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Machine Learning-based Skin Disease Classification

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1.1 Introduction

Skin diseases are prevalent among adults and can significantly impact their quality of life. The traditional methods of diagnosing these conditions often involve time-consuming processes and subjective assessments by healthcare professionals. With the advent of machine learning and artificial intelligence, there is a promising opportunity to enhance the accuracy and speed of skin disease classification, thereby improving patient outcomes and aiding healthcare providers in their diagnostic efforts.
This project aims to develop a machine learning-based system that classifies common skin diseases affecting adults through image analysis. By leveraging AI, we intend to create a user-friendly platform that not only provides accurate diagnostic predictions but also recommends potential next steps for users, guiding them towards seeking professional medical advice when necessary.

In recent years, advancements in machine learning have transformed various fields, including healthcare. Skin diseases, which often require visual assessment for diagnosis, are ideally suited for machine learning applications that can analyze images and provide accurate classifications. This project focuses on developing a robust machine learning model specifically for adults, addressing the need for faster and more reliable skin disease diagnostics.

1.1.1 Background study

Skin diseases represent a significant global health challenge, affecting millions of adults. The complexity of these conditions often leads to misdiagnosis and delayed treatment, negatively impacting patient quality of life. Traditional dermatological assessments, relying primarily on visual examinations by trained professionals, are time-consuming and can be subjective. Machine learning (ML) and advanced image processing offer a promising solution. ML algorithms can analyze extensive datasets of skin images, identifying subtle patterns and features invisible to the unaided eye, thereby improving diagnostic accuracy and efficiency. The widespread availability of high-quality smartphone cameras further enhances this potential, enabling the development of user-friendly applications for preliminary skin health assessments. This accessibility empowers individuals to proactively manage their skin health.

1.1.2 Reasons to study

The impetus for researching machine learning-based skin disease classification is compelling:

1. Rising Incidence: The prevalence of skin diseases in adults is increasing due to environmental factors, lifestyle changes, and an aging population. An accurate and accessible classification system is crucial to address this growing public health concern.

2. Timely Diagnosis: Early and accurate detection is paramount for effective treatment. A rapid, ML-powered preliminary diagnosis can significantly reduce delays in seeking professional medical attention.

3. Reduced Healthcare Burden: By providing initial assessments, an automated system can alleviate the strain on healthcare providers, allowing them to focus resources on complex cases and shorten wait times.

4. Technological Advancements: Recent breakthroughs in ML algorithms, particularly Convolutional Neural Networks (CNNs), and image processing techniques present unprecedented opportunities to improve dermatological diagnostics.

5. Enhanced Accessibility and Convenience: A smartphone-accessible ML application can democratize access to preliminary skin disease assessments, promoting proactive health management and early intervention. This project will explore integration with telemedicine platforms for seamless consultation with dermatologists**.**

1.1.3 Motivation

This project is driven by a commitment to leveraging technology for improved healthcare outcomes:

1. **Addressing Diagnostic Gaps:** Personal experiences highlight the frustrations associated with delayed or inaccurate diagnoses. This project aims to provide faster, more accessible preliminary assessments.

2. **Patient Empowerment:** By offering initial recommendations and tailored skincare advice, the system empowers individuals to make informed decisions about their health. This will include personalized skincare regimen suggestions based on the classification results.

3. **Healthcare Innovation:** This research contributes to the exciting intersection of ML and healthcare, potentially revolutionizing dermatological diagnostics. The integration of educational resources within the application will further enhance patient understanding of skin health.

4. **Collaborative Potential:** This project facilitates collaboration between dermatologists, ML specialists, and software engineers, fostering interdisciplinary innovation. Partnership with dermatologists will be key for validating the system's accuracy and facilitating telemedicine integration. The creation of educational resources will involve collaboration with dermatological experts.

1.2 Problem Statement

The diagnosis of skin diseases often requires the expertise of a dermatologist, and in many regions, access to such specialists is limited. The problem is further compounded by the sheer variety of skin conditions, some of which may appear visually similar, making diagnosis difficult even for trained professionals. A machine learning-based classification system can alleviate this challenge by offering a fast and accessible solution, potentially improving early detection rates and treatment outcomes. This project seeks to develop a tool that classifies common skin diseases based on images and provides recommendations,thereby assisting patients and healthcare professionals.

1.3 Objective of the project

1.3.1 General Objectives:

To develop a machine learning-based classification system for common adult skin diseases, enabling preliminary diagnosis through image input and providing users with initial recommendations to support early detection and timely medical consultation.

1.3.2 Specific Objectives:

- Collect a comprehensive data-set of skin disease images for training and validation of the machine learning model.
- Curate high-quality images of different skin conditions, focusing on adult skin characteristics and variations.
- Ensure the data-set is sufficiently comprehensive, representative, and optimized for machine learning model training.
- Train the model to identify and classify various skin disease conditions accurately in adult patients.
- Develop a disease classification algorithm capable of analyzing and identifying different skin conditions based on image data.
- Create a recommendation system within the algorithm to guide users based on disease classification results.
- Design and develop a user-friendly mobile or web application integrated with the trained model.
- Collaborate with dermatologists to enable telemedicine consultations directly through the app for users requiring professional evaluation.
- Provide users with access to articles, videos, and infographics on skin health, prevention tips, and the importance of early disease detection.
- Develop a feature that generates a tailored skincare routine based on the identified skin condition, including product recommendations, application techniques, and usage frequency.
- Conduct thorough testing and validation of the model, evaluating its performance on metrics such as accuracy, precision, recall, and F1 score.

