Artificial Intelligence in Dermatology: Improving Diagnostic Accuracy in Nail Disorders Through Deep Learning Algorithms

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Outline

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Introduction

In dermatology, AI, supported by ML and deep learning, has shown potential in diagnosing skin and nail disorders by detecting patterns in visual data, similar to how a dermatologist would [1]. AI's capacity to identify dermatological issues early can lead to timely interventions, ultimately improving patient outcomes and reducing costs [2].

Research Gap

The existing gap in dermatology lies in the insufficient focus on diagnosing nail disorders, which are often overlooked in clinical training and current diagnostic techniques. The curriculum, such as that of the American Academy of Dermatology, provides inadequate coverage of nail examinations, leading to frequent misdiagnoses of non-fungal nail disorders [3]. Present diagnostic methods rely heavily on clinical assessments, which can result in delayed or incorrect diagnoses.

Contribution of the Paper

This paper contributes to filling this gap by developing AI-based deep learning models—Roboflow and YOLO—to improve the accuracy of diagnosing nail disorders [4]. These models enhance diagnostic performance and enable early detection of nail-related diseases, thereby addressing the lack of focus on nail health in existing dermatological practices. Furthermore, this research explores the practical application of AI in real-world medical settings, offering potential solutions to alleviate diagnostic errors and improve patient care, particularly in underserved regions.

Review of Literature

- **AI in Healthcare**: AI, especially machine learning (ML) and deep learning, has been applied in medical diagnostics, such as detecting lung cancer, skin lesions, and diabetic retinopathy using image recognition [5].
- **AI in Dermatology**: Dermatology's visual nature makes it ideal for AI, with access to large image datasets. AI enhances diagnostic accuracy by recognizing visual patterns similar to dermatologists.
- **Nail Disease Diagnosis**: Nail disorders are often underdiagnosed due to inadequate training. Current methods, relying on visual examination, are prone to misdiagnosis, especially for non-fungal conditions.

Methodology

This study employed two artificial intelligence (AI) models—Roboflow and YOLO (You Only Look Once)—to develop a system capable of accurately diagnosing various nail disorders using deep learning algorithms [4]. The following steps outline the methodology for model development, data collection, and performance evaluation

Research Aim

The primary objective of this research was to utilize AI-based tools to improve the detection and diagnosis of nail diseases. This was achieved by developing and testing two deep learning models: Roboflow and YOLO.

- A comprehensive dataset of nail images was collected, representing various nail disorders. Two datasets were created for training the AI models:

1. **Roboflow Model Dataset**:
    1. 7,264 images of 11 different nail conditions.
    2. Nail conditions included Acral Lentiginous Melanoma (ALM), Terry’s Nails, Beau’s Line, Blue Finger, Clubbing, Koilonychia, Lindsay’s Nails, Muehrcke's Lines, Onychogryphosis, Pitting, and healthy nails.
    3. Split into training (87%), validation (8%), and testing (4%) sets.
2. **YOLO Model Dataset**:
    1. 3,081 images of 6 specific nail disorders.
    2. The dataset was also supplemented with 852 images of healthy nails to improve the model’s detection accuracy.

Data Augmentation

Given the relatively small size of the datasets, various augmentation techniques were applied to increase the variety and robustness of training data.

For Roboflow Model:

- After the augmentations were applied, