ACNE FACE DETECTION USING MACHINE LEARNING MODELS:A REVIEW  
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*Abstract*—**This review explores the recent advancements in using artificial intelligence, particularly convolutional neural networks (CNNs), to accurately and efficiently detect and classify acne.The research describes into a variety of AI techniques, such as ensemble models, HSV-based segmentation, and attention mechanisms, were it can applied to various acne-related tasks.The studies analyzed showing significant progress level in automating acne assessment, from identifying distinct lesions to grading their severity.For Image extraction CNN placed vital role in AI, which enabling accurate classification of distinct acne types and their severity. Along with incorporating attention mechanisms has improved the models where it can focus on relevant acne lesions,which leading to better overall performance.Although these studies indicate the capability of AI for acne diagnosis,still the challenges remain in terms of data quality, generalization, and real-world implementation.The Future study should focus on understanding the drawbacks of AI-powered acne detection systems and testing using different techniques to improve their accuracy, efficiency, and accessibility.**

***Keywords—****CNNs,DeepLearning,Ensemble Methods,HSV-Based Segmentation,Acne detection,Medical image analysis,Data quality*

# Introduction

Acne Vulgaris is a chronic inflammatory condition where it affects the sebaceous glands. The formation of Acne Vulgaris can be in the form of whiteheads, blackheads, small red tender bumps, pimples with pustules, nodules, and cystic lesions. The factors of acne can be many reasons, considering parameters such as hormonal changes, certain medications, diet, stress, hygiene, and family history. It impacts approximately 9.4% of the global population, with a particularly high prevalence among adolescents—up to 85% of this group experiences acne at some point. While often, it leads to mental illness such as lack of confidence and self-esteem.

Given the widespread incidence of acne and the psychological ramifications it entails, timely and accurate diagnosis is crucial. Traditional diagnostic methods, primarily reliant on visual assessment by dermatologists, are subject to inter-observer variability and can be time-consuming. As such, there is an urgent need for advancements in automated diagnostic tools. Recent developments in artificial intelligence (AI) and deep learning techniques offer promising alternatives to conventional methods.

Through there are various factors to prediction the acne which is impossible were we need to consider the various parameter,since traditional diagnostic methods where the primarily depends on the consultant the dermatologists which is time consuming process.To make this process easier using the Advancement of today's era of Artificial Intelligence an d Machine learning model using there advancement of the model where it can able to detect the type of the acne and severity level of it which is easier to analysis the treatment level for every acne type consuming the medicine is not only the solution to the problem following dietary sheet, maintain the mental health Understanding the root cause of it which is the best solution for the problem using the AI techniques understanding the severity level and taking medication

The evolution of the deep learning model for acne detection and classification.Considering,[1] which highlights the persistent nature of acne and its psychosocial impacts, which implies the along wait for dermatologist appointments where they made the collaboration work with the CHOLLEY a swiss company focus on the skin care product.[2] introduces the identification of acne using a Laplacian of Gaussian-based

blob detection strategy. Then, texture features are extracted from acne candidates using either a Gabor Filter or Gray Level Cooccurrence Matrix (GLCM).

Additionally, attention-based deep regression models have been proposed [3] incorporate an attention startegy by introducing prior knowledge of bounding boxes which is generated by Faster R-CNN into the regressor model. This attention strategy describe the regression model on where to locating the most salient features related to the understudied acne lesions. [4] which describe the develop an AI-powered acne grading system and compare it performance with physician image-based scoring and the usage of VISIA complexion analysis system to photograph 276 facial images sample underscores the need for effective acne scar treatment options, stressing the importance of accurate classification of acne types to inform treatment choices. Similarly, [5 ]discusses the integration of deep learning for automated detection and classification of acne lesions, highlighting the advancements made in this area. Moreover, [9] and [8] focus on constructing deep learning models using clinical images to evaluate acne vulgaris effectively. These models aim to provide objective assessments, potentially enhancing the decision-making process for treatment. The development of mobile applications [7] further illustrates the shift towards accessible and user-friendly diagnostic tools, allowing individuals to assess their acne remotely.

Finally, [9] presents a convolutional neural network-based approach for the automatic diagnosis of acne vulgaris, addressing the limitations of traditional methods and the need for standardized classification. This unified approach underscores the potential of AI-driven technologies to provide timely, accurate, and scalable solutions for acne diagnosis.including Shen et al. (2021), who focused on interpretation CNN-based models for acne severity evaluation; Chai et al. (2022), which introduced a dual CNN model for enhanced detection and classification; Liu et al. (2023), which highlighted improved accuracy using ensemble neural networks; and Yadav et al. (2021), which employed HSV color space transformations for effective detection. Additionally, Zhao et al. (2024) presented the AcneDet system, combining Faster R-CNN and LightGBM models for smartphone-based acne diagnosis. This integrated approach leverages the strengths of these methodologies to provide a robust and practical solution for acne detection and severity assessment.

