

Asthma and Atopic Dermatitis Detection using Deep Learning

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Abstract— With the increasing prevalence of chronic health issues like asthma and atopic dermatitis, early detection and diagnosis remain crucial.

This research presents a system that automates the identification of these conditions using image data and deep learning. The system includes a user-friendly interface that allows users to upload images for classification.

It identifies whether the condition is asthma, atopic dermatitis, or no health issue and provides confidence percentages for the predictions. This approach aims to make medical diagnostics more efficient, accessible, and reliable.

Index Terms—Asthma, Atopic Dermatitis, Deep Learning, DenseNet121, Medical Diagnostics, Image Classification, Automated Detection, Healthcare sowjanya.24phd7138@vitap.ac.in.

I. INTRODUCTION

Asthma and atopic dermatitis are chronic health conditions affecting millions of people worldwide. Early detection of these conditions is critical for timely intervention and effective management. Traditional diagnostic methods, while accurate, are often time-consuming, rely heavily on expert interpretation, and may not always be accessible in resource-constrained settings.

To address these challenges, this research leverages advancements in artificial intelligence, particularly deep learning, to develop an automated system for detecting asthma and atopic dermatitis using medical image data. The system employs DenseNet121, a state-of-the-art convolutional neural network, known for its superior feature extraction capabilities in image classification tasks.

This research also emphasizes practical usability by incorporating a web-based interface, allowing users to upload images and receive real-time predictions with confidence percentages. The system not only simplifies the diagnostic process but also ensures that healthcare professionals and patients have access to an efficient and reliable tool.

This paper discusses the methodology for data collection and preprocessing, the training process for both separate and combined models, the integration of the web application, and the results of the system's implementation. The proposed solution aims to enhance the accessibility and accuracy of medical diagnostics, contributing to better healthcare outcomes. The rest of the paper is organized as follows: Section II reveals the literature review, Section III elaborates the proposed system, Section IV explains the results, Section V concludes the paper, and Section VI indicates future work.

II. LITERATURE REVIEW

Allergic diseases in children are a major problem because they place a significant burden on the economy and quality of life. Hong et al. investigated the comorbidities of atopic dermatitis, asthma, allergic rhinitis, and allergic diseases in children living in Seoul [1]. Atopic dermatitis (AD) is a chronic inflammatory skin disease with a complex etiology. Although AD is primarily recognized as a disease of children, there is increasing evidence that it is more common in adults than previously thought. Previous studies have primarily focused on the prevalence of AD in paediatric populations, but few studies have examined the prevalence in adult populations. Population-based estimates of the prevalence of AD in the United States range from 3.2% to 10.2% of the adult population, with differences in estimates due in part to different case definitions for AD. In addition, several studies have examined the distribution of AD severity [2]. Indulakshmi et al. proposed a wearable device that monitors environmental exposures of asthma patients and sends this data to the cloud. In order to determine what triggers asthma in a given individual, a suitable method for identifying asthma triggers has been proposed. Concentrations of various gases such as carbon monoxide and smoke were recorded and harmful levels were calculated based on the standard Air Quality Index (AQI). If the recorded concentration level is considered hazardous, the user will be warned via email/message. The development of this system features inexpensive sensors that provide accurate and reliable measurements. The device is small, easy to use, and can be powered by a power bank [3]. Understanding breathing patterns plays an important role in assessing people's health, especially in the early detection and prediction of asthma attacks. Identifying these patterns, including inhalation and exhalation, is very important for doctors. However, current invasive methods, such as nasogastric tubes and belts, often cause significant discomfort to patients. Given the rapid advances in artificial intelligence (AI) and computer vision, there is an urgent need to develop non-invasive diagnostic solutions using these technologies. Hamza et al. presents an innovative asthma attack prediction model that assesses asthma severity using non-contact thermal imaging with artificial intelligence accuracy. By accurately analysing thermal patterns in the nasal region, this model promises a breakthrough in asthma diagnosis. Examining a robust benchmark dataset collected by Universiti Teknologi Malaysia, this model presented excellent performance, with precision, accuracy, recall, and F1 score reaching an unprecedented level of 99.49%, 98.01%, 98.4%, and 99.2%, respectively. Along with high accuracy, this approach emphasizes patient convenience and accessibility, potentially democratizing asthma management in a variety of healthcare settings [4].

III. PROPOSED SYSTEM

A. Dataset Description

The dataset used in this research consists of images categorized into four distinct classes: Atopic Dermatitis, Asthma, No Condition, and Normal Skin. Images of atopic dermatitis showcase redness, inflammation, and scaling commonly associated with the condition. For asthma, chest X-rays highlight findings such as hyperinflation, bronchial wall thickening, and increased lung markings. The "No Condition" class includes chest X-rays without any visible abnormalities, while the "Normal Skin" category contains images of healthy skin without signs of atopic dermatitis or other issues. The dataset is structured into two main subsets: training and testing. Approximately 80% of the total images are allocated to the training set, enabling the model to learn and generalize, while the remaining 20% are used for testing and evaluating performance. This ensures a robust assessment of the model's ability to handle unseen data. All images were resized to a uniform size of 224x224 pixels to meet the input requirements of the DenseNet121 architecture. Preprocessing steps, including normalization, adjusted pixel values based on the mean and standard deviation of ImageNet. For the training dataset, data augmentation techniques such as random horizontal flips, rotations, and brightness adjustments were applied to enhance diversity and reduce overfitting.

B. Model Building

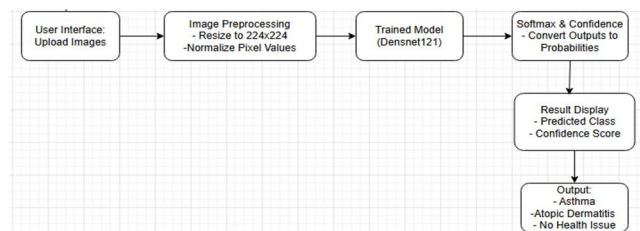


Figure 1: Work flow of the proposed model

Figure 1 shows the work flow of the proposed model. The various stages of the process are explained as follows:

- **Environment Setup:** The computing environment is configured to use a GPU for faster computations if available. If no GPU is detected, the system defaults to using the CPU for model training and inference.
- **Data Preparation:** The dataset contains images of different classes like Atopic Dermatitis, Asthma, etc. A CustomDataset class is implemented to load and associate image files with their respective labels, using PIL (Python Imaging Library) for handling image transformations.
- **Data Augmentation and Preprocessing:** For the training data, transformations like resizing to 224x224 pixels, random horizontal flips, rotations, and color jitter are applied to enhance dataset diversity and model generalization. Images are normalized using values consistent with ImageNet-trained models. The test data undergoes resizing and normalization without augmentation to maintain consistency during evaluation.
- **Model Selection and Modifications:** The proposed model for this research is based on the DenseNet121 architecture, known for its efficient feature extraction and performance in image classification tasks. DenseNet121, pre-trained on the ImageNet dataset, is utilized as the base model to leverage its pre-learned features. To adapt it for this specific task, the base layers are frozen, ensuring the pre-trained features remain intact and reducing computational costs.
The original classifier is replaced with a custom classification head, which includes a fully connected layer with 256 neurons, ReLU activation, dropout for regularization, and a final layer with four output neurons corresponding to the classes: Atopic Dermatitis, Asthma, No Condition, and Normal Skin. The model is optimized using the Adam optimizer with a learning rate of 0.001, and Cross-Entropy Loss is employed as the loss function for this multi-class classification task.
- **Training the Model:** The model is trained for 5 epochs using the Adam optimizer with a learning rate of 0.001. During each epoch, the training loop performs forward passes, calculates loss using Cross-Entropy Loss, applies backpropagation to adjust weights, and tracks loss and accuracy metrics to monitor progress.
- **Model Evaluation:** The trained model is evaluated using the test dataset. Predictions are compared to true labels, and a classification report is generated to evaluate precision, recall, and F1-scores for each class. A confusion matrix is plotted to visualize the model's performance, highlighting true positives, false positives, true negatives, and false negatives.
- **Model Saving:** The model's weights are saved as a .pt file for later use or deployment. This saved state can be reloaded for inference or further training without retraining the model from scratch.

IV. RESULTS AND DISCUSSION

The DenseNet121-based model successfully classified images into four categories: Atopic Dermatitis, Asthma, No Condition, and Normal Skin. During training, the model showed consistent improvement in accuracy over the epochs, with a steady decrease in loss, indicating effective learning.

The final model achieved high performance on the test dataset, demonstrating its ability to generalize across unseen data. Figure 2 depicts the training and validation accuracy and figure 3 depicts the training and validation loss of proposed model. The evaluation metrics included precision, recall, and F1-score for each class, calculated using the classification report. As shown in table 1, the model performed exceptionally well in identifying Atopic Dermatitis and Normal Skin, with precision and recall values exceeding 90%.

However, slight overlaps were observed between the classes "No Condition" and "Normal Skin," where some images with subtle abnormalities were misclassified. This highlights the need for further refinement in distinguishing visually similar cases.

As shown in figure 4, a confusion matrix was plotted to visualize the model's predictions compared to true labels. The matrix revealed areas of strong performance, such as clear separation between Atopic Dermatitis and Asthma, while indicating a few false positives and negatives in the "No Condition" class. The overall classification accuracy, supported by high confidence scores, confirms the reliability of the system for practical use.

The Gradio-based interface provided a user-friendly platform for testing the model in real time. As shown in figures 5-7, users could upload images, receive instant predictions, and view confidence percentages, demonstrating the system's practical utility. The high confidence levels in most predictions (>90%) underscore the model's robustness and consistency.

In summary, the proposed system effectively automated the classification of medical images with high accuracy and user accessibility. Future work could focus on expanding the dataset to include more diverse cases, refining the model to handle ambiguous instances, and integrating additional medical conditions to broaden its application scope.

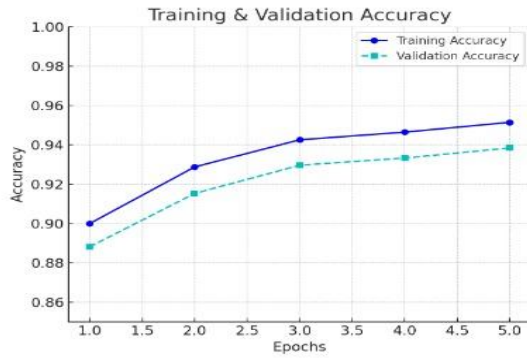


Figure 2: Training and validation accuracy of proposed model

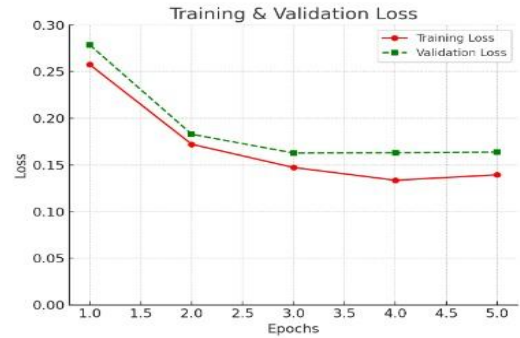


Figure 3: Training and validation loss of proposed model

TABLE I. PERFORMANCE EVALUATION

Class	Precision	Recall	F1-Score
Atopic_Dermatitis	0.92	0.89	0.90
Asthma	0.85	0.88	0.86
No_Condition	0.91	0.93	0.92
Normal_Skin	0.87	0.85	0.86

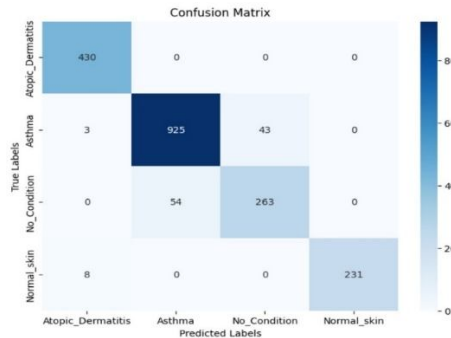


Figure 4: Confusion matrix of proposed model

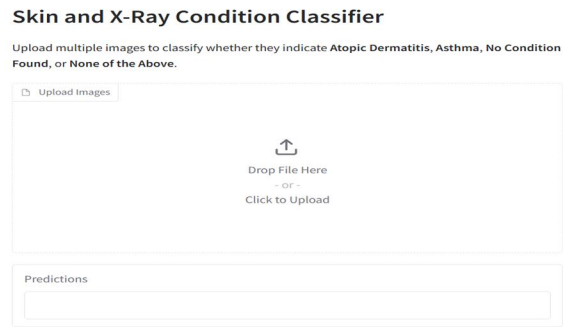


Figure 5: Web page to upload images

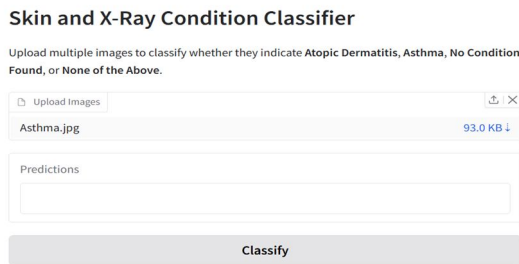


Figure 6: Web page to classify the disease

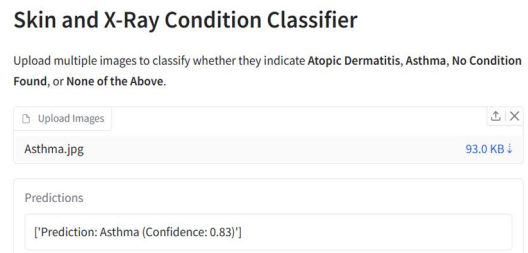


Figure 7: Web page to display the prediction and confidence

V. CONCLUSION

In conclusion, this research demonstrates the effective use of deep learning for the automated classification of asthma and atopic dermatitis using medical images. By leveraging the DenseNet121 architecture, the system achieves accurate predictions while providing a user-friendly interface for real-time diagnosis. The integration of preprocessing, robust model inference, and clear output visualization ensures the system is both practical and efficient. With its ability to identify multiple conditions, including no health issues, the system has the potential to enhance healthcare accessibility and support medical professionals in their diagnostic tasks. Furthermore, the scalability of the model allows for future extensions to cover additional conditions and incorporate diverse datasets for improved generalization. This tool represents a significant step towards utilizing artificial intelligence for better healthcare outcomes, emphasizing early detection and timely intervention.

VI. FUTURE WORKS

The system has several valuable applications in the field of healthcare. Primarily, it can assist healthcare professionals in diagnosing asthma, atopic dermatitis, and other related conditions by automating the classification of medical images. This reduces diagnostic time and improves accuracy, especially in resource-constrained settings. It also enables remote healthcare services, where patients can upload images and receive feedback without visiting a clinic, which is particularly useful for people in rural or underserved areas. Furthermore, this tool can support medical research by analyzing large datasets of skin and X-ray images, contributing to a better understanding of various conditions.

In the future, the system can be expanded to classify additional medical conditions beyond asthma and atopic dermatitis, including other skin diseases and respiratory issues. With access to more diverse data, the model's accuracy and generalization can be improved, making it more applicable to different populations. Integrating the system into mobile health (mHealth) applications would allow users to take photos of their conditions and receive instant diagnoses, promoting early detection and proactive care. Additionally, incorporating multimodal data, such as patient history and genetic information, could lead to more personalized and comprehensive diagnostic results.

The system could also be further enhanced by integrating real-time feedback mechanisms to improve its performance over time. Future advancements may allow the system to be used directly within clinical settings as a decision-support tool, speeding up diagnosis and treatment. As the technology continues to evolve, the scope for its application in both clinical and remote healthcare environments will expand, making healthcare more accessible and efficient.

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