Honors Thesis Proposal: A Deep Learning Approach for Reliable At-home Severity Assessment and Management of Psoriasis

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Abstract

Psoriasis, a chronic autoimmune skin disorder affecting approximately 2-3% of the Western population, presents significant challenges for patients and healthcare providers (Schaap et al., 2022). Accurate assessment of psoriasis severity is critical for effective management, with commonly used methods including the Physician Global Assessment (PGA), Body Surface Area (BSA), and the Psoriasis Area and Severity Index (PASI). However, PASI's complexity and time-consuming nature make it impractical for routine use, particularly in busy clinical settings or at-home self-assessments. This study proposes the development of an AI-powered mobile application that automates psoriasis severity scoring by combining the PGA and BSA methods, offering a more efficient, accessible, and user-friendly alternative (Walsh et al., 2011). The application aims to improve the accuracy of psoriasis assessments and enhance patient self-management by providing personalized recommendations while reducing clinician workload. The AI model will be trained on diverse psoriasis images, utilizing advanced segmentation and classification techniques such as U-Net, Mask R-CNN, and Vision Transformer (ViT). The system will also incorporate dermatologist-approved treatment recommendations, further improving care. By simplifying the psoriasis severity scoring process, this tool has the potential to significantly enhance both clinical practice and patient outcomes, providing a scalable and cost-effective solution for psoriasis management. The findings of this study will contribute to the growing field of AI-powered healthcare solutions and the transformation of dermatology.

Introduction

Psoriasis is a chronic autoimmune skin disorder affecting approximately 2-3% of the Western population, presenting a significant challenge to patients and healthcare providers. This inflammatory condition is characterized by rapid skin cell growth, leading to thick, scaly patches, which can cause physical discomfort and emotional distress (Schaap et al., 2022). Psoriasis is typically assessed through three primary methods: Physician Global Assessment (PGA), Body Surface Area (BSA) tracking, and Psoriasis Area and Severity Index (PASI). These tools help determine the severity and extent of the disease, guide treatment decisions, and monitor patient progress (Kim et al., 2017).

PGA is a widely used, simple, and standardized tool where clinicians visually assess the severity of psoriasis on a scale from 0 (clear) to 4 (severe) (Pascoe et al., 2015). BSA tracks the percentage of the body affected by psoriasis, often using the "rule of nines," which divides the body into regions representing approximately 9% of the body surface (Kim et al., 2017). PASI, on the other hand, is a more detailed scoring system that assesses psoriasis severity based on redness, thickness, scaling of lesions, and the affected body surface area across different regions of the body, with scores ranging from 0 to 72 (Oakley, A., 2024).

While PASI is considered the gold standard for psoriasis severity assessment, it is complex and time-consuming, requiring detailed calculations and clinical expertise. The overall complexity makes it impractical for routine use, especially in settings with high patient volumes or for at-home self-management by patients (Wu et al., 2020). As a result, more experienced clinicians may need help with accurate assessments, leading to misdiagnosis or delays in treatment (Zhao et al., 2022).

Given the challenges of PASI, an equally effective but simpler alternative involves combining the Physician Global Assessment (PGA) and Body Surface Area (BSA) methods. PGA x BSA offers a more practical solution for psoriasis severity assessment. PGA provides a quick visual estimate of psoriasis severity on a standardized 5-point scale, enabling clinicians to make rapid judgments with minimal training (Pascoe et al., 2015). BSA, which tracks the percentage of the body affected by psoriasis, is straightforward and can be easily understood and calculated using essential anatomical landmarks (Kim et al., 2017). Together, PGA and BSA provide a comprehensive yet simplified assessment, capturing both the intensity of lesions and their distribution across the body. This combination allows for efficient and accurate psoriasis monitoring without the need for extensive calculations, making it more accessible for both clinicians and patients, especially in busy clinical settings or for at-home self-assessments. By simplifying the scoring process while still providing meaningful data about the severity and extent of the disease, PGAxBSA offers a more user-friendly alternative to PASI while maintaining clinical relevance and accuracy (Walsh et al., 2011).

In recent years, advances in artificial intelligence (AI) and machine learning have shown promise in automating psoriasis severity assessments, improving both accuracy and efficiency. A notable example is the SkinTeller application, developed in China and successfully used in clinical settings to automate PASI scoring. SkinTeller utilizes deep learning algorithms to process and analyze skin images, generating PASI scores 33.2% more accurately than dermatologists. However, despite its success in hospital settings, SkinTeller remains primarily a tool for clinicians and is not designed for use by patients at home. Furthermore, its AI model is biased toward individuals of Chinese descent due to the dataset used to train the model, which primarily consisted of images from that population (Huang et al., 2023). While SkinTeller represents a promising step forward, the complexity of PASI scoring limits its widespread use in both clinical environments and self-management scenarios. Additionally, the time and cost required to develop PASI-scored images make removing biases from the dataset challenging, further restricting the model's applicability to a more diverse patient population.

Thus, there is a need for a more accessible and user-friendly solution that simplifies psoriasis severity scoring while maintaining clinical accuracy. This study proposes the development of an AI-powered mobile application that automates psoriasis severity scoring by combining the PGA and BSA methods. By doing so, the application will offer a more efficient and practical tool for tracking and managing psoriasis, allowing for timely, accurate assessments that are both comprehensive and easier to implement in real-world scenarios. This approach can significantly improve patient self-management, reduce clinician workload, and ultimately enhance overall care and outcomes for individuals living with psoriasis.

Purpose

Will now be a web app for accessibility

This study aims to develop a user-friendly, AI-powered mobile application that automates psoriasis severity scoring by combining the Physician Global Assessment (PGA) and Body Surface Area (BSA) methods. This application aims to enhance the accuracy of psoriasis assessments and improve patient self-management by providing personalized management recommendations. By simplifying the psoriasis severity scoring process, the application will empower patients to take a more active role in managing their condition and streamline workflows for healthcare providers, reducing clinician workload and associated costs. Ultimately, this tool seeks to foster greater confidence in psoriasis care and improve overall patient outcomes.

Significance

This research is significant in advancing the field of psoriasis management by demonstrating the potential of AI to enhance both the efficiency and accuracy of psoriasis severity assessments. By automating the PGAxBSA method through AI, this study will provide strong evidence for the utility of AI in streamlining these assessments, making them more efficient, cost-effective, and accessible. This tool can help reduce clinician workload and associated healthcare costs, ensuring timely and accurate monitoring of psoriasis severity. Moreover, a user-friendly application for at-home assessments empowers patients to actively manage their condition, improving self-management and confidence in their care. Integrating AI and the PGAxBSA method in this context will also contribute valuable evidence to the growing field of AI-powered healthcare solutions, underscoring the potential of AI to transform dermatology. Ultimately, this research has the potential to significantly improve clinical practice, enhance patient outcomes, and reduce the overall burden on healthcare systems, providing a more effective, scalable solution for managing psoriasis.

Research Questions

- How can an AI-powered mobile application that combines the Physician Global Assessment (PGA) and Body Surface Area (BSA) methods improve the accuracy, efficiency, and accessibility of psoriasis severity assessments while also enhancing patient self-management and reducing clinician workload in both clinical and at-home settings?

- What innovative AI classification and segmentation tools can enhance an AI-powered mobile application's accuracy and efficiency to automate the Physician Global Assessment (PGA) and Body Surface Area (BSA) scoring for psoriasis severity?

Research Assumptions

- Automating psoriasis severity assessment using Artificial Intelligence (AI) is feasible.
- PGA x BSA is a valid and reliable method for assessing psoriasis severity.
- It is possible to design an AI-powered application that is user-friendly and accessible for patients.
- The development of an AI-powered psoriasis severity scoring application will reduce clinician workload.
- Patient self-management of psoriasis will improve with the use of an AI-powered psoriasis severity scoring application.
- The AI-powered psoriasis severity scoring application will be applicable across diverse populations.
- The AI-powered psoriasis severity scoring application will be more cost-effective than traditional psoriasis severity scoring methods.
- The AI tools used in this psoriasis severity scoring application will be more advanced and effective than previously used technologies.
- Healthcare providers and patients will be open to adopting this AI-powered tool in their treatment plans.

Definition of Terms

- Accuracy: A general metric that measures the proportion of correct predictions (both true positives and true negatives) made by the model compared to the total number of predictions (Lgayhardt, 2024).
- Body Surface Area (BSA): A method used to estimate the percentage of the body affected by psoriasis. It is often assessed using the "rule of nines," dividing the body into areas representing about 9% of the body surface area (Kim et al., 2017).
- Convolutional Neural Network (CNN): A type of deep learning architecture commonly used for image classification tasks. CNNs are effective for processing visual data, automatically learning features such as edges, textures, and patterns from raw image data (Ibm, 2024).
- DeepLabV3+: A semantic image segmentation model that is used to accurately classify and segment pixels within an image (Chang, 2022).
- Deep Learning (DL): A class of machine learning techniques that use neural networks with multiple layers (often called deep neural networks) to model and solve complex problems (Holdsworth et al., 2024).
- Dermatologist/Clinician Consultations: Expert evaluations of the AI model's treatment recommendations and psoriasis severity assessments, providing feedback to ensure clinical relevance and the accuracy of the AI-generated outputs (Kim et al., 2017).

- DINO v2: A self-supervised learning model that allows the model to learn representations from unlabeled data. It has been used in image segmentation tasks for its ability to generalize across different datasets without requiring extensive labeled data (Meta, 2023).
- F1 Score: A metric to evaluate the precision and recall balance. It is the harmonic mean of precision and recall, providing a single measure of the model's accuracy, particularly in imbalanced datasets (Lgayhardt, 2024).
- Loss Function: A function used during training to evaluate how well the model's predictions match the true labels. A lower loss indicates that the model's predictions are closer to the actual outcomes (Lgayhardt, 2024).
- Mask R-CNN: A deep learning model that combines the ability of CNNs for object detection with a segmentation branch to produce pixel-level masks of objects in images. It is highly effective for segmenting complex medical images (Chang, 2022).
- PGA x BSA Method: A simplified approach to psoriasis severity assessment that combines the Physician Global Assessment (PGA) and Body Surface Area (BSA) methods. This method provides a more practical, yet clinically relevant, tool for assessing the severity and extent of psoriasis (Walsh et al., 2011).
- Physician Global Assessment (PGA): Physician Global Assessment (PGA): A clinical tool healthcare professionals use to visually assess the severity of psoriasis based on the appearance of skin lesions. It uses a 5-point scale ranging from 0 (clear) to 4 (severe) (Pascoe et al., 2015).
- Precision: A metric that measures the proportion of positive predictions that are correct (Lgayhardt, 2024).

- Psoriasis: A chronic autoimmune disorder that results in the rapid growth of skin cells, leading to scaling and inflammation on the skin's surface. (Schaap et al., 2022).
- Psoriasis Area and Severity Index (PASI): A detailed scoring system that quantifies the severity and extent of psoriasis, considering lesion redness, thickness, scaling, and the percentage of body surface area affected. The score ranges from 0 (no disease) to 72 (maximal severity) (Oakley, A., 2024).
- Recall: A metric that measures the proportion of actual positives correctly identified by the model (Lgayhardt, 2024).
- Transfer Learning: A machine learning technique where a model trained on one dataset (e.g., ImageNet) is adapted for a new task or domain (Mural & Kavlakoglu, 2024).
- U-Net: U-Net: A deep learning model primarily used for image segmentation tasks, especially in medical imaging. U-Net is known for its architecture, which enables precise segmentation of image regions by capturing both local and global features (Ronneberger et al., 2015).
- Vision Transformer (ViT): A deep learning model that applies transformer architectures, typically used in natural language processing, to image classification and segmentation tasks. (Wang et al., 2022).

Methodology

Data Collection

Large datasets of psoriasis images will be collected to train the AI model. These images will undergo preprocessing to ensure high-quality data, standardizing aspects such as resolution, More like 700 + images now

lighting, and skin tone variation. Currently, 325 psoriasis images have been sourced from DermNet and a Kaggle dataset (Goel, 2020). Additional images will be obtained by contacting medical institutions and securing permission to use their resources to expand the dataset further. This will ensure the model is trained on a diverse set of images, enhancing its accuracy and generalizability across different populations and skin types.

Image Labeling and Annotation

The collected images will be labeled and processed for training purposes. For segmentation tasks, dermatologists manually annotate the images using an online annotation tool such as Labelbox. For the Physicians Global Assessment (PGA) classification, three dermatologists will score each image. The average of these scores will then be used as the label for each image in the dataset, ensuring a high level of accuracy and consistency in the training data

Due to time and resources. There will be 2 dermatologists working together to evaluate their own portion of the dataset. This will be mentioned as a potential limitation.

Image Preprocessing

Also using roboflow instead of label box

We will apply several preprocessing techniques using the SkinTeller method to ensure high-quality, standardized images for model training. First, image normalization will be performed to standardize the pixel intensity values across the dataset, ensuring consistency and reducing variability in lighting and exposure. To improve image clarity, Contrast Limited Adaptive Histogram Equalization (CLAHE) will be applied. This method enhances the local contrast in images, making finer details, such as lesion boundaries, more distinguishable. To address variations in lighting conditions, gamma correction will be implemented to adjust the brightness and contrast, ensuring uniform lighting across images.

Additionally, white balance correction will be applied to standardize color temperature, eliminating color casts caused by different lighting conditions. Finally, we will perform color space conversion, shifting the images to a more suitable color space (such as Lab or HSV) to reduce the impact of skin tone variation, further aiding in the model's ability to generalize across diverse populations (Huang et al., 2023). These preprocessing steps will ensure the images are consistently prepared for AI training, enhancing the accuracy of the model's predictions and improving overall performance.

Image Segmentation

To segment the areas affected by psoriasis, several well-established and innovative segmentation models will be tested to determine the most effective approach for this task. U-Net, Mask R-CNN, and DeepLabV3+ were selected for evaluation due to their proven success in medical image segmentation, particularly in tasks like segmenting burns and the palm of the hand for Body Surface Area (BSA) assessments, where they achieved accuracies of 0.9836, 0.9841, and 0.9846, respectively for burn wounds. These models have demonstrated high accuracy in delineating complex lesions, making them strong candidates for accurately identifying psoriasis-affected regions (Chang 2023). U-Net is known for its efficiency in segmenting small datasets with fine-grained details, while Mask R-CNN excels in detecting and segmenting objects, ensuring precise lesion boundaries. DeepLabV3+, with its robust handling of complex image structures, is particularly effective in capturing detailed variations in skin texture and lesion appearance. In addition to these established models, more innovative approaches like DINO v2 and Vision Transformer (ViT) will also be tested. DINO v2, a self-supervised learning model, offers the potential to learn from unlabeled data, making it an attractive option for generalizing across diverse datasets without extensive labeling (Meta, 2023).

Will instead evaluate MedSam and Panderm instead of DINO and ViT

The Vision Transformer (ViT), known for its ability to capture long-range dependencies, will be tested for its capacity to improve segmentation accuracy, particularly in challenging images with varying lesion distribution and skin tones (Wang et al., 2022). The performance of these models will be evaluated based on segmentation accuracy, boundary precision, and generalizability across different skin types and image conditions, helping to identify the most suitable approach for psoriasis lesion detection and BSA scoring.

Ther measurement for accuracy will be based off Dice-Score and hausdorff distance comparision

PGA Classification with Transfer Learning

For the Physician Global Assessment (PGA) classification, several well-established convolutional neural network (CNN) architectures will be tested to determine the most effective model for evaluating psoriasis severity. ResNet, Inception-v3, and DenseNet will be evaluated due to their proven success in image classification tasks, including medical image analysis. ResNet, with its deep residual learning framework, is known for its ability to train very deep networks without the problem of vanishing gradients, making it ideal for handling complex image classification tasks (Liang, 2020). Inception-v3 is selected for its efficient use of computational resources, employing multiple filter sizes in parallel to capture a wide variety of features in psoriasis images, which can be essential for classifying different levels of severity (Wang, 2019). DenseNet, which utilizes dense connections between layers, helps improve feature propagation and reduces overfitting, making it an effective model for more accurate classification, especially in small or unbalanced datasets (Zhang et al., 2022). To enhance the classification accuracy further, these models will be fine-tuned using ImageNet weights via transfer learning, leveraging pre-trained features on a large, diverse dataset to boost performance on the psoriasis images. The performance of these models will be compared based on classification accuracy, precision, and recall to select the most effective model for psoriasis severity assessment.

Matching Dermatologist Recommendations with Psoriasis Severity

To match real dermatologist recommendations with varying severities and conditions of psoriasis, a comprehensive dataset will be compiled, including different psoriasis cases categorized by severity (mild, moderate, severe) and clinical presentation (e.g., plaque, guttate, inverse psoriasis). Dermatologists will provide treatment recommendations for each case. These recommendations will be standardized across dermatologists to ensure consistency and paired with severity scores derived from the PGA x BSA method. The dataset will be used to train a Deep Neural Network (DNN) model through supervised learning, enabling the model to learn the correlation between severity scores and appropriate treatment options.

Once trained, the DNN model will generate personalized treatment plans based on the assessed severity and condition of a patient’s psoriasis. The model’s performance will be validated by comparing its recommendations to those made by experienced dermatologists, using evaluation metrics such as accuracy, precision, and recall. This approach aims to enhance patient care by enabling the AI-powered application to provide dermatologist-approved, personalized treatment recommendations, improving the accessibility, efficiency, and consistency of psoriasis management.

Calculating the PGA x BSA Score

To calculate the overall severity score, the application multiplies the BSA by the average PGA score, $PGAxBSA = [(E + I + D)/3] \times BSA$, where E is erythema, I is induration, and D is desquamation (Walsh et al., 2011). The found score is then matched with its specific severity:

- Very Low Score (e.g., < 50): Likely indicates mild psoriasis with either a low severity (low PGA) or a low affected area (low BSA), or both.

- Moderate Score (e.g., 50-150): Reflects moderate psoriasis, with either moderate severity or a moderate extent of psoriasis.

- High Score (e.g., 150-300): Indicates severe psoriasis, with either high severity (high PGA) or significant body surface involvement (high BSA).

- Very High Score (e.g., > 300): Reflects severe, widespread psoriasis that affects a large portion of the body with severe lesions.

Analysis Plan

The analysis plan for this study will focus on evaluating the performance of the AI-powered psoriasis severity scoring and treatment recommendation system using several accuracy metrics, including F1 score, precision, recall, accuracy, and loss. These metrics will provide a comprehensive understanding of the model's ability to make accurate and reliable predictions. The F1 score will be used to evaluate the balance between precision and recall, particularly in handling false positives and false negatives. Precision and recall will assess the model's ability to identify the severity of psoriasis and recommend appropriate treatments correctly. Accuracy will provide an overall measure of the model's performance, while loss will help track the model's learning progress during training and fine-tuning. In addition, dermatologist and clinician consultations will be incorporated to validate the AI model's recommendations against expert judgment, ensuring clinical relevance and consistency with current medical standards. These evaluations will guide the refinement of the model and ensure it meets the practical needs of healthcare providers and patients.

Dissemination Plan

Most likely Fall 2025

The results of this work will be shared with the FSC community during the Spring 2026 Fiat Lux event. Additionally, the findings will be disseminated to professionals within the field of dermatology and AI applications through presentations at national and international conferences (e.g., Medical Image Computing and Computer Assisted Intervention) and publications in relevant peer-reviewed journals. This dissemination will allow for broader research exposure, facilitate knowledge exchange, and foster collaboration with experts in the field.

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