**RQ1: How do different deep learning models, including CNNs and ensemble methods, compare in their accuracy for acne detection and severity classification?**

**RQ2: What are the key factors that influence the performance of these models in acne diagnosis, particularly when applied to smartphone-captured images?**

**RQ3: How can the integration of object detection and severity grading models, as seen in the AcneDet system, enhance the overall effectiveness of acne diagnosis?**

By exploring these questions, this research aims to provide a comprehensive understanding of the strengths and weaknesses of various deep learning models in acne detection. We will examine their respective training requirements, computational efficiency, and adaptability to different types of acne images. Additionally, we will discuss the implications of these findings for future research and practical applications in dermatology and smartphone-based healthcare solutions.

# Literature Review

The field of acne detection and classification has seen significant advancements through the application of deep learning techniques. **Shen et al. (2021)** developed a model focusing on interpretable convolutional neural networks (CNNs) for acne severity evaluation, providing insights into the internal workings of CNNs in medical diagnostics. **Chai et al. (2022)** introduced a dual integrated CNN model that enhances the accuracy of acne vulgaris detection and classification, demonstrating the potential of combining different CNN architectures.[1] discusses a deep learning-based facial acne classification system. The authors highlight the complexity of acne's pathogenesis and its various forms, particularly emphasizing the need for efficient diagnosis due to the scarcity of dermatologists and lengthy waiting times for appointments. They advocate for technological interventions that can enhance diagnostic accuracy and accessibility.

In [2], the focus shifts to the application of Gaussian Mixture Models (GMM) for acne classification based on texture features. This research addresses the subjective nature of traditional assessments by dermatologists and introduces a method that leverages image analysis to determine acne severity objectively. The authors demonstrate that utilizing texture-based features can significantly enhance the accuracy of acne evaluations.[3] presents an attention mechanism-guided deep regression model for grading acne severity. The paper underscores the psychological impacts of acne, such as low self-esteem and anxiety, and the challenges posed by its polymorphic structure. By employing advanced deep learning techniques, this research aims to provide a more nuanced assessment of acne severity, addressing the need for effective evaluation criteria.In [4], the development and validation of a novel deep convolutional neural network (CNN) model for acne scar classification are explored. The authors note that acne scars often present a more significant challenge than the acne itself, impacting patients' quality of life. This study emphasizes the importance of accurate classification for effective treatment planning, proposing a new dataset to improve model training.

[5] highlights the integration of deep learning for the automated detection and classification of acne lesions. The authors advocate for the use of AI technologies to streamline the diagnostic process, thereby alleviating the burden on dermatologists. Their findings suggest that automated systems can enhance real-time assessments and improve patient outcomes.[6] focuses on constructing deep learning models utilizing clinical images for acne evaluation. The authors discuss the importance of robust datasets and effective preprocessing methods to ensure reliable model performance. By aiming to automate the diagnostic process, this research seeks to facilitate objective assessments in clinical settings.

**[7]** explores the development of mobile applications for remote acne assessment. This paper reviews existing tools that empower users to analyze their skin conditions independently, reducing the need for in-person consultations. The authors emphasize how these applications leverage AI to promote proactive skincare and increase accessibility to dermatological care.[8] evaluates various deep learning techniques for acne detection from clinical images. The authors provide a comparative analysis of different models, assessing their accuracy and computational efficiency. Their research highlights the necessity for diverse training datasets to enhance the reliability of these systems in practice.

Finally, [9] introduces a CNN-based approach for the automatic diagnosis of acne vulgaris. By addressing the limitations of traditional methods, this study underscores the potential of AI technologies to deliver timely and standardized diagnoses. The authors advocate for the scalability of these solutions in dermatology, potentially transforming acne management practices.

The integration of diverse methodologies across these studies highlights significant advancements in acne vulgaris detection and classification. This trend towards automation and AI-driven diagnostics paves the way for future research and practical applications in dermatology

# Methodology

**Data Collection and Preprocessing:**

**Data Sources:**

**AcneDet Dataset:** This dataset comprises 1,572 labeled images captured using smartphone cameras, providing a diverse representation of acne types and severities. It is particularly valuable for its real-world applicability.

**Mobile Application Data [7]:** This study collects data from a mobile application designed for the detection and classification of acne lesions. The application captures user-uploaded facial images, contributing to a user-generated dataset that reflects various acne presentations.

**Convolutional Neural Network Dataset[9]:** This study utilizes a dataset of clinical images specifically curated for acne vulgaris diagnosis. The dataset includes images collected from dermatological clinics, ensuring a variety of acne severities and patient demographics.

**Deep Learning Model Dataset [6]:** This paper employs a collection of clinical images sourced from dermatology departments, focusing on a diverse range of acne vulgaris cases. The images are annotated for accurate model training and validation.

**Object Detection Dataset [5]:** This study utilizes a dataset specifically constructed for deep learning object detection, including annotated images of acne lesions from various sources to train and evaluate the detection algorithms.

**Deep CNN Model Dataset [4]:** This research relies on a novel dataset developed for acne scar classification, which includes images of inflammatory acne lesions and scars. The dataset aims to provide comprehensive data for training deep learning models to assess scar severity accurately.

**Data Augmentation:** To enhance the robustness of the models and prevent overfitting, data augmentation techniques will be employed. These techniques include cropping, contrast adjustment, rotation, flipping, and scaling. By artificially expanding the dataset, By artificially expanding the dataset, researchers aim to enhance the models' generalization capabilities, ensuring effective performance on unseen data.

**Image Segmentation Techniques:**

**HSV Model-Based Transformations:** Image segmentation is a vital step in isolating acne lesions from the surrounding skin. Several studies utilize the HSV (Hue, Saturation, Value) color space to improve image clarity and facilitate precise segmentation. Transforming images into the HSV color space allows for better discrimination between acne lesions and normal skin, which is essential for accurate analysis.

**Comparative Evaluation:** The effectiveness of HSV-based segmentation techniques is evaluated against traditional methods, such as thresholding and region-based approaches, as well as more advanced techniques like CNN-based segmentation models. This comparative analysis helps to identify the most effective segmentation strategy for the specific requirements of acne detection.

**Deep Learning Models:**

**Convolutional Neural Networks (CNNs)**: Many studies utilize CNN architectures for acne classification and severity assessment. This includes both single CNN models and dual integrated CNN models that combine different architectures to achieve higher accuracy. The use of CNNs facilitates automated feature extraction, significantly improving the diagnostic process.

**Attention Mechanisms**: Certain research incorporates attention-based deep regression models that focus on the details of acne lesions. This enables a more nuanced grading of severity, which is particularly useful given the complex nature of acne presentations.

**Ensemble Methods**: Ensemble neural networks are examined in various studies to harness the strengths of multiple models. By combining the outputs of different models, this approach enhances prediction accuracy, leading to more reliable classifications.

**Gaussian Mixture Models (GMM)**: In specific studies, GMMs are employed for texture-based acne severity assessment, providing an alternative method for classification and enhancing the robustness of predictions.

**Object Detection Models**: Some research focuses on deep learning object detection frameworks (e.g., Faster R-CNN) for detecting acne lesions, which allows for precise localization and identification of various acne types.

**4. Classification and Evaluation:**

**Model Performance Assessment:** The performance of each model will be rigorously assessed using a range of metrics, including accuracy, precision, recall, and F1-score. These metrics provide a comprehensive view of each model’s effectiveness in detecting and classifying acne lesions.Assesses the performance of the Gaussian Mixture Model (GMM) based on these metrics to measure acne severity.Utilizes standard metrics to evaluate attention-based models for nuanced acne severity grading.Validates a deep CNN model's classification accuracy for acne scars using multiple performance metrics.Measures detection accuracy using deep learning object detection methods and assesses model reliability.Assesses clinical image models with precision and recall metrics to evaluate acne vulgaris.Evaluates the mobile application’s performance metrics for acne detection and classification.Examines the efficacy of models using accuracy and diagnostic metrics on clinical images.Implements CNN-based methods to measure various performance metrics for automated acne diagnosis.

**Computational Efficiency**: For each model, we will also examine the computational efficiency during the evaluation phase. This includes measuring the time required for training and inference, as well as the computational resources consumed (e.g., CPU/GPU usage).Analyzes computational resources and training times for the CNN model in acne detection.Assesses computational load and efficiency of GMM techniques in acne severity assessment.Evaluates training and inference times for attention-based deep regression models.Examines computational efficiency and resource utilization of deep CNNs for acne scar classification.Measures resource usage and efficiency in object detection frameworks for acne lesions.Analyzes computational demands and efficiency in clinical model assessments.Evaluates the mobile app's resource utilization for acne detection tasks.Explores computational efficiency of deep learning models in acne assessments.Considers the efficiency of CNN-based automated diagnosis concerning resource consumption.These factors are crucial for determining the feasibility of deploying these models in clinical settings or on mobile devices.

**Localization Modules and Severity Assessment**:This research emphasizes the importance of accurately evaluating the severity of acne lesions through localized feature extraction techniques. By integrating these methods, we can assess how severe the acne is and apply attention mechanisms that allow for more precise grading within deep learning models. The focus also includes classifying acne scars, where detailed assessments of localized lesions are crucial. Object detection methods will be employed to accurately locate acne lesions on the skin. Using clinical images will enhance the precision of both localization and grading of acne vulgaris.

Additionally, mobile app functionalities will be integrated to help users detect lesion locations and assess their severity easily. The AcneDet system will play a key role by incorporating localization modules that pinpoint the exact spots of acne lesions. For severity assessment, we will utilize integrated models, including the LightGBM-based grading system from AcneDet. This comprehensive approach aims to provide accurate results efficiently, ensuring that our models can be deployed in real-world scenarios without demanding excessive computational resources.

### **5.Performance Comparison**

#### Comparative Results of Different Models:The performance of various models in acne detection and classification will be rigorously analyzed through comparative evaluations, focusing on several key aspects:

**HSV Segmentation**: The effectiveness of HSV-based segmentation in isolating acne lesions from normal skin will be assessed. This method’s performance metrics will include segmentation accuracy and computational efficiency, allowing for a comparison against traditional techniques like thresholding and edge detection, as utilized in [2] and [3].

**CNN Architectures**: Different CNN models, including those proposed in [1] and [9], will be compared based on critical metrics like accuracy, precision, recall, and F1-score. This analysis will highlight performance improvements observed with dual CNN models and ensemble approaches, showcasing advancements in classification capabilities across the various studies.

**Ensemble Neural Networks**: The effectiveness of ensemble methods will be evaluated for their ability to combine predictions from multiple CNN models, including those explored in [4]. This comparison will illustrate how ensemble techniques enhance overall accuracy and reduce classification errors, drawing on strengths from different models.

**AcneDet System**: The AcneDet system, integrating a Faster R-CNN model for acne detection and a LightGBM model for severity grading, will be thoroughly evaluated. Key metrics, including mean Average Precision (mAP) for object detection and mean accuracy for severity grading, will be utilized to demonstrate how this system compares to others, particularly those employing AI-powered grading systems that incorporate lesion identification, as discussed in [7].

**Improvements in Accuracy, Localization, and Severity Assessment:**

**Accuracy**: Comparative results will showcase enhancements in detection accuracy across various models. Dual CNN models, as seen in [1] and [3], are expected to demonstrate significant improvements over single CNN models, particularly in handling complex cases of acne.

**Localization**: The capacity of models to accurately locate acne lesions within images will be assessed. Models incorporating localization modules, such as those developed for [8] and the AcneDet system, are anticipated to excel in pinpointing the exact positions of lesions, providing substantial advantages in real-world applications.

**Severity Assessment**: The effectiveness of models in grading acne severity will be compared. Integrated approaches, particularly those leveraging the AcneDet system's grading capabilities alongside methodologies from [6] and [4], are expected to show superior performance in accurately classifying the severity of acne lesions.

#### *2. Practical Implications*

#### *Integrated Approach for Dermatology Applications:*

#### ***Real-World Applicability****:* The integration of various segmentation and deep learning techniques has shown strong potential for practical applications in dermatology. By utilizing datasets like those from the AcneDet system, which are tailored for real-world scenarios, these technologies can facilitate effective acne diagnosis across diverse populations.

**Smartphone-Based Systems**: Emphasizing the practicality of smartphone-based systems, research demonstrates how tools developed in studies [1], [5], and [7] can enable real-time acne diagnosis. The combination of advanced deep learning models with smartphone capabilities provides a feasible and user-friendly solution for widespread acne detection and ongoing monitoring, making it accessible to individuals without immediate access to dermatological services.

**Clinical Benefits**: The enhanced accuracy and efficiency achieved through these integrated approaches carry significant clinical benefits. Advanced diagnostic tools derived from studies [3], [4], and [8] empower dermatologists with reliable methods for diagnosing acne and determining appropriate treatment plans. This not only improves patient care but also streamlines clinical workflows, reducing unnecessary visits and enabling timely interventions for those affected by acne.

By harnessing the advancements highlighted in these studies, the practical implementation of deep learning technologies in dermatology promises to transform the landscape of acne diagnosis and management, making it more accessible and effective for patients worldwide.

##### **DISUSSION,RESULTS AND CONCLUSIONS**

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ABSTRACT: