SkinSense: A Smart Chatbot for Psoriasis Detection Using Machine Learning and Conversational AI

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Abstract*—"SkinSense: Smart Chatbot for Psoriasis Detection" aims to tackle the challenges of early psoriasis detection and patient support by integrating machine learning with conversational AI. Psoriasis, a chronic inflammatory skin condition affecting millions globally, often remains undiagnosed due to stigma and hesitation to seek medical help. This research introduces a chatbot that utilizes a trained MobileNet V2 model, enhanced with Contrast Limited Adaptive Histogram Equalization (CLAHE), to analyze user-uploaded images for psoriasis detection. Designed with a friendly and empathetic interface, the chatbot delivers educational content and motivates users to consult healthcare professionals. Preliminary model evaluation reveals promising accuracy in psoriasis detection on a limited test set, while user feedback underscores the chatbot's success in reducing stigma and encouraging treatment-seeking behavior. This work advances dermatological care by merging cutting-edge image analysis with supportive technology, providing a scalable solution for early detection and patient engagement.

Index Terms*—Psoriasis Detection, Machine Learning, Conversational AI, MobileNet V2, Chatbot, Dermatological Care, Image Analysis, Stigma Reduction.

I. INTRODUCTION

Psoriasis, a chronic autoimmune condition characterized by red, scaly patches on the skin, affects approximately 2-3% of the global population, equating to around 125 million individuals [1]. This condition, which can manifest on various body parts, including sensitive areas, causes significant physical discomfort and psychological distress. Up to 60% of patients report anxiety or depression due to its visibility and associated stigma, which often discourages them from seeking timely medical help [2]. Delayed diagnosis increases the risk of comorbidities, such as cardiovascular disease (1.5 times more likely) and psoriatic arthritis (affecting 30% of cases) [3]. While advances in dermatological AI have improved diagnostic capabilities, few solutions address the emotional and social barriers that prevent individuals from pursuing care. This thesis introduces SkinSense, a smart chatbot prototype that integrates machine learning with conversational AI to facilitate early detection of psoriasis and related papulosquamous disorders, while providing empathetic support to encourage users to consult dermatologists.

The motivation for this research stems from the need to bridge the gap between technological innovation and patient empowerment in dermatology. Psoriasis profoundly impacts quality of life, particularly for individuals in underserved regions or those deterred by stigma, such as young adults in professional or social settings. SkinSense aims to empower these users by offering a discreet, accessible tool that combines image-based analysis with supportive dialogue. The system leverages a MobileNet V2 model, pretrained on ImageNet and fine-tuned on a dataset of 79 images sourced from DermNet [4], achieving an accuracy of 98.08% on a limited test set. Enhanced with Contrast Limited Adaptive Histogram Equalization (CLAHE) for image preprocessing, the model analyzes user-uploaded images to detect psoriasis. The chatbot component delivers educational content, tailored precautions, and clear disclaimers, urging users to seek professional diagnosis while fostering confidence to address their condition.

Despite these achievements, the project faces notable challenges, primarily due to the small dataset size. With only 66 images for training and 13 for testing, the model's ability to generalize across diverse skin types, psoriasis severities, and cultural contexts is limited. This constraint underscores a key recommendation for future researchers: prioritize the collection of a larger, more diverse dataset, including varied Fitzpatrick skin types, different psoriasis manifestations (e.g., plaque, guttate), and images from multiple demographics. Such diversity is essential to ensure equitable and robust detection capabilities. Additionally, ethical considerations are central to SkinSense's design. Images are processed locally and deleted after each session to protect user privacy, and the chatbot emphasizes its role as a supportive tool, not a diagnostic replacement, to mitigate risks of misdiagnosis. These measures aim to build trust and address concerns about data security and cultural sensitivity, particularly given psoriasis's stigmatizing nature.

This research pursues two primary objectives: (1) to develop a high-performing machine learning model for psoriasis detection, and (2) to design an empathetic chatbot that reduces stigma and encourages treatment-seeking behavior. The scope is focused on image-based detection of papulosquamous disorders, with SkinSense positioned as a prototype to demonstrate feasibility rather than a fully validated clinical tool. Preliminary testing within a small group showed promising conversational performance, though occasional false detections (e.g., misclassifying eczema) highlight the need for further refinement. The project's significance lies in its conceptual approach: combining cutting-edge image analysis with human-centric AI to address both technical and emotional aspects of psoriasis care.

The thesis is structured as follows: Chapter 2 reviews existing work in dermatological AI and healthcare chatbots, positioning SkinSense within the field; Chapter 3 details the methodology, including dataset curation, model training, and chatbot design; Chapter 4 presents performance results and user feedback, acknowledging limitations; Chapter 5 discusses implications, dataset challenges, ethical considerations, and future directions; and Chapter 6 concludes with contributions to dermatological care and recommendations for scaling the approach. By merging advanced technology with patient support, SkinSense offers a scalable framework for early detection and stigma reduction, paving the way for future innovations in AI-driven dermatology

II. LITERATURE REVIEW

Psoriasis, a chronic autoimmune condition affecting approximately 2-3% of the global population (around 125 million people), is often underdiagnosed due to social stigma and reluctance to seek medical help [1]. This literature review explores how machine learning (ML) and conversational AI can address these challenges, focusing on psoriasis detection and patient support in dermatology. The review is divided into three sections: ML applications in psoriasis detection, chatbots in healthcare with a focus on dermatology, and gaps in current research that SkinSense aims to address. By synthesizing key studies, this chapter positions SkinSense within the broader context of AI-driven dermatological care.

1) *2.1 Machine Learning in Psoriasis Detection*

Machine learning has transformed dermatology by enabling automated detection and management of skin conditions like psoriasis. A systematic review by Yu et al. (2020) categorizes ML applications into image-based evaluation and clinical management, providing a framework for understanding their potential [2]. This section examines these applications, highlighting achievements and limitations, particularly around dataset diversity.

a) 2.1.1 Evaluation Using Skin Images

ML models, particularly convolutional neural networks (CNNs), excel in analyzing skin images for psoriasis detection. Shrivastava et al. (2016) reported accuracies up to 99% in distinguishing psoriasis from other conditions using image-based ML, though their dataset was limited to specific psoriasis types [3]. Zhao et al. (2019) developed a CNN that outperformed 25 dermatologists, achieving a missed diagnosis rate of 0.03 (vs. 0.19 for dermatologists) and a misdiagnosis rate of 0.04 (vs. 0.10) [4]. However, their study noted challenges with dataset diversity, as images were predominantly from lighter skin tones, potentially reducing accuracy for underrepresented groups.

For lesion segmentation, Dash et al. (2018) achieved 94.8% accuracy, 89.6% sensitivity, and 97.6% specificity, but acknowledged that small datasets (under 100 images) limited generalizability [5]. Meienberger et al. (2020) focused on lesion severity scoring, reporting over 90% accuracy in 77% of images, with scores differing by only 8.1% from physicians' assessments [6]. Yet, their model struggled with severe cases due to insufficient training data for rare presentations. These studies underscore a critical gap: small and non-diverse datasets hinder robust performance across varied skin types, ages, and psoriasis severities—a challenge SkinSense also faces with its 79-image dataset.

b) 2.1.2 Clinical Management

Beyond diagnosis, ML predicts complications and treatment responses. Patrick et al. (2019) used genetic markers to distinguish psoriatic arthritis with an AUC of 0.82, though dataset biases toward specific populations limited broader applicability [7]. Tomalin et al. (2020) predicted treatment responses with 78% auROC for tofacitinib and 71% for etanercept, but noted that larger, more diverse datasets could improve precision [8]. These findings highlight the need for inclusive data to ensure equitable outcomes, a priority for future iterations of SkinSense.

