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Research Article

Integrating Artificial Intelligence and Neural Networks for Enhanced Diagnosis of Atopic Dermatitis

Mahajabeen Madarkar[1*], D Purshotam B[1], Seema Sankeshwari[2], Muskan Jain[3]

[1]Professor and Head of the Dermatology Department, SR Patil Medical College, Badagandi, Bagalkot, India

[2]Assistant Professor Physiology Department, SR Patil medical college, Badagandi, Bagalkot, India

[3]Medical Intern, Himalayan Institute of Medical Sciences, Jollygrant, Dehradun, Uttarakhand, India

***Correspondence author:** Mahajabeen Madarkar, Professor and Head of the Dermatology Department, SR Patil Medical College, Badagandi, Bagalkot, India; Email: mahajabeenmadarkar@gmail.com

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Abstract

Introduction: Atopic dermatitis, a chronic inflammatory skin condition, disproportionately affects young children. Statistics show that up to 90% of cases are diagnosed before the age of five. Despite its prevalence, the exact cause of this condition remains a mystery, frustrating both patients and healthcare professionals. This article delves into the exciting potential of Artificial Intelligence (AI) methods in diagnosing atopic dermatitis in this particularly vulnerable age group. We'll explore how AI can be used to improve diagnostic accuracy and efficiency, potentially leading to earlier intervention and better management of the condition.

Methods: Atopic dermatitis, particularly prevalent among children under the age of five, remains a condition without a clearly defined etiology. This study investigates the application of artificial intelligence-specifically an Artificial Neural Network (ANN) for the diagnosis of atopic dermatitis in early childhood. The model incorporates input parameters including age, gender, presence of asthma, skin pH levels, dermoscopic findings and Immunoglobulin E (IgE) levels to enhance diagnostic accuracy.

Results: The research focuses on developing and evaluating an artificial neural network designed for the automated detection of Atopic Dermatitis (AD). Utilizing age, gender, asthma status, skin pH, dermoscopy and IgE levels, this approach has the potential to improve AD diagnosis accuracy, paving the way for similar models to further enhance future diagnostics.

Conclusion: This paper demonstrates a successful Artificial Neural Network for distinguishing atopic dermatitis from healthy skin, potentially impacting millions with this common condition.

Keywords: Atopic Dermatitis; Artificial Intelligence (AI); Neural Networks; Atopic Eczema; Atopy; Dermoscopy

Introduction

Atopic dermatitis, also known as eczema, is a chronic inflammatory skin condition that primarily affects children, especially those under the age of five [1-20]. This condition is characterized by dry, itchy skin and the appearance of red rashes, which can significantly disrupt a child's daily life, including their ability to sleep, engage in physical activities and participate in social interactions [1,2,11]. The intense itching and skin irritation often lead to constant scratching, which can exacerbate the condition and cause secondary infections, further complicating management [5].

Although some children may eventually outgrow eczema as they age, the condition can persist into adulthood for others. This persistence can vary in severity, with some individuals experiencing occasional flare-ups while others may have continuous symptoms throughout their lives [2,20]. While the exact cause of atopic dermatitis remains elusive, it is widely believed to result from a combination of genetic predisposition and environmental triggers. Genetic factors are thought to affect the skin's ability to retain moisture and protect against irritants and allergens, thereby making individuals more susceptible to developing the condition [3,17]. Several studies have identified specific genes related to immune response and skin barrier function that may

contribute to the development of atopic dermatitis [21].

In addition to genetic factors, environmental triggers also play a crucial role in the onset and exacerbation of atopic dermatitis. For instance, individuals with a family history of eczema, asthma or other allergic conditions are at a significantly higher risk of developing the disease. This hereditary link is thought to involve a dysregulated immune response that causes the skin to react excessively to various environmental stimuli. Common environmental triggers for eczema flare-ups include dry weather, which can cause the skin to lose moisture and become more prone to irritation and irritants such as soaps, detergents and fragrances that can strip the skin of its natural oils. Allergens like dust mites, pet dander and pollen are also known to trigger flare-ups, especially in individuals who have heightened sensitivity to these substances [3].

Furthermore, environmental pollutants, food allergens and stress are additional factors that may contribute to the worsening of atopic dermatitis symptoms [16,19]. Managing the condition often involves a combination of strategies, including moisturizing the skin to maintain its barrier function, avoiding known irritants, and, in some cases, using topical corticosteroids or other treatments to control inflammation and itching [4,13].

As research continues to investigate the underlying causes of atopic dermatitis, new therapeutic approaches, such as biologic drugs that target specific immune pathways, are being developed [22]. Early diagnosis and intervention remain essential in managing the condition and improving the quality of life for individuals affected by atopic dermatitis.

Symptoms and Causes

Atopic dermatitis, also known as eczema, manifests with a range of distinctive symptoms [1,4]. Intense and persistent itching, often leading to irritation from scratching, is a hallmark feature [4]. The affected skin typically appears red, inflamed and may even ooze or crust over. Individuals with this condition experience dry, sensitive skin that may become scaly, cracked or flake. During flare-ups, small raised bumps or fluid-filled blisters may develop. Prolonged inflammation and scratching can lead to thickened skin, particularly in frequently scratched areas [5]. These symptoms, often beginning in childhood and persisting into adulthood, significantly impact the quality of life for those affected by this chronic and inflammatory skin condition [2].

Atopic dermatitis has a strong hereditary component. Individuals with a family history of atopic conditions like eczema, asthma or hay fever are significantly more likely to develop it. Specific genes associated with skin barrier function and immune response play a crucial role [1,6]. For example, mutations in the filaggrin gene have been extensively studied and are associated with an increased risk [6,12]. While genetics and immune system dysfunction play a major role in atopic dermatitis, environmental factors can also act as triggers. Common triggers include dry weather, exposure to dust mites and allergens, harsh soaps and detergents and certain fabrics like wool [3]. These triggers can exacerbate existing symptoms and contribute to flare-ups.

Artificial Intelligence

Artificial intelligence, as a branch of computer science, deals with the analysis of complex medical data. Neural networks have shown potential in aiding diagnosis, guiding treatment decisions and forecasting outcomes across various clinical situations [23]. In dermatology specifically, their application offers benefits like quicker data acquisition and faster result generation, which contribute to the streamlined development of effective treatment strategies [7].

Clinical features of atopic dermatitis are lesions distributed on the skin that can be of different morphology, intensity and duration, which is an aggravating circumstance for diagnosis [8].

Multiphoton Tomography (MPT) is frequently employed in these contexts, as it offers a non-invasive and label-free method for performing optical biopsies [14,15]. This paper aims to highlight how artificial intelligence can be applied in diagnosing atopic dermatitis, potentially enabling quicker diagnostic processes and more prompt treatment initiation [9,10].

Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Methodology

Dataset Benchmarks:

For the development of the Artificial Neural Network (ANN), a dataset consisting of 500 samples was used, each categorized into one of two groups:

1. Healthy subjects
2. Subjects with atopic dermatitis

The dataset includes six key input parameters based on medical indicators of atopic dermatitis:

- Age: The age of the individual (in years)
- Gender: The biological sex of the individual (Male/Female)
- Presence of Asthma: Whether the individual has a history of asthma (Yes/No)
- Skin pH: The pH level of the skin, measured using a skin pH meter
- Dermoscopy: Clinical skin examination using dermoscopy to observe lesions
- IgE: Immunoglobulin E (IgE) levels, a marker for allergic responses

The output of the model is categorical, represented as either 0 (healthy subjects) or 1 (subjects with atopic dermatitis).

Summary statistics for the dataset are presented in the given Table 1,2.

Age (Years)	**Gender** (Male/Female)	**Percentage** (%)
1-5	98 Male 123 Female	41.88% 46.24%
5-15	95 Male 103 Female	40.59% 38.72%
15-25	33 Male 29 Female	14.10% 10.93%
25-30	8 Male 11 Female	3.41% 4.13%
TOTAL	234 Male 266 Female	100% 100%

Table 1: Parameters based on medical indicators.

	Class 0	**Class 1**	**Total**
Training	90	320	410
Testing	10	80	90
Total	100	400	500

Table 2: The output of the model is categorical atopic dermatitis.

Artificial Neural Network Development (Fig. 1)

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression from
sklearn.preprocessing import LabelEncoder
from sklearn.metrics import classification_report, confusion_matrix
import matplotlib.pyplot as plt
import seaborn as sns

# Load the data from a CSV file
data = pd.read_csv('/content/reviseddata.csv')

# Inspect the first few rows of the dataframe
print(data.head())

# Identify categorical columns
categorical_cols = data.select_dtypes(include=['object']).columns

# Apply label encoding to categorical columns
label_encoders = {}
for col in categorical_cols:
    label_encoders[col] = LabelEncoder()
    data[col] = label_encoders[col].fit_transform(data[col])

# Assuming the last column is the target variable and the rest are
features
X = data.iloc[:, 3:-1]  # Features
y = data.iloc[:, -1]    # Target

# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)

# Create a logistic regression model
model = LogisticRegression(max_iter=1000)

# Train the model
model.fit(X_train, y_train)

# Make predictions
y_pred = model.predict(X_test)
```

```
       Name   Age  Gender Asthma  Skin pH
Dermoscopy \
0     Arjun 15.0     Male     yes       2.0  pinpoint vessels with
yellow clods
1     Rahul 18.0     Male     yes       2.0  pinpoint vessels with
yellow clods
2    Manoj   26.0     Male     yes       2.0  pinpoint vessels with
yellow clods
```

```
3   Deepika   3.0  Female    yes      2.0  pinpoint vessels with
 yellow clods
4    Ganesh 16.0     Male  yes   2.0  pinpoint vessels
with yellow clods
```

```
  IgE    status
0  400 1
1  400 1
2  400 1
3  400 1
4  400 1
```

```
# Evaluate the model
print("Confusion Matrix:")
print(confusion_matrix(y_test, y_pred))
print("\nClassification Report:")
print(classification_report(y_test, y_pred))

# Visualize the confusion matrix
conf_matrix = confusion_matrix(y_test, y_pred)
plt.figure(figsize=(8, 6))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Actual')
plt.title('Confusion Matrix') plt.show()
```

```
Confusion Matrix:
[[13  1]
 [ 0 86]]
```

```
Classification Report:
```

	precision	recall	f1-score	support
0	1.00	0.93	0.96	14
1	0.99	1.00	0.99	86
accuracy			0.99	100
macro avg	0.99	0.96	0.98	100
weighted avg	0.99	0.99	0.99	100

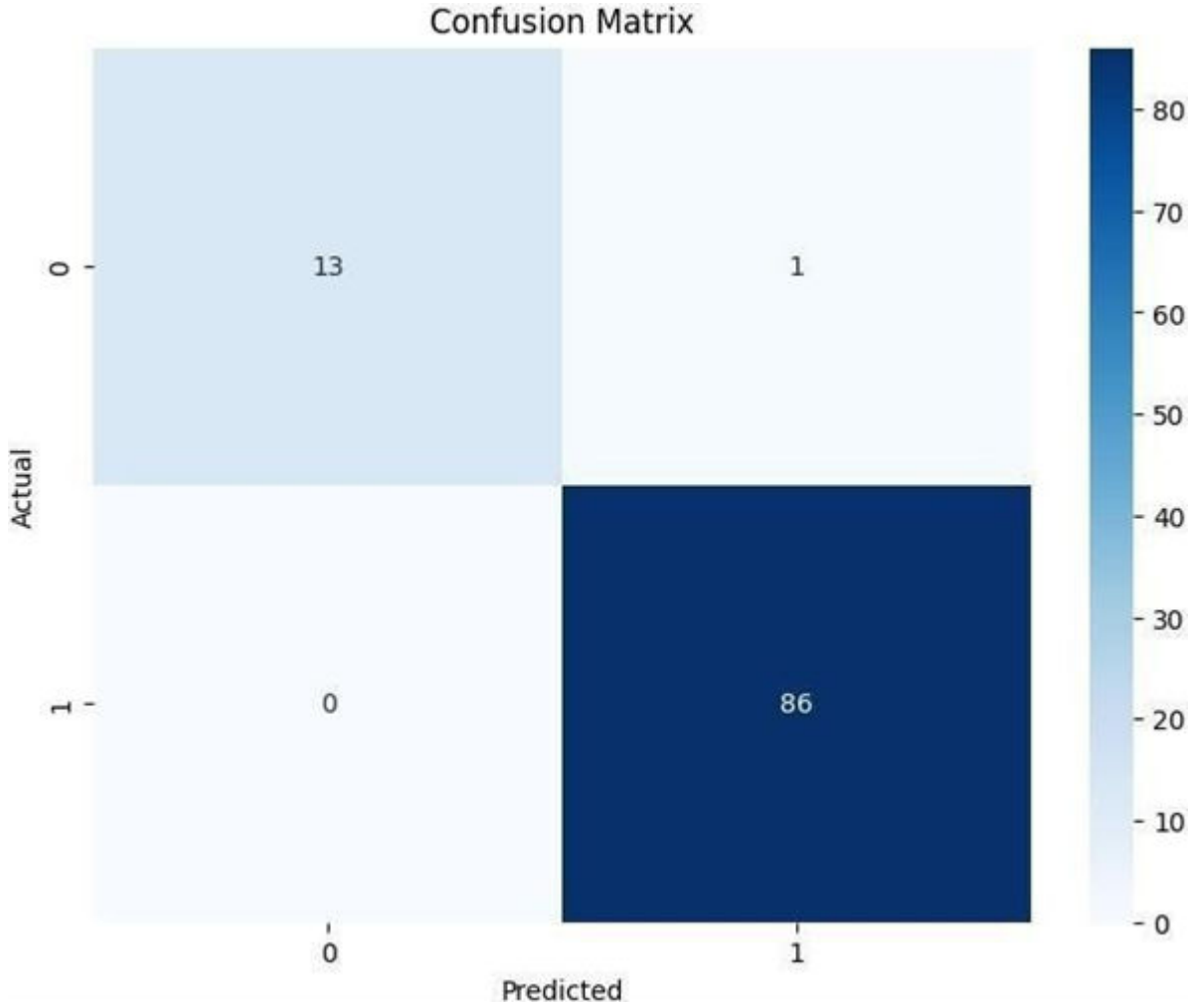

Figure 1: All parameters representation.

Result

For the purposes of this study, an Artificial Neural Network was designed to enable the automated diagnosis of atopic dermatitis.

The Evolving Role of AI in Skin Disease Diagnosis and Management

This study exemplifies the growing focus on deep learning algorithms and neural networks in diagnosing atopic dermatitis [7,8]. These models, alongside future advancements, hold promise for improving the accuracy of AD severity scoring. This translates to earlier and more precise treatment responses for patients, potentially leading to better treatment compliance through improved patient communication (Fig. 2-4) [9].

Broader Applications of AI in Skin Care

Given that the skin is our largest organ, Artificial Neural Networks (ANNs), Convolutional Neural Networks (CNNs) and other deep learning algorithms can play a significant role in diagnosing various skin conditions [18]. Their application can assist doctors in selecting the most effective treatment strategies, potentially reducing the reliance on a trial-and-error approach often encountered in skin disease management [10].

Figure 2: Dennie-morgan infraorbital fold in patient of atopic dermatitis.

Figure 3: Chelitis in patient of atopic dermatitis.

Figure 4: Anterior neck folds in patient of atopic dermatitis.

Discussion

Atopic dermatitis is a complex, chronic inflammatory skin condition that stems from both genetic and immunological factors. One of the core contributors to disease pathology is the dysfunction of the skin barrier, often linked to mutations in the filaggrin gene [12]. Filaggrin is critical in maintaining skin hydration and structural integrity and its deficiency results in a weakened barrier, making the skin more susceptible to environmental allergens and irritants [12,17]. This compromised barrier not only leads to increased dryness and sensitivity but also facilitates the onset and progression of inflammation [21].

