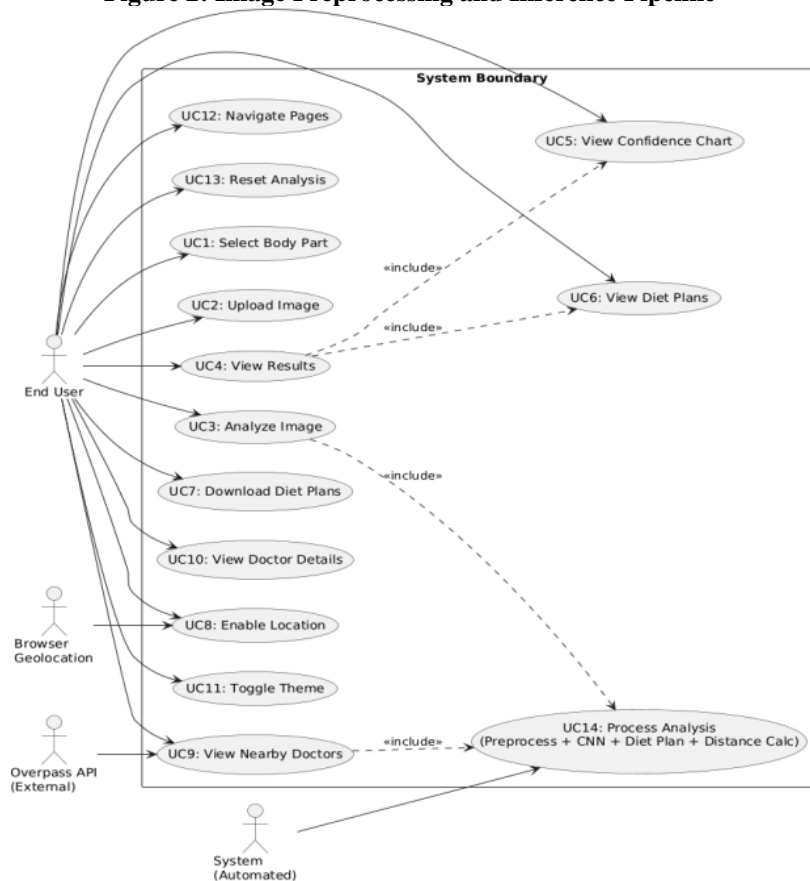
4.2 Image Preprocessing Pipeline

Each uploaded image undergoes a standardized preprocessing pipeline before inference.

The preprocessing stages include:

1. Image resizing to 224×224 dimensions
2. Color conversion from BGR to RGB
3. Pixel normalization to the range [0,1]
4. Batch dimension expansion
5. Tensor preparation for CNN inference

Figure 2: Image Preprocessing and Inference Pipeline



4.3 Model Architecture and Training

Three independent CNN models were developed and trained using TensorFlow/Keras.

Model	Body Part	Input Size	Output Classes
Nail CNN	Nails	224×224	3 Classes
Tongue CNN	Tongue	224×224	2 Classes
Skin CNN	Skin	224×224	2 Classes

Transfer learning techniques using MobileNetV2 and ResNet-based architectures were used to improve accuracy and reduce overfitting.

Data augmentation techniques including:

- Rotation
- Horizontal flipping
- Brightness adjustment
- Zoom transformation

were applied to improve model generalization.

The trained models were saved in .keras format and loaded dynamically into the FastAPI backend during application startup.

4.4 Backend API Architecture

The backend was implemented using FastAPI due to its asynchronous capabilities, automatic API documentation generation, and high-performance request handling.

The backend provides the following REST endpoints:

Endpoint	Purpose
/api/analyze	Image Analysis
/diet-plan	Diet Recommendation
/location-services	Nearby Doctors
/health	System Health Monitoring

The backend performs:

- Image validation
- OpenCV preprocessing
- CNN inference
- Prediction aggregation
- Diet plan generation
- JSON response formatting

All image processing is performed in-memory without permanent image storage, ensuring privacy preservation.

4.5 Frontend Architecture

The frontend interface was developed using React and Vite.

Key frontend features include:

- Drag-and-drop image upload
- Body part selection
- Real-time result visualization
- Interactive confidence charts
- Responsive UI design
- Dark/light theme support
- Downloadable reports
- Geolocation-enabled doctor search

Axios was used for backend communication while Chart.js was used for confidence visualization.

Figure 3: Sequence Diagram – Image Analysis Workflow

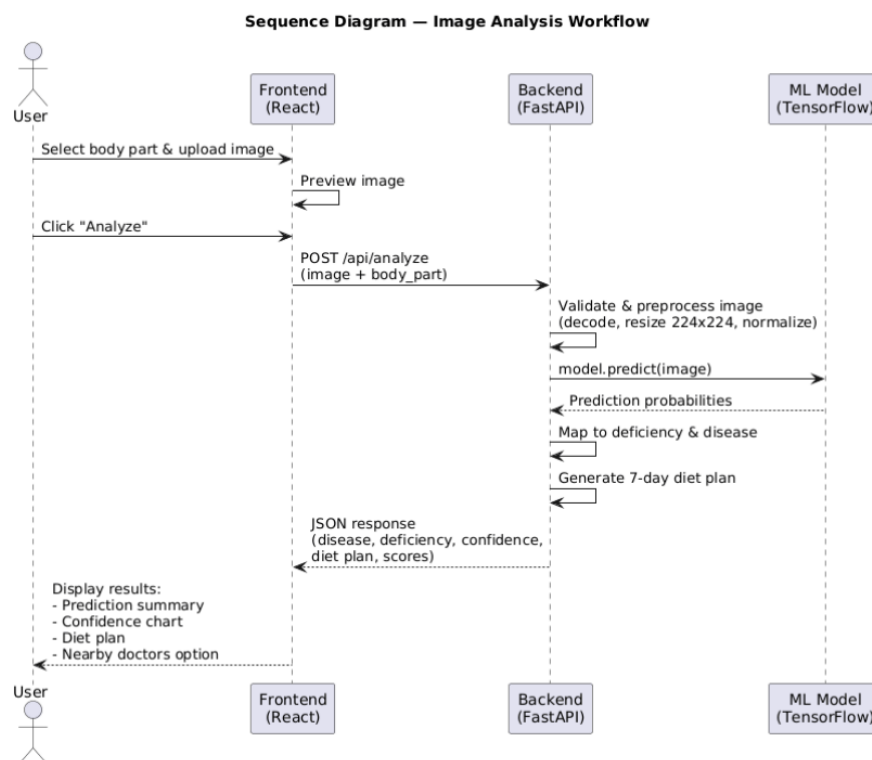


Figure 4 : Diet plan generation and download

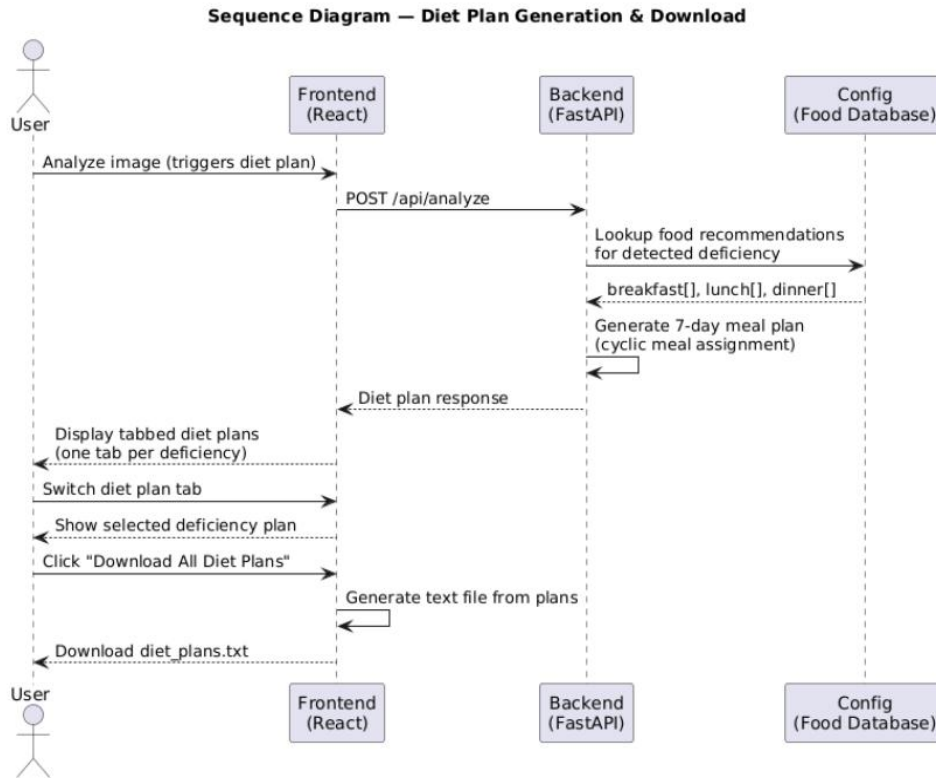
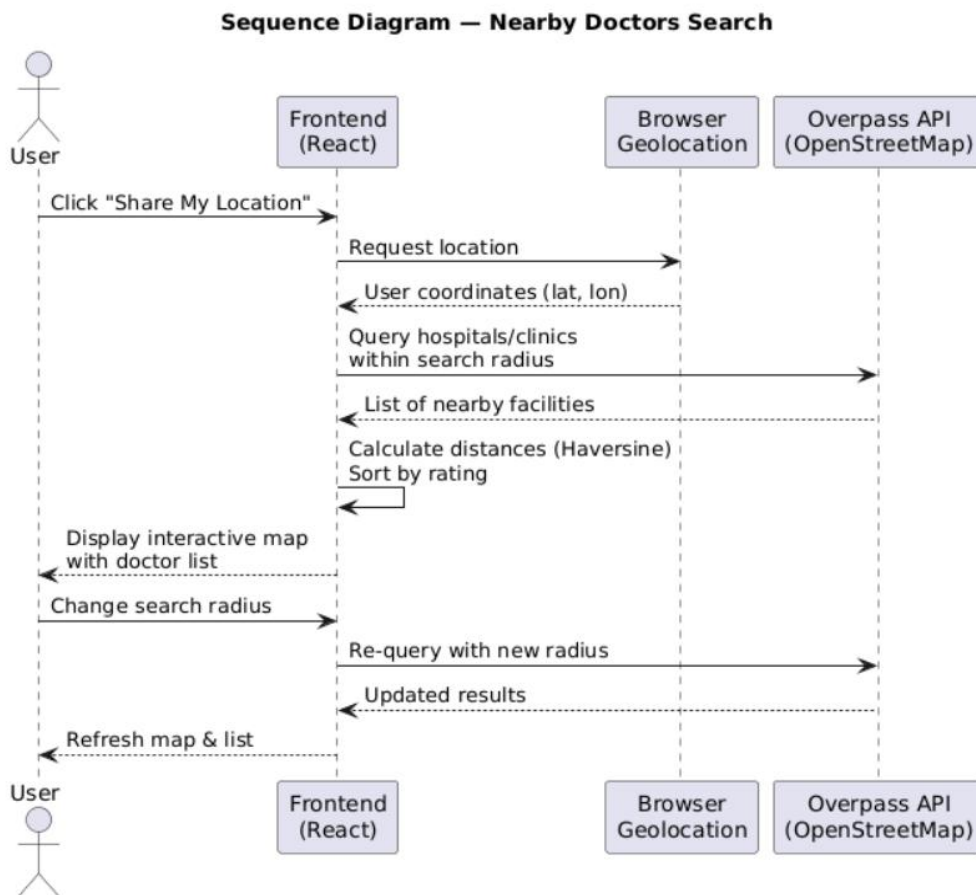


Figure 5: Nearby Doctors Search Workflow



5. RESULTS AND DISCUSSION

The VitaDetect system was successfully implemented and tested as a complete end-to-end healthcare assistance platform.

The CNN models successfully detected vitamin deficiency-related conditions from images of nails, tongue, and skin with real-time inference speeds.

The frontend interface provided a smooth and responsive user experience with:

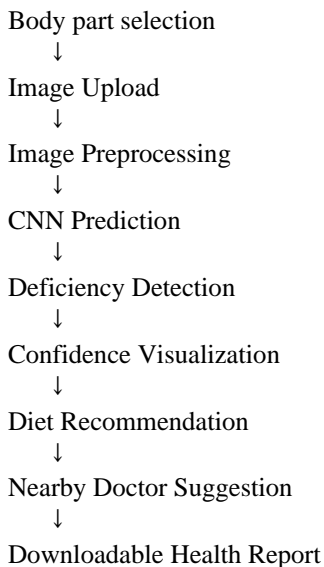
- Real-time image upload
- Prediction visualization
- Confidence analysis
- Diet recommendations
- Nearby doctor suggestions

The backend handled API requests efficiently while maintaining low inference latency.

Key Observations

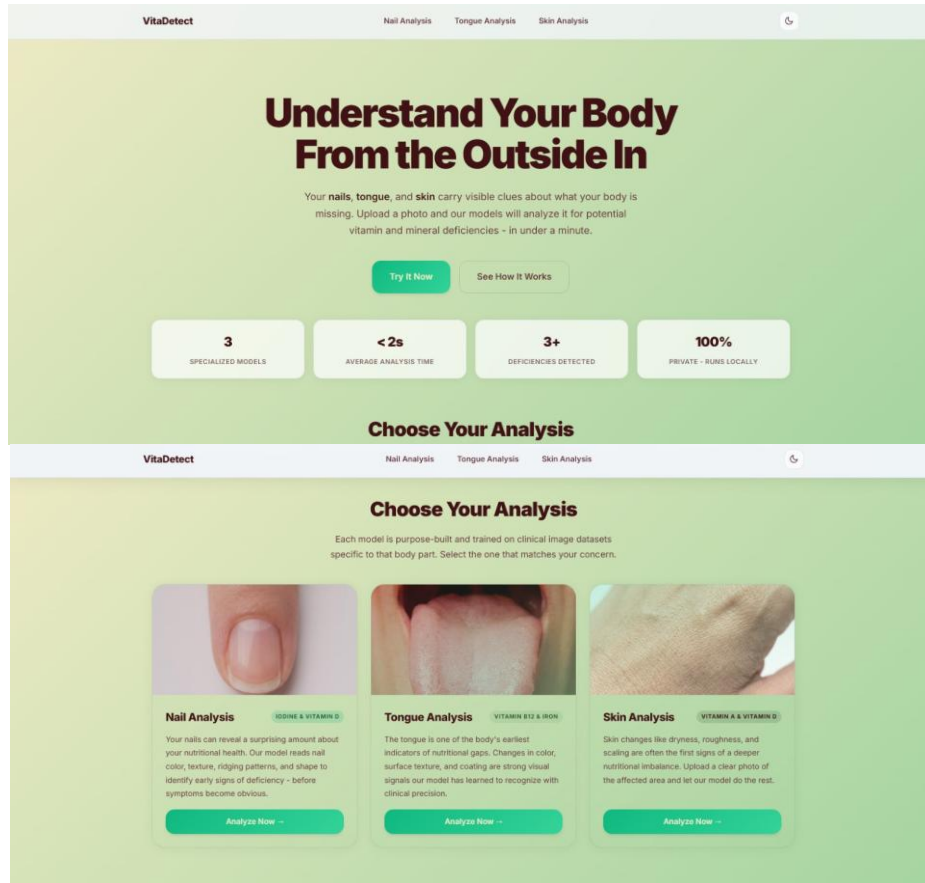
- Average model inference time ranged between 92 ms and 146 ms.
- The system successfully processed image uploads and predictions in under 500 ms.
- Confidence visualization improved interpretability of AI predictions.
- Personalized diet plans increased practical usability.
- Nearby doctor recommendations improved healthcare accessibility.
- The lightweight deployment architecture enabled CPU-based inference without GPU dependency.

Figure 5: Functional Workflow of VitaDetect



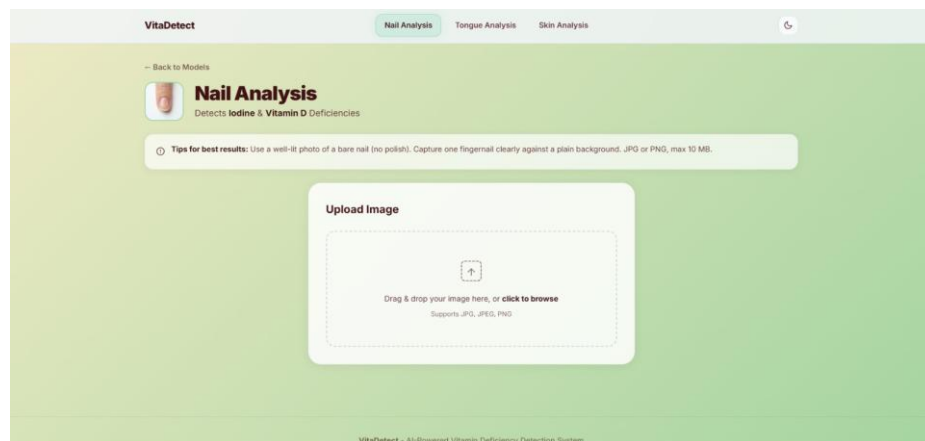
User Dashboard:

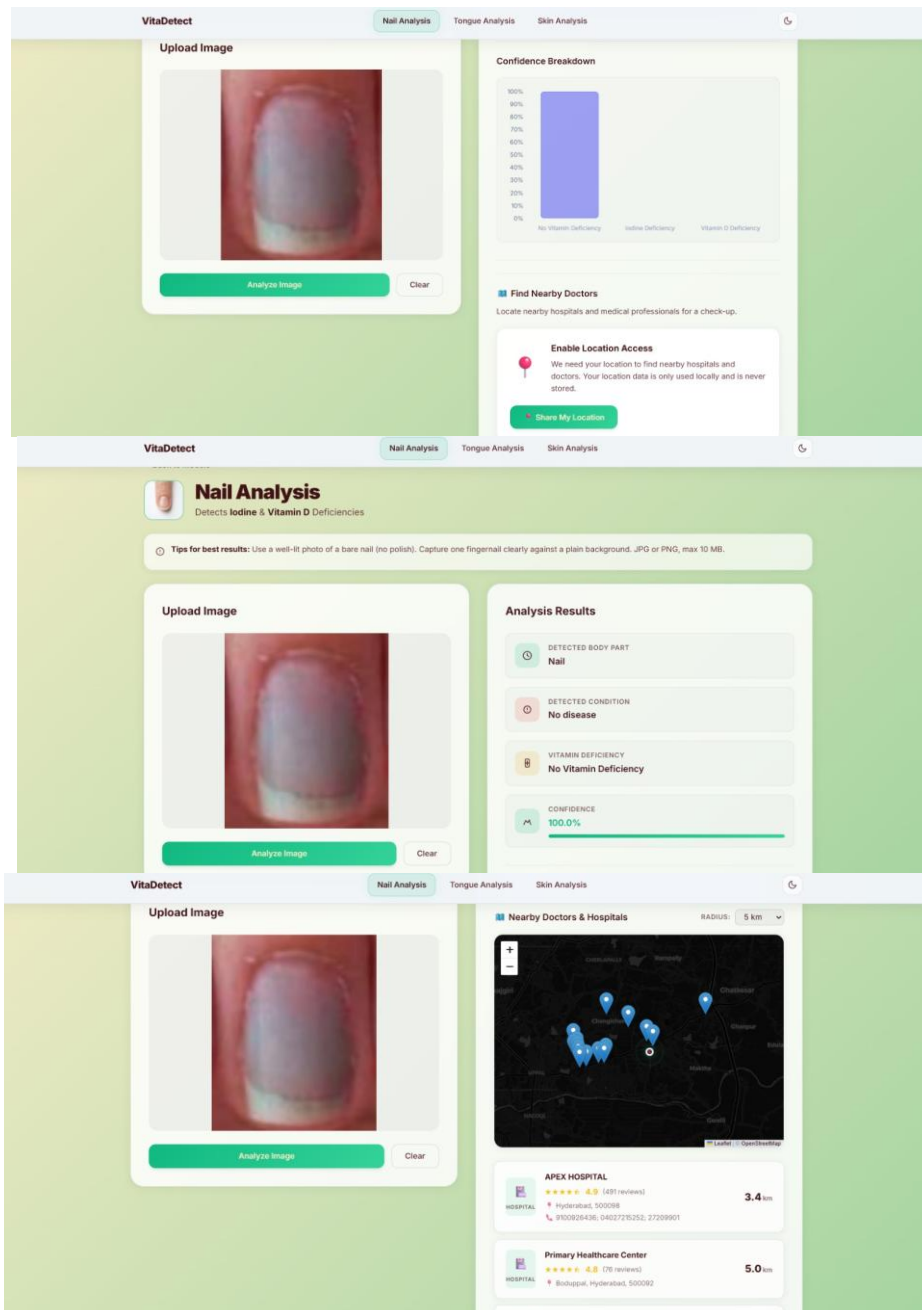
The interface provides interactive navigation for specialized analysis categories and a "Try It Now" entry point to begin the detection process. It features a three-part selection menu where users can specifically choose to examine their nails, tongue, or skin using dedicated AI diagnostic modules. Finally, the platform presents a guided four-stage workflow that facilitates image submission, automated model scanning, results reporting, and actionable health recommendations. Refer to the below images.



Nail Result:

In the Nail Analysis page in the VitaDetect platform, showcasing the deficiency detection results after a fingernail image has been uploaded and analyzed. The Analysis Results panel displays key findings including the detected condition, vitamin deficiency status, and confidence score, with this instance revealing No Disease, No Vitamin Deficiency.





6. ADVANTAGES OF THE PROPOSED SYSTEM

The proposed VitaDetect system offers several advantages compared to traditional healthcare screening methods:

- Non-invasive nutritional screening
- Real-time AI-powered analysis
- Low-cost healthcare accessibility
- Lightweight deployment without GPU dependency
- Privacy-preserving image processing
- Integrated dietary guidance
- User-friendly web interface
- Geolocation-based healthcare assistance
- Interactive prediction transparency
- Cross-platform accessibility

7. FUTURE ENHANCEMENTS

Several future improvements can further enhance the capabilities of the VitaDetect platform.

Future enhancements include:

- Integration of additional body regions such as eyes, lips, gums, and hair
- Larger clinically validated datasets
- Mobile application deployment
- Vision Transformer (ViT)-based architectures
- Multilingual healthcare assistance
- AI chatbot integration for symptom guidance
- Cloud-native scalable deployment
- Integration with electronic health records
- Personalized nutrition tracking dashboards
- Real-time telemedicine integration

8. CONCLUSION

This work successfully developed VitaDetect, a comprehensive AI-powered vitamin deficiency detection platform that combines deep learning, medical image analysis, and healthcare recommendation systems.

The system demonstrates the feasibility of using CNN-based image classification for preliminary nutritional screening through analysis of nails, tongue, and skin images. By integrating FastAPI backend services, React-based frontend interaction, confidence visualization, diet planning, and nearby doctor discovery, the platform extends beyond traditional prediction systems into a practical healthcare assistance solution.

The lightweight architecture, real-time inference performance, and privacy-conscious design make the proposed system suitable for deployment in educational institutions, clinics, rural healthcare environments, and preventive healthcare programs.

The proposed system highlights the growing potential of AI-driven healthcare technologies in improving accessibility, affordability, and early-stage medical awareness.

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