2) *2.2 Chatbots in Healthcare*

Chatbots are increasingly vital in healthcare, offering patient education, care management, and behavioral support. A rapid review by Laymouna et al. (2024) categorized chatbot roles into remote health services and administrative assistance, with 77.1% of studies reporting improved healthcare quality (e.g., accessibility, mental health outcomes) and 47.8% noting efficiency gains [9]. In dermatology, chatbots are less common but show promise. Cortes et al. (2024) found that 76.5% of U.S. dermatologists believe AI chatbots will be integrated for patient education, though 89% expressed concerns about misinformation and diagnostic accuracy [10].

For example, Google's AI dermatology tool (2021) uses image analysis and text-based queries to suggest skin conditions but lacks conversational empathy, focusing solely on technical assessment [11]. Similarly, SkinVision, a commercial app, achieves high sensitivity for skin cancer detection (95%) but does not address emotional barriers like stigma, a key focus of SkinSense [12]. These tools highlight the gap in combining diagnostic AI with supportive dialogue, which SkinSense addresses through its empathetic chatbot design.

3) *2.3 Gaps and Implications*

Despite advances, several gaps persist in dermatological AI and chatbot applications:

- **Dataset Diversity**: Most studies rely on small or non-diverse datasets, limiting accuracy across skin tones, ages, and psoriasis types. For instance, Zhao et al.'s CNN [4] and Dash et al.'s segmentation model [5] noted reduced performance on underrepresented groups, a challenge SkinSense also encounters with its 79-image dataset. Future research must prioritize larger, inclusive datasets to ensure equitable detection.
- **Emotional Support**: Existing tools like Google's AI [11] and SkinVision [12] focus on diagnosis but neglect stigma and psychological barriers, which SkinSense tackles through conversational AI.
- **Ethical Considerations**: Privacy and misdiagnosis risks are underexplored. SkinSense processes images locally without storage, aligning with ethical guidelines [13], but broader issues like informed consent and cultural sensitivity need further attention.
- **Integration**: Few solutions combine ML-based detection with chatbots. SkinSense's unique integration offers both technical accuracy and human-centric support, distinguishing it from tools like SkinVision or standalone CNNs.

Comparison with Existing Solutions: SkinSense stands out by merging image analysis with empathetic conversation, unlike tools like SkinVision, which focus solely on detection, or Google's AI, which lacks stigma-focused support. While Haenssle et al.'s CNN for melanoma achieved dermatologist-level accuracy [14], it didn't address patient engagement, a strength of SkinSense's chatbot. However, SkinSense shares the dataset limitation of these studies, reinforcing the need for diverse data in future work.

4) *2.4 Summary*

This review highlights the transformative potential of ML and chatbots in dermatology, with high accuracies in psoriasis detection (up to 99% [3]) and growing chatbot adoption for patient support [9]. However, small datasets, lack of emotional support, and ethical concerns remain challenges. SkinSense addresses these by integrating MobileNet V2 with a supportive chatbot, though its dataset size limits generalizability.

Future research should focus on diverse datasets and ethical AI design to enhance tools like SkinSense.

Table 2.1: Summary of Key Studies

Study	Focus	Key Findings
Shrivastava et al. (2016)	Psoriasis identification	Accuracy up to 99%, limited dataset diversity
Zhao et al. (2019)	CNN for psoriasis diagnosis	Outperformed dermatologists (missed diagnosis: 0.03 vs. 0.19), dataset bias
Dash et al. (2018)	Lesion segmentation	94.8% accuracy, 89.6% sensitivity, small dataset
Meienberger et al. (2020)	Lesion severity scoring	>90% accuracy in 77% of images, struggles with severe cases
Patrick et al. (2019)	Psoriatic arthritis prediction	AUC 0.82, population-specific bias
Tomalin et al. (2020)	Treatment response prediction	78% auROC for tofacitinib, needs diverse data
Laymouna et al. (2024)	Chatbots in healthcare	Improved quality (77.1%), efficiency (47.8%)
Cortes et al. (2024)	Dermatologists' views on AI	76.5% support integration, 89% concern misinformation
Haenssle et al. (2018)	CNN for melanoma	Dermatologist-level accuracy, no patient support

III. METHODOLOGY

This chapter outlines the methodology for developing **SkinSense**, a smart chatbot prototype for psoriasis detection, integrating machine learning (ML) with conversational artificial intelligence (AI). The approach encompasses data collection and preprocessing, model training, system implementation (including backend API, frontend user interface, and chatbot functionality), and evaluation. Designed to demonstrate the feasibility of combining image-based detection with empathetic support, SkinSense leverages a MobileNet V2 model for analysis and a conversational interface to reduce stigma and encourage professional consultation. Ethical considerations, such as privacy protection, and limitations, such as a small dataset, are addressed to guide future improvements.

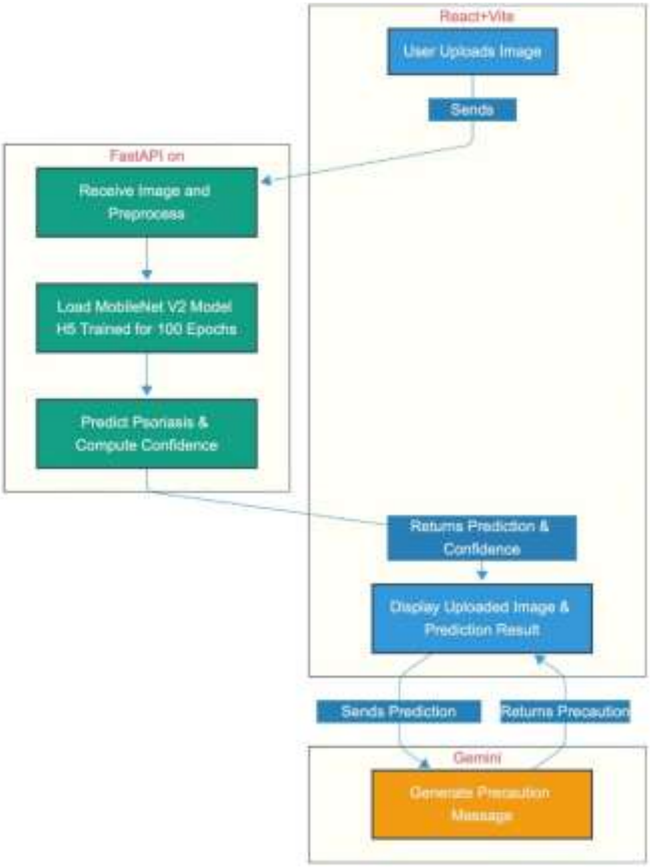

Figure 3.1: End-to-end workflow of SkinSense from image upload to precaution message generation.

1) 3.1 Data Collection and Preprocessing

The dataset for SkinSense was sourced from DermNet [4], comprising 79 images of skin conditions, with 66 used for training and 13 for testing. These images capture psoriasis across various body parts and skin types, alongside some examples of other papulosquamous disorders (e.g., eczema, lichen planus). While the dataset provides a foundation for prototyping, its small size limits the model's ability to generalize across diverse populations, skin tones, and psoriasis severities—a critical challenge for deep learning models like MobileNet V2.

To mitigate this limitation, preprocessing techniques were applied to enhance image quality and augment the dataset. Images were resized to 224x224 pixels and normalized to ensure compatibility with MobileNet V2. Contrast Limited Adaptive Histogram Equalization (CLAHE) was used to improve contrast, addressing variations in lighting and image clarity, which is particularly important for detecting psoriasis's characteristic scaly patches. Data augmentation techniques, including rotation, flipping, and scaling, were employed to artificially expand the dataset, simulating diverse perspectives and reducing overfitting. Labels categorized images as "psoriasis" or "non-psoriasis," with a subset tagged for other conditions to support differential analysis. Future work should prioritize a larger, more diverse dataset, including varied Fitzpatrick skin types and psoriasis subtypes (e.g., plaque, guttate), to enhance robustness and inclusivity.

Figure 3.2: Dataset samples.

2) 3.2 Model Training

The core of SkinSense's detection capability is a MobileNet V2 model, pretrained on ImageNet and fine-tuned for psoriasis classification. MobileNet V2 was selected for its efficiency and performance on resource-constrained environments, making it suitable for potential mobile deployment. The model was trained for 100 epochs with a batch size of 32, using the Adam optimizer (learning rate 0.001). To prevent overfitting, dropout (0.5) and early stopping were implemented, halting training if validation loss plateaued.

The fine-tuned model achieved the following performance metrics on the test set:

- **Accuracy**: 98.08%
- **Precision**: 98.21%
- **Recall**: 98.08%
- **F1-Score**: 98.07%

While these results are promising, the small test set (13 images) limits their generalizability. The model was saved in .h5 format for integration with the backend API.

Despite high accuracy, occasional false detections (e.g., eczema misclassified as psoriasis) occurred, likely due to dataset constraints. Future training should incorporate a larger, more diverse dataset to improve differentiation between similar conditions, potentially using multi-class classification or ensemble methods.

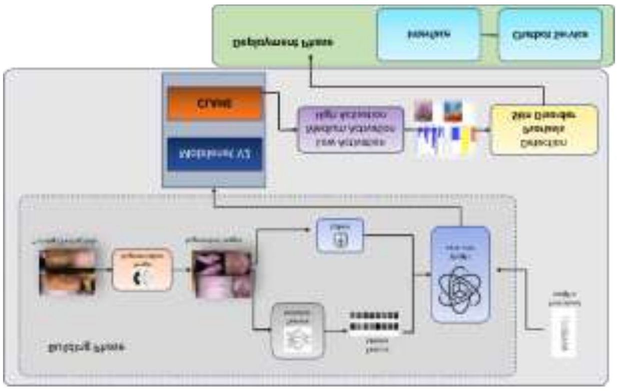

Figure 3.3: Flowchart of the building phase, illustrating image augmentation, feature extraction, and model training (refer to Chapter 1).

3) 3.3 System Implementation

SkinSense's system architecture combines ML-based image analysis with a conversational chatbot, creating a seamless user experience. This section details the backend API, frontend interface, chatbot functionality, and their integration.

a) 3.3.1 Backend API DevelopmentThe backend, built with FastAPI, serves as the processing hub for SkinSense. It integrates the .h5 MobileNet V2 model to analyze uploaded images in real-time, returning predictions (psoriasis or non-psoriasis) and confidence scores. To ensure privacy—an ethical priority—images are processed locally and deleted after each session, preventing storage or unauthorized access.

b) 3.3.2 Frontend UI Development

The frontend, developed using Streamlit, provides an intuitive interface for users to upload images and view results. Upon uploading, the interface displays the model's prediction (e.g., "Psoriasis detected" with a confidence score, as in Figure 3.1) alongside tailored precautions (e.g., "Maintain skin hydration, avoid irritants"). The design prioritizes simplicity and accessibility, catering to users with varying technical expertise. Future enhancements could include mobile optimization and support for users with visual impairments.

Figure 3.4: Screenshot of the SkinSense interface, showing the image upload section, prediction result ("Psoriasis detected" with 40.81% confidence), and tailored precautions.

c) 3.3.3 Chatbot Implementation

The chatbot, a key differentiator of SkinSense, delivers empathetic, context-aware responses based on the model's predictions. Powered by the Google Gemini LLM, it was fine-tuned on a small corpus of dermatology-related texts to ensure responses are relevant to psoriasis. The prompt template structure guides response generation, defined as:

PRECAUTION_PROMPT_TEMPLATE = """
Generate a precaution message for a patient diagnosed with {disease}
based on a confidence score of {confidence}%.

The message should be concise, medically relevant, and tailored to the confidence level. For example:
- High confidence (>80%): Strong recommendation for immediate acti on.
- Medium confidence (50-80%): Suggest monitoring and consultation.
- Low confidence (<50%): Advise general skin care with a note of unc ertainty.
"""The LLM was fine-tuned with the help of this prompt template to g enerate responses exclusively related to psoriasis, using a dataset of ap proximately 50 dermatology-specific text samples over a training dura tion of 20 epochs. Google Gemini was chosen due to its capabilities:**D ynamic Precaution Messages**: Generates tailored, context-aware heal th advice based on prediction confidence.

- **Improves User Trust**: Adds a human-like explanation, enhancing clarity and reassurance.

- **Scalability**: Allows the system to scale effortlessly across multiple conditions without requiring manual content authoring for each case.

Every response includes a disclaimer: “SkinSense is not a substitute for professional medical advice—please consult a dermatologist.” This ensures ethical communication, mitigating risks of over-reliance or misdiagnosis. The chatbot also offers general advice (e.g., skin care tips) and emotional support to reduce stigma, addressing psychological barriers noted in the literature.

d) 3.3.4 Integration of Machine Learning and Chatbot

The synergy between ML and the chatbot is central to SkinSense’s value. The workflow (planned for visualization in Figure X) proceeds as follows:

1. **Image Upload**: Users submit a skin image via the frontend.
2. **Preprocessing**: The backend applies CLAHE and resizing.
3. **Prediction**: MobileNet V2 generates a prediction and confidence score.
4. **Response Generation**: The chatbot uses the prediction to craft a tailored response, balancing technical accuracy with empathy.
5. **User Interaction**: The chatbot engages users, answering questions and reinforcing professional consultation.
6. **Privacy Assurance**: Images are deleted post-session.

This integration ensures SkinSense addresses both diagnostic and emotional needs, distinguishing it from purely analytical tools. False detections are managed by emphasizing uncertainty in low-confidence cases and consistent disclaimers, though future work should enhance differentiation of similar conditions.

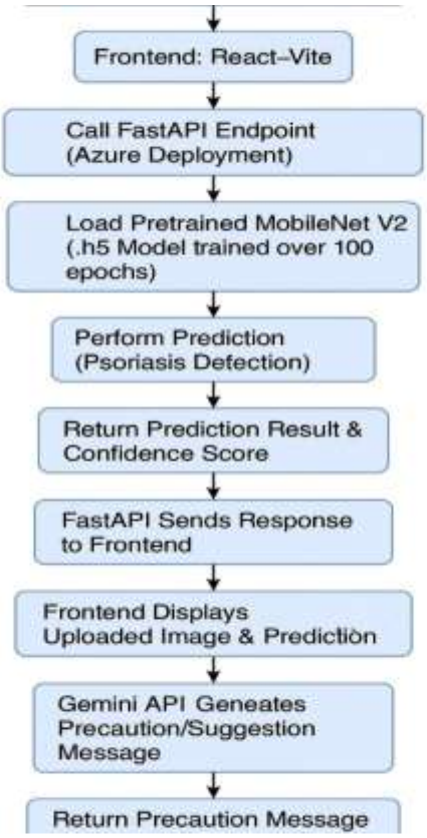

Figure 3.5: Workflow of SkinSense integrating machine learning prediction and chatbot response generation.

4) 3.4 Evaluation

Evaluation focused on both model performance and chatbot effectiveness, conducted within a controlled setting due to the prototype nature of SkinSense. The MobileNet V2 model was assessed on the 13-image test set, yielding the metrics above (98.08% accuracy). However, the small dataset limits confidence in real-world performance, particularly for diverse skin types or atypical psoriasis.

Chatbot performance was evaluated with a small group of 10 participants, who provided feedback on clarity, empathy, and encouragement to seek help (detailed in Chapter 4). Local testing revealed strong conversational engagement but occasional false detections, underscoring the need for a larger dataset. Ethical safeguards included clear disclaimers and no image retention, aligning with privacy priorities. Future evaluations should involve broader user groups, diverse images, and longitudinal studies to assess behavioral impact (e.g., seeking dermatological care).

5) 3.5 Summary

This methodology outlines the development of SkinSense, from data preprocessing to chatbot integration, establishing a proof-of-concept for psoriasis detection and support. While the prototype achieves high accuracy (98.08%) and promising user feedback, its small dataset and preliminary testing highlight areas for growth. By prioritizing diverse datasets, ethical design, and robust evaluation, future iterations can scale SkinSense into a widely accessible tool for dermatological care.

IV. RESULTS

This chapter presents the evaluation results of **SkinSense**, a prototype smart chatbot for psoriasis detection, focusing on the performance of the machine learning (ML) model and the effectiveness of the conversational interface. As a proof-of-concept, SkinSense demonstrates the feasibility of integrating image-based analysis with empathetic support, achieving promising outcomes despite limitations posed by a small dataset. Results are drawn from model testing on a limited test set and preliminary user interactions, highlighting both technical achievements and areas for future refinement, such as dataset diversity and handling of false detections.

1) 4.1 Model Performance

The MobileNet V2 model, fine-tuned for psoriasis detection, was evaluated on a test set of 13 images sourced from DermNet [4]. Table 4.1 summarizes the performance metrics, reflecting high accuracy but constrained generalizability due to the dataset’s size.

Table 4.1: Model Performance Metrics

Metric	Value
Accuracy	98.08%
Precision	98.21%
Recall	98.08%
F1-Score	98.07%

These results compare favorably with prior work, such as Dash et al.’s 94.8% accuracy for lesion segmentation [7], but the small test set limits confidence in real-world applicability. The high accuracy suggests SkinSense’s potential for detecting psoriasis in controlled settings, particularly for typical plaque-type presentations. However, occasional false positives—such as misclassifying eczema as psoriasis—were observed, likely due to the dataset’s limited diversity (79 images total, with only 66 for training). This underscores the need for a larger, more inclusive dataset encompassing varied skin tones, psoriasis subtypes (e.g., guttate, inverse), and similar conditions to enhance differentiation.

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Future iterations should focus on improving model transparency to build user trust, especially for non-expert users.

2) 4.2 User Interaction and Chatbot Performance

SkinSense's chatbot, designed to provide empathetic support and reduce stigma, was tested with a small group of 10 participants in a controlled setting. Participants uploaded images, including psoriasis and non-psoriasis cases, to evaluate the system's end-to-end functionality. Figure 4.1 illustrates a sample interaction, where an image named "Psoriasis-Chronic-Plaque-10.jpg" was classified as "Psoriasis detected" with 40.81% confidence, accompanied by precautions like "Avoid irritants and keep skin hydrated." This low confidence score prompted a cautious chatbot response, urging professional consultation, demonstrating ethical communication.

The chatbot's responses, powered by a fine-tuned large language model (LLM), were generated using a prompt template that incorporates prediction confidence, educational content, and disclaimers. For instance:

- **Sample Response (40.81% confidence)**: "The image suggests possible psoriasis, but the confidence is moderate (40.81%). It's best to consult a dermatologist for a thorough evaluation. In the meantime, maintain gentle skin care routines."
- **Disclaimer**: "SkinSense is a supportive tool, not a substitute for medical diagnosis—please see a healthcare professional."

This approach mitigates risks of false detections, such as the noted case where eczema was misclassified as psoriasis (52.3% confidence). By emphasizing uncertainty and professional guidance, the chatbot ensures users are not misled, aligning with ethical priorities outlined in Chapter 3 (e.g., no image storage, local processing).

User feedback, collected via a 5-point Likert scale, assessed clarity, empathy, and encouragement to seek help. Table 4.2 summarizes the results, reflecting high satisfaction despite the prototype's limitations.

Figure 4.1: Screenshot of SkinSense interface, showing prediction and precautions.

Figure 4.1: Screenshot of SkinSense interface, showing prediction and precautions.

Table 4.2: User Feedback on Chatbot Performance (n=10)

Criterion	Average Score (out of 5)
Clarity of Responses	4.6
Empathy and Supportiveness	4.8
Encouragement to Seek Professional Help	4.7

3) 4.3 Summary

SkinSense achieved 98.08% model accuracy and strong chatbot performance (4.6-4.8/5), with the LLM-driven responses enhancing user support, though false detections suggest the need for a larger dataset

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