This immune imbalance results in heightened levels of inflammatory cytokines, which exacerbate the itching, redness and irritation that define atopic dermatitis [4].

Furthermore, diagnostic challenges remain a significant issue, particularly for early-career clinicians. Differentiating between dermatological conditions such as atopic dermatitis, psoriasis and eczema can be difficult due to their overlapping visual features. To bridge this diagnostic gap, this study proposes a deep learning model that can analyse clinical skin images and accurately classify skin diseases [23]. By automating the diagnostic process, this tool offers valuable support to healthcare providers, reducing the likelihood of misdiagnosis and enabling timely, targeted treatment [9,10].

In summary, the combination of genetic susceptibility, immune dysregulation and environmental triggers contributes to the multifaceted nature of atopic dermatitis [3]. The integration of artificial intelligence into dermatological diagnostics holds promising potential to improve early detection, reduce diagnostic errors and ultimately enhance patient outcomes [24].

Inexperienced and early-career dermatologists are especially prone to diagnostic mistakes, as conditions like psoriasis, eczema and atopic dermatitis are often easily confused. To address this issue and provide support to clinicians, this study introduces an end-to-end deep learning model that utilizes clinical skin images to automatically diagnose these dermatological conditions [23].

Conclusion

Atopic dermatitis or eczema, is a common skin condition that can be difficult to diagnose accurately due to symptom overlap with other dermatological disorders. This often leads to delays in treatment and prolonged patient discomfort. This study introduces an Artificial Neural Network (ANN) model capable of distinguishing atopic dermatitis from healthy skin with promising accuracy. By automating key aspects of diagnosis, the model has the potential to streamline clinical decision-making and improve early detection.

However, its current application is limited to binary classification—healthy skin versus atopic dermatitis. To increase its clinical value, the model should be expanded to include data from a variety of other skin conditions. Doing so would enable more precise differential diagnosis, helping clinicians identify and manage skin disorders more efficiently and accurately.

In conclusion, expanding the ANN's scope could significantly enhance its diagnostic utility, offering faster, more reliable support for healthcare providers and better outcomes for patients.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Consent to Participate

The authors certify that they have obtained all appropriate patient consent.

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Data Availability

Data is available for the journal. Informed consents were not necessary for this paper.

Author's Contribution

The authors contributed equally.

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