1.4 Scope of the project:

The scope of this project is to develop a machine learning model capable of classifying images of adult skin as either healthy or showing signs of specific skin diseases, including eczema, psoriasis, melanoma, and acne. The model focuses on conditions with visible skin surface markers, excluding diseases that require advanced diagnostic tools or tests beyond image analysis. By utilizing a dataset comprising images of both healthy skin and skin affected by these conditions, the project aims to ensure high accuracy and effectiveness in classification.

The project also includes additional functionalities to enhance its usability and impact. These features include telemedicine integration, allowing users to connect with dermatologists for professional consultations directly through the application. Educational resources will provide users with accessible information on skin health, prevention tips, and the importance of early detection.

Additionally, the application will offer a personalized skincare regimen tailored to the identified skin condition, including product recommendations and application routines.

While the model is limited to analyzing visual markers and excludes diseases with sub-dermal symptoms or those requiring laboratory diagnostics, the incorporation of these features ensures a comprehensive solution for skin health management. By focusing on visible conditions and providing actionable insights, the project aims to empower users and support healthcare providers in their efforts to improve skin health outcomes.

1.5. System Development Methodology

In the system development phase of the skin disease detection for adults project, a comprehensive methodology will be employed to ensure the creation of an effective and innovative solution. This methodology spans data collection, model training, and the implementation of user-centric features like telemedicine integration, personalized skincare recommendations, and educational resources.

1.5.1. Investigation (Fact-Finding) Methods

In this project focused on identifying various skin diseases in adults, fact-finding involved identifying relevant data sources and assessing the quality and suitability of image datasets for training a classification model:

Dataset Source and Overview

- Data Source: The primary dataset used in this project is sourced from Kaggle, a reputable dermatology image database.
- Dataset Content: It consists of approximately 19,500 images across 23 different skin disease categories.
    - Categories include conditions such as acne, melanoma, eczema, seborrheic keratoses, tinea ringworm, bullous disease, poison ivy, psoriasis, vascular tumors, and more.

Data Splitting and Format

- Training and Testing Split:
    - Training Set: Contains 15,500 images, used to train the model and develop its classification capabilities.
    - Test Set: The remaining 4,000 images are reserved for validating model performance and assessing generalization accuracy.
- Image Format and Properties:
    - Format: All images are in JPEG format.
    - Color Channels: Each image has 3 channels (RGB), suitable for processing by standard image recognition models.
    - Resolution: Image resolutions vary across the dataset and categories. While these are not extremely high resolution, they offer sufficient detail for machine learning classification tasks.

Categories and Classification Goals

The dataset's diverse categories present unique classification challenges, as each type of skin disease has distinct visual characteristics. The primary goal is to train a model that can accurately differentiate between various types, including, but not limited to:

- Common Skin Conditions: Acne, eczema, and psoriasis.

Telemedicine and Recommendation Feature Research:

- We will leverage APIs and frameworks for real-time dermatologist consultations.

1.5.2. System Development Tools

Table 1.1 development tools

Category	**Technology**	**Purpose**
Machine Learning	TensorFlow, PyTorch	Develop disease classification model
	Convolutional Neural Networks (CNN)	Implement specific algorithms for classification
	Jupyter notebook, Anaconda	Model development and algorithm testing
Image Processing	Keras	Image pre-processing, feature extraction, data optimization
Cloud Computing	Vercel	Scalability, efficient deployment of machine learning model
User Interface	Flutter, React	Develop a user-friendly interface for image analysis
Backend	Django, Firebase	Application server development
Database	MySQL	Persistent data storage
Version Control	Git, GitHub	Collaborative development, systematic tracking of changes

1.6 Significance of the project:

The application of machine learning in skin disease detection holds immense significance in the realm of healthcare and dermatology. Skin diseases are prevalent worldwide and can profoundly impact an individual's quality of life. However, diagnosing these conditions accurately can be challenging due to

the variability in presentation and the complexity of certain diseases. By harnessing the power of machine learning algorithms, researchers and healthcare professionals can revolutionize the diagnostic process, leading to more efficient and accurate detection of skin diseases.

One of the key advantages of using machine learning for skin disease detection is its ability to analyze large datasets and identify patterns that may not be immediately apparent to the human eye. Machine learning models can be trained on vast amounts of data, including images of skin lesions and clinical information, to learn complex patterns associated with different skin diseases. This allows for the development of highly accurate diagnostic algorithms that can assist healthcare providers in making more informed decisions.

Furthermore, machine learning-based skin disease detection has the potential to improve access to dermatological care, particularly in underserved areas where access to specialized healthcare services may be limited. With the development of telemedicine platforms, individuals can capture images of their skin lesions and receive automated assessments from machine learning algorithms. This integration with telemedicine enables real-time consultations with dermatologists, ensuring timely evaluation and professional guidance for cases requiring expert attention. This not only speeds up the diagnostic process but also bridges the gap in accessing quality healthcare services in remote or underserved areas.

Additionally, personalized skincare recommendations generated through machine learning algorithms add another layer of significance. These tailored recommendations, based on the user's classification results, provide actionable insights such as suggested skincare routines and suitable products. By offering this level of customization, the project empowers users to take proactive steps in managing their skin health effectively and conveniently.

Moreover, the inclusion of educational resources enhances the overall value of the system. Informative articles, videos, and infographics on skin health and disease prevention provide users with a deeper understanding of their conditions and promote informed decision-making. These resources also serve to raise awareness about the importance of early detection and proper skin care, contributing to improved public health outcomes.

Overall, the significance of skin disease detection using machine learning lies in its ability to enhance diagnostic accuracy, provide personalized care, and improve access to specialized services. By leveraging telemedicine, personalized recommendations, and educational tools, this project can positively impact patient outcomes and empower individuals to manage their skin health more effectively. Researchers and healthcare professionals can utilize these advanced technologies to develop more efficient strategies for diagnosing and managing skin diseases, ultimately leading to better healthcare delivery and improved quality of life for individuals affected by these conditions.

1.7 Beneficiaries

The machine learning-based skin disease classification system will benefit both individuals (patients) and healthcare professionals (doctors and health experts). By providing faster, more accessible diagnostics, personalized care recommendations, and educational resources, the project aims to improve health outcomes, assist in early detection, and optimize healthcare resource utilization.

1.7.1 Patients

Patients, especially those without easy access to dermatologists, will greatly benefit from this system as it provides a quick and convenient way to identify potential skin conditions using image-based diagnostics. Key benefits include:

- Preliminary Insights: Users can gain an initial understanding of their skin health without the need for an immediate visit to a healthcare facility.
- Timely Care Guidance: The system's telemedicine integration allows patients to consult dermatologists directly through the application for professional evaluations and advice.
- Personalized Skincare Recommendations: By offering tailored skincare regimens based on the diagnostic results, the system empowers users to take proactive steps in managing their skin health.
- Educational Resources: Access to articles, videos, and infographics on skin diseases and prevention strategies helps patients become more informed about their conditions, reducing anxiety and encouraging proactive health management.
- Improved Outcomes: Accurate predictions and recommendations lead to earlier treatment, which can significantly improve recovery and overall quality of life.

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1.7.2 Doctors (Health Experts)

Healthcare providers, particularly dermatologists, will benefit from the system's ability to streamline workflows and enhance diagnostic accuracy. Key advantages include:

- Prioritization of Cases: The system's preliminary assessments help prioritize cases, enabling dermatologists to focus on more complex conditions while handling a larger patient volume effectively.
- Accurate Early Diagnoses: By supporting accurate preliminary classifications, the model reduces instances of misdiagnosis and enhances overall patient care.
- Enhanced Telemedicine Capabilities: The integrated telemedicine feature allows doctors to consult with patients remotely, extending their reach to underserved or remote areas and optimizing their time.
- Support for Research: The tool generates valuable datasets, offering insights into common skin conditions, trends, and patient demographics, thereby contributing to data-driven improvements in dermatology.
- Patient Education: By providing educational materials through the system, healthcare providers can enhance patient understanding of their diagnoses and recommended treatments, improving adherence and outcomes.

1.8 Time Schedule

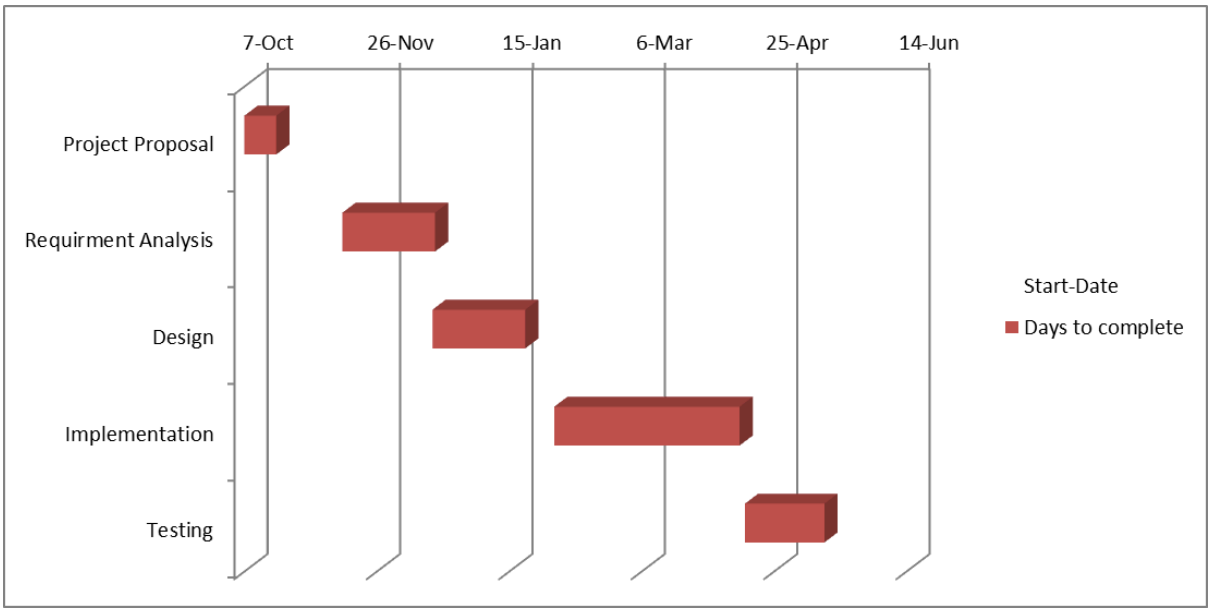

Fig-1 Gantt-Chart

CHAPTER TWO

2. REQUIREMENT ANALYSIS

2.1 Introduction

This requirement analysis aims to assess the current state of such methods, identify their strengths and limitations, and develop requirements for an advanced AI-based system. The analysis considers the needs and challenges to enhance disease management practices.

2.2 Current Skin disease classification system

Currently, there are no skin disease classification system software implemented in Ethiopia. Even though there has been researched solutions, the detection and classification of skin diseases in the country primarily relies on manual observation by experienced Dermatologists.

2.2.1 Major Function of the current method

In Ethiopia, where healthcare resources for dermatological conditions may be limited, several approaches are employed for skin disease detection and diagnosis. These systems often combine traditional methods and emerging technological advancements to address skin health challenges. The major functions of the current system include:

1. **Manual Visual Inspection:**
    - Manual visual inspection is the primary method used by healthcare providers in rural and urban areas.
    - Healthcare professionals and traditional healers visually examine the skin for abnormalities, such as discoloration, rashes, or lesions.
    - This method heavily relies on the experience and knowledge of practitioners and is often the first step in identifying skin conditions.
2. **Field Surveys and Community Outreach:**
    - Health extension workers and non-governmental organizations conduct field surveys and community awareness campaigns.
    - These efforts aim to identify common skin conditions within the population and provide education on prevention and basic management.
    - Samples or photographs of suspicious skin conditions are occasionally collected for further analysis.

3. **Laboratory-based Diagnosis (Limited Access):**
    - For complex cases, patients may be referred to specialized laboratories in urban centers for diagnosis.
    - Laboratory methods include histological analysis, culturing of pathogens, and occasionally molecular techniques like PCR.
    - Limited access to these facilities means this method is often reserved for severe or ambiguous cases.
4. **Traditional Remedies and Local Practices:**
    - In rural areas, traditional remedies, such as herbal treatments and natural oils, are often employed as first-line treatments.
    - Local practices are deeply rooted in cultural beliefs and are commonly used alongside or before seeking formal medical care.

2.2.2 Problem of the Existing System

- **Limited Access to Dermatological Care**
  The country has an extreme shortage of dermatologists, with the majority stationed in urban areas like Addis Ababa. This leaves rural populations without access to specialized care, forcing them to rely on general practitioners or traditional healers.
- **Reliance on Traditional Healers**
  In rural areas, the absence of modern healthcare systems leads many individuals to consult traditional healers. Although these practices are culturally important, they often lack scientific backing and may delay proper treatment for serious skin conditions such as melanoma or cutaneous leishmaniasis.
- **Underreporting and Data Gaps**
  The healthcare system suffers from a lack of comprehensive data on the prevalence and types of skin diseases. Diseases like cutaneous leishmaniasis and scabies remain underreported due to poor diagnostic facilities and the limited ability to collect data systematically in rural Ethiopia.
- **Financial Barriers**
  High out-of-pocket healthcare costs deter individuals from seeking timely medical care for skin conditions. This issue is more severe in rural areas, where poverty is prevalent, forcing people to delay or avoid treatment.
- **Stigma and Social Perception**
  Individuals with visible skin diseases face significant social stigma. Cultural beliefs often link skin conditions to uncleanliness or supernatural causes, discouraging affected individuals from seeking timely medical attention.
- **Inadequate Diagnostic Tools and Facilities**
  Most healthcare centers, especially in rural Ethiopia, lack the equipment necessary for accurate skin disease diagnosis. Advanced techniques like dermoscopy, histopathology, and molecular diagnostics are limited to a few urban hospitals and laboratories.

- **Limited Public Awareness and Education**
  There is minimal public awareness regarding the causes, symptoms, and prevention of skin diseases. This lack of knowledge leads to late reporting of conditions and reliance on unproven treatments. Educational campaigns are often insufficient or completely absent in rural areas.

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- ResearchGate. "Automatic Skin Disease Diagnosis Using Deep Learning Models."

2.3 Requirement Gathering

2.3.1. Requirement Gathering Methodologies

Table 2.1 requirement analysis result

Requirement Gathering Methodology		Results Found
Interviews were conducted to learn more about the experiences, obstacles, and expectations of skin disease diagnosis in Ethiopia.	Patients	- Expressed challenges in accessing timely and accurate skin disease diagnosis, especially in rural areas. - Highlighted a strong need for affordable and reliable diagnostic tools. - the need to getting advice more accessible without having to travel or wait a long time.
	Dermatologists	- Noted the importance of high-quality datasets representing diverse skin tones and conditions to improve AI-based models. - Highlighted the lack of user-friendly systems to integrate technology into their workflows. - There is a clear need for accessible, educational resources that empower individuals with the knowledge to recognize, prevent, and manage common dermatological conditions effectively.

	Stakeholder	- Emphasized the importance of designing an AI system that integrates seamlessly with existing healthcare infrastructure. - Stressed the need for consistent updates, maintenance, and technical support.

2.4 Proposed System

2.4.1. Overview

DermaAI addresses the challenges of inefficient and potentially inaccurate skin disease diagnosis by providing a convenient and accessible mobile application. It leverages state-of-the-art machine learning techniques to analyze skin images, offering preliminary diagnoses with confidence scores. The app empowers users to take proactive steps towards managing their skin health. Target users include individuals concerned about skin conditions, dermatologists seeking efficient triaging tools, and healthcare providers. Key features include AI-powered image analysis, personalized recommendations, educational resources, and optional teledermatology consultations. The anticipated outcome is faster, more accessible, and more accurate diagnosis of skin diseases, leading to improved patient care and reduced burden on healthcare systems.This section provides an overview of the key features and functionalities envisioned for the system.

2.4.2 Functional Requirements

The functional requirements of the machine learning skin disease classification system for adults encompass a range of
features aimed at providing a comprehensive and user-friendly solution:

Image Upload and Processing

Enabling users to upload images of the affected area of Skin for analysis. The system should support the upload of images through an intuitive user interface. Upon upload, the system will process the images using image pre-processing techniques to enhance quality and extract relevant features.

Develop a Real-time Disease Classification and Diagnosis System

The system must develop a real-time disease classification and diagnosis system that utilizes a robust machine learning model for accurate disease identification. Upon image upload, 17 the system should promptly analyze the input images and provide real-time feedback by displaying the identified disease along with relevant information. The machine learning model should be trained to classify adult Skin diseases based on visual patterns. This real-time diagnosis capability is essential for enabling Patients and Dermatologists to make timely decisions for disease management and prevention.

Integrate Information Resources and Knowledge Base

The system must integrate information resources and a knowledge base to enhance user understanding of different adult Skin diseases, their causes, and prevention strategies. This integration will include comprehensive information about identified diseases, recommended management practices, and additional resources for further learning. By providing users with access to information resources, users can acquire detailed information about Skin diseases and make informed decisions regarding disease management and prevention strategies.

Reporting and Analytics

Facilitate reporting and analytics for system performance. Implement reporting tools to track the performance of the disease classification model. Analytics should include metrics on accuracy, processing speed, and user engagement to continuously optimize and enhance the system and notification system to alert users about the identification results and recommended actions for disease management.

Teledermatology Integration

The system will enable users to have virtual consultations with licensed dermatologists via video call, providing a convenient way to receive professional skin care advice remotely. Users can easily schedule and initiate consultations from their preferred location. The video call will facilitate real-time discussions, allowing users to share concerns and receive personalized recommendations. All consultations will be conducted securely, ensuring privacy and confidentiality of medical information. This feature offers accessible dermatological care, especially for users with limited access to in-person appointments

Personalized Skincare Recommendations

The system will generate customized skincare advice for users based on their diagnosed skin conditions. After analyzing the user's symptoms and medical history, the system will provide specific product recommendations, treatment plans, and lifestyle adjustments to address their unique skincare needs. These recommendations will be tailored to the severity and type of the condition, ensuring that users receive effective and relevant guidance for managing their skin health.

Signing up

Users can securely register and establish their unique identity within the platform.

Logging in

Users can securely log in to the system using their credentials, to make analytical reports based on the region of the user

Historical Data Tracking

Record and maintain a history of disease identification results for each user, allowing for trend analysis and long-term monitoring.

2.4.3 Non-Functional Requirements

User Interface and Human Factors

The system will have an intuitive and user-friendly web-based and mobile based interface accessible across devices. Its interface will be designed for users with varying levels of technological expertise, ensuring accessibility for both experienced and novice users, particularly individuals seeking skin health management solutions. The interface will adhere to web accessibility standards, ensuring usability for individuals with diverse abilities and disabilities.

Documentation

- User Documentation: Provide comprehensive user documentation to guide individuals and stakeholders in using the system effectively.

- Development Process Documentation: Document the development process to ensure transparency and facilitate future enhancements. This documentation will cover methodologies, tools used, and the rationale behind key decisions made during development.

Hardware Consideration

- Requirements: The system will be compatible with a range of devices, including smartphones, tablets, and desktops, to ensure flexibility for users with varying hardware resources. However, for the scope of this project, we intend to implement only the smartphone version of the software.

- Interoperability: The system will not have specific hardware dependencies and will be designed to interact seamlessly with common devices.

Performance Characteristics

- Expectation: The system will be highly responsive to user interactions; the user experience will be seamless and descriptive.

- Load Handling: The system will be designed to handle a significant number of concurrent users, accommodating usage spikes during health awareness campaigns or public health initiatives.

- Capacity: The system will support a scalable number of concurrent users to ensure optimal performance during periods of high demand.

- Typical Load Testing: Perform load testing to determine the system's performance under typical usage scenarios, ensuring responsiveness and stability.

- Extreme Load Testing: Conduct stress testing to identify the system's limits under extreme loads, allowing for proactive measures to handle unexpected usage peaks.

Error Handling and Extreme Conditions

- Exception Handling: The system will implement robust error-handling mechanisms to gracefully manage exceptions and prevent critical failures. It will handle exceptions related to image processing errors, model inference failures, and issues arising from user inputs.

- Worst-Case Environment: The system is expected to perform optimally even in suboptimal conditions, such as low-bandwidth internet connections or instances of intermittent connectivity and low-quality images.

- Safety Requirements: The system will adhere to safety standards to prevent any harm to users. Safety measures will be implemented to avoid misdiagnosis and the subsequent application of incorrect treatments.

Quality Issues

- Reliability: The system will exhibit high reliability, ensuring consistent and accurate disease classification under various conditions.

- Availability: The system will always be available for use, with minimal downtime for maintenance.

- Robustness: The system will be robust, capable of recovering gracefully from unexpected failures and disruptions.

- Client Involvement: The client's involvement in assessing system quality will be solicited through regular feedback sessions, usability testing, and evaluation of system performance against predefined benchmarks.

System Modifications

- Anticipated Scope: Future changes may include updates to the machine learning model for improved accuracy, the addition of new disease classifications, and enhancements to the user interface based on user feedback.

- Change Management: System modifications will be performed by the development team, with careful consideration of user feedback and industry advancements.

Physical Environment

- Deployment: The system will be deployed in diverse settings, ranging from individual users at home to dermatology clinics.

- External Factors: The system will withstand varying environmental conditions, such as fluctuating lighting for image capturing, ensuring operational integrity across different settings.

Security Issues

- Protection: The system will implement security measures to protect against external intrusions, unauthorized access, and malicious use.

- Security Level: The security measures will be implemented at a high level to safeguard sensitive user data, such as medical history and images, ensuring the integrity of the disease classification process.

Resource Issues

- Resource Constraints: The system will be designed to operate efficiently within defined resource constraints, including processing power, memory, and storage.

- Optimization: Regular optimization efforts will be undertaken to minimize resource consumption and enhance overall system efficiency.

These non-functional requirements address critical aspects of error handling, quality, system modifications, physical environment considerations, security, and resource constraints, ensuring the robustness, reliability, and security of the skin disease classification system.

2.5 Constraints/Pseudo Requirements

The development and implementation of the skin disease classification system are subject to certain constraints and pseudo-requirements based on real-world considerations and bottlenecks. These constraints are crucial to consider for a practical and effective deployment of the system.

1. Image Quality Variability

- Constraint: Images uploaded by users may vary in quality, impacting the accuracy of disease classification.

- Mitigation: Implement advanced image processing techniques to enhance the quality of uploaded images and normalize them for consistent analysis.

2. User Technology Accessibility

- Constraint: Users may have varying levels of access to technology, with some relying on basic devices.

- Mitigation: Optimize the system for accessibility across a range of devices, providing a streamlined experience even for users with limited technological resources.

3. Machine Learning Model Training Data

- Constraint: The effectiveness of the machine learning model depends on the quality and diversity of the training dataset.

- Mitigation: Continuously update and diversify the training dataset, incorporating new images of healthy and affected skin from various demographics and regions to improve the model's robustness.

4. Data Privacy and Security

- Constraint: Handling sensitive data, including images of users' skin, requires stringent data privacy and security measures.

- Mitigation: Implement encryption protocols for data in transit and at rest. Adhere to data privacy regulations and guidelines to ensure the secure handling of user data.

5. Environmental Conditions

- Constraint: The system must handle challenges such as varying lighting conditions and user environments during image capture.

- Mitigation: Design the image-capturing module to compensate for lighting variations and ensure accurate analysis under diverse conditions.

6. Scalability and Resource Scaling

- Constraint: The system needs to accommodate scalability requirements, especially during public health campaigns or telemedicine initiatives.

- Mitigation: Leverage cloud computing resources that allow for seamless scalability based on demand. Implement resource scaling mechanisms to optimize performance under varying loads.

7. Regulatory Compliance

- Constraint: Adherence to local and international regulations related to healthcare, data privacy, and technology.

- Mitigation: Regularly review and update the system to ensure compliance with relevant regulations, obtaining necessary certifications and approvals.

These constraints and pseudo-requirements provide a realistic framework for the development and deployment of the skin disease classification system, considering the complexities and challenges inherent in real-world healthcare contexts. Mitigation strategies are designed to address these constraints and ensure the system's adaptability and effectiveness in diverse settings.

2.6 System Model

2.6.1 Action and Scenario

Table 2.2 Actors

Actors	**role**	**Description**
User	Patients	This user accesses the system to perform tasks such as: - uploading image , - receiving classified the disease result and - See his/her only history - Access educational materials about skin diseases, preventive measures, and treatment options.
	Dermatologist	- This user can do all what the patient can do and accesses the analyzed report to perform further analysis and research. - Post educational materials about skin diseases, preventive measures, and treatment options.
	Admin	- The Admin reviews and approves registration requests from dermatologists and skin care professionals, verifying their credentials to ensure only qualified and authorized experts are registered on the platform. - The Admin manages skincare product listings by uploading details like names, descriptions, prices, usage instructions, and benefits, ensuring users access high-quality, relevant products for their skincare needs.

- **Scenarios**

Table 2.3 image uploading Scenario

Scenario ID	SC001

Scenario Name	Uploading the affected area of Skin images
Participating actor instances	Kebede(Patient)
Flow of events	1. Upload images of affected area of the skin for analysis. 2. He navigates to the "Upload Image" section of the system interface. 3. Kebede selects the image from his local device or scans directly and uploads it to the system. 4. The system initiates the upload process, transferring the images to its storage. 5. Once uploaded, the system presents the classification results to the Patient. Based on the result, Kebede takes an action aimed at keeping or restoring the Skin health.

Table 2.4 posting educational resources scenario

Scenario ID	SC002
Scenario Name	Post educational resources about skin diseases
Participating actor instances	Samuel(Dermatologist)
Flow of events	1. Logs in to the system using his credentials 2. Samuel navigates Blogger dashboard of system interface 3. Creates and uploads educational content, including text and media files. 4. Reviews and publishes the content. 5. The system processes and stores the uploaded content. 6. The content becomes accessible to users in the Educational Resources section.

Table 2.5 history tracking scenario

Scenario ID	SC003

Scenario Name	Tracking Historical Data of Disease Identification Result
Participating actor instances	Alemu(Patient)
Flow of events	1. Alemu logs into the system using his credentials. 2. He navigates to the "History" section of the system interface, where he finds a record of his past disease identification results associated with his account. 3.The system displays a list of previously uploaded images along with their disease identification results. 4. Alemu selects a specific entry to view detailed information. 5. The system presents the detailed disease identification result, including the date of upload, the identified disease, and relevant recommendations. 6. Alemu reviews the historical data and recommendations to ensure he hasn't missed any important information.

2.6.2 Use Case

Table 2.6 Upload Skin Image Use Case

Use Case ID	UC01
Use Case Name	Upload Affected Skin Image
Participating actor	User (general user, expert
Initiated by	User (general user, expert)
Entry Condition	User must be logged in
Flow of events	1. User navigates to the "Upload Image" page. 2. System displays the "Upload Image" interface, including options to select and submit an image. 3. User selects the image file to upload. 4. System validates the file type, size, and format.

	5. User submits the image for upload. 6. System processes the upload, saving the image to storage and verifying completion. 7. System confirms successful submission by displaying a success message to the **user**
Alternative Flow	4a. Image file is too large or in an incorrect format. 4b. System prompts the user to upload a correct image file.
Exit Condition	The image is uploaded and ready for analysis
Special Requirements	None

Table 2.7 Login Use Case

Use Case ID	UC02
Use Case Name	User Login
Participating actor	User (general user, expert)
Initiated by	User (general user, expert)
Entry Condition	User must be registered.
Flow of events	1. User navigates to the login page. 2. System displays the login interface, including fields for username and password. 3. User enters their username and password. 4. System validates the provided credentials against the stored records. 5. The **system** grants access and redirects the **user** to the dashboard or appropriate page.
Alternative Flow	3a. User forgets password and clicks on "Forgot Password". 3b. System sends a password recovery email. 3c. User follows the link to reset the password. 4a. The credentials are incorrect. 4b. The **system** displays an error message and prompts the **user** to try again.

Exit Condition	The user is logged into the system and can access their dashboard.
Special Requirements	None

Table 2.8 Track History Use Case

Use Case ID	UC03
Use Case Name	Track History
Participating actor	User (general user, expert)
Initiated by	User (general user, expert)
Entry Condition	User must be logged in.
Flow of events	1. User navigates to the history section. 2. System displays a list of previously uploaded images and classification results. 3. User selects a specific entry to view detailed information.
Alternative Flow	None
Exit Condition	User can view his/her historical data.
Special Requirements	1. The system should provide efficient and accurate search results based on the User's specified criteria. 2. The system's database should contain comprehensive and well-documented historical reports on coffee diseases

Table 2.10 Schedule Telemedicine Use Case

Use Case ID	UC04

Use Case Name	Schedule Telemedicine Consultation
Participating actor	User (general user)
Initiated by	User (general user)
Entry Condition	Users must be logged in.
Flow of events	1. User Logs into the system using credentials. 2. The System Verifies the credentials and grants access to the dashboard. 3. User Navigates to the **Telemedicine** section and requests a consultation. 4. The System Displays available dermatologists and appointment slots. 5. User Selects a dermatologist and is preferred among the available time slots. 6. The System Confirms the appointment and sends notifications to both the user and the dermatologist.
Alternative Flow	None
Exit Condition	- The appointment is scheduled successfully. - Notifications are sent to the user and dermatologist.
Special Requirements	None

Table 2.11 Conduct Telemedicine Use Case

Use Case ID	UC05
Use Case Name	Conduct Telemedicine Consultation
Participating actor	User (general user)
Initiated by	User (general user)
Entry Condition	Users must be logged in.
Flow of events	1. User navigates to the **Scheduled Appointments** section. 2. The System Displays the scheduled consultation details, including time and a "Join Session" button or the option to reschedule or

	cancel an appointment. 3. User Clicks the **Join Session** button at the scheduled time. 4. The System Connects the user and the dermatologist through the video interface. **5. Dermatologist** Provides recommendations, prescriptions, or further advice during the session. 6. System: Logs the consultation metadata.
Alternative Flow	2a. User selects **"Reschedule Appointment"**. 2b. System displays available dates and times for the dermatologist. 2c. User selects a new date and time. 2d. System updates the appointment details, sends notifications to both the user and the dermatologist, and displays a confirmation message. 2.1 User selects **"Cancel Appointment".** 2.2 System prompts the user to confirm the cancellation. 2.3 User confirms the cancellation. 2.4 System cancels the appointment, sends notifications to both the user and the dermatologist, and logs the cancellation.
Exit Condition	The telemedicine consultation is completed.
Special Requirements	None

Table 2.12 Access Educational Resources Use Case

Use Case ID	UC06
Use Case Name	Access Educational Resources
Participating actor	User (general user)
Initiated by	User (general user)
Entry Condition	Users must be logged in.
Flow of events	1. User: Navigates to the **Educational Resources** section of the system. 2. System: Displays a list of posts (articles,

	videos, infographics) created by dermatologists. 3. User: Selects a post to read or view. 4. System: Opens the selected post, showing the full content (text, images, or video). 5. User: Reads or views the post and can optionally interact with it (e.g., like, comment, or share). 6. System: Records the user's interaction, such as likes, comments, or views, and updates the post's engagement metrics.
Alternative Flow	None
Exit Condition	- The user successfully views the educational content.
Special Requirements	None

Table 2.13 View Skincare Product Use Case

Use Case ID	UC07
Use Case Name	View Skincare Products
Participating actor	User (general user)
Initiated by	User (general user)
Entry Condition	Users must be logged in.
Flow of events	1. User Navigates to the "Product Promotions" page. 2. System Displays a list of all posted product promotions, including a preview of the product image, name, and a short description. 3. User Selects a product to view more details. 4. System: Displays the full product details, including usage instructions, benefits, and promotional offers.
Alternative Flow	2a. no products are posted. 2b. The system displays a message: "No promotions available at the moment.
Exit Condition	- Users can view detailed information about the

	promoted products.
Special Requirements	None

Table 2.14 Post Educational Resources Use Case

Use Case ID	UC08
Use Case Name	Post Educational Resources
Participating actor	User (Expert)
Initiated by	User (Expert)
Entry Condition	-The User has valid credentials and access to the system interface to post educational resources.
Flow of events	1.User Navigates to the "Educational Resources" section. 2. User Selects the option to create a new post. 3. System: Displays a form for creating a new educational resource post. 4.User: ● Uploads content, which may include images, videos, or infographics. ● Adds a title, description, and tags for the resource (e.g., "Skin Cancer Awareness," "Acne Prevention Tips"). 5.User Submits the post. 6. System: ● Validates the input for completeness and compliance (e.g., file size, format). ● Saves the post in the database. ● Confirms successful posting to the User.
Alternative Flow	4a. The User provides invalid or incomplete data

	(e.g., missing title or unsupported file type) 4b. The system prompts them to correct the errors before resubmission. 5a. The system encounters network or server issues during submission. 5b. The system notifies the dermatologist and prompts them to try again later.
Exit Condition	- The User receives confirmation that the post has been successfully created and published
Special Requirements	None

Table 2.15 Manage Appointment Use Case

Use Case ID	UC09
Use Case Name	Manage Appointment Notification
Participating actor	User (Expert)
Initiated by	The System
Entry Condition	The User must have an active account and be logged into the system.
Flow of events	1.System sends an appointment notification to the dermatologist. Notification includes details of the scheduled consultation: ○ Patient's name or ID. ○ Scheduled date and time. ○ Any notes or uploaded images. 2. User logs into the system and navigates to the notifications or appointment section. 3. The System Displays the appointment with details and options to confirm or reschedule. 4. The User confirms the appointment
Alternative Flow	4a. The User chooses to reschedule the appointment 4b. The System Provides a rescheduling interface to propose a new date and time 4c. The User Selects a new date and time and submits the reschedule request.

Exit Condition	- The appointment is either confirmed or updated with a reschedule request. - Both Users are notified of the updated status.
Special Requirements	None

Table 2.16 Post Educational Resources Use Case

Use Case ID	UC10
Use Case Name	Post Skin Products
Participating actor	Admin
Initiated by	Admin
Entry Condition	- Admin must be logged into the system and get access to the admin page interface.
Flow of events	1. Admin Navigates to the "Product Management" section in the system dashboard. 2. The System Displays the product posting interface with fields for product name, description, price, image upload, and additional details (e.g., benefits, usage instructions). 3. Admin Fills in the required details about the skin product, including uploading relevant images. 4. The System Validates the entered data and confirms all mandatory fields are completed. 5. Admin Clicks the "Post Product" button to submit the product details. 6. The System Saves the product information to the database and displays a confirmation message indicating the product has been successfully posted.
Alternative Flow	3a. The System Highlights any missing or invalid fields and prompts the admin to correct the errors before proceeding. 3b. Corrects the highlighted fields and resubmits the form. 6a. The System Displays an error message if the image upload fails. 6b. Reattempts the upload or selects a different image.

Exit Condition	- The skin product is successfully posted and available for users to view under the "Skin Products" section.
Special Requirements	None

2.6.3 Object Model

2.6.3.1 Data Dictionary

Table 2.17 User Data Dictionary

Attributes	Type	Length	Description
userId	String		Unique identifier for the user
name	String	100	Full name of the user
email	String	100	Email Address of the user
password	String	128	Encrypted password for user account
contactNumber	String	15	User's contact number
role	String	20	Role of the user (e.g., Patient, Dermatologist, Admin)
profilePicture	String (URL)	255	Link to the user's profile picture

Table 2.18 Appointment Data Dictionary

Attributes	Type	Length	Description
appointmentId	String		Unique identifier for the appointment
userId	String		Identifier of the user who scheduled the appointment
dermatologistId	String		Identifier of the dermatologist assigned

date	Date	YYYY-MM-DD	Scheduled date of the appointment
time	Time	HH:MM AM/PM	Scheduled time of the appointment
status	Enum	20	Current status of the appointment (Scheduled, Completed, Rescheduled)
notes	String	500	Additional notes provided by the user or dermatologist

Table 2.19 Educational Resource Data Dictionary

Attributes	Type	Length	Description
resourceId	String		Unique identifier for the resource
title	String	200	Title of the educational resource
content	String	5000	Body of the resource (article or description)
authorId	String		Identifier of the dermatologist who posted the resource
mediaLink	String (URL)	255	Link to associated images or videos
datePosted	DateTime	YYYY-MM-DD HH:MM	Date and time the resource was posted

Table 2.20 Skin Image Data Dictionary

Attributes	Type	Length	Description
imageId	String		Unique identifier for the uploaded image
userId	String		Identifier of the user who uploaded the image
imageUrl	String (URL)	255	URL of the uploaded image

uploadDate	DateTime	YYYY-MM-DD HH:MM	Date and time the image was uploaded

Table 2.21 Disease Data Dictionary

Attributes	Type	Length	Description
name	String	100	Full name of a disease
description	String	10000	Detailed Description of the disease characteristics
symptoms	List	255	Possible symptoms the disease shows
treatmentRecommendations	List		The treatments recommended for this specific disease

Table 2.22 Skincare Product Data Dictionary

Attributes	Type	Length	Description
productId	String		Unique identifier for the product
name	String	100	Name of the skincare product
description	Text	5000	Detailed description of the product
uploadDate	DateTime	YYYY-MM-DD HH:MM	Date and time the image was uploaded
price	Decimal	10	Price of the product

Table 2.23 PasswordReset Data Dictionary

Attributes	Type	Length	Description
id	Integer		Unique identifier for the password reset request

code	String	6	The randomly generated secret reset code to be sent to the user’s email
expiration	DateTime	5000	Time where the reset code expires
userId	String		Id for the user who initiates the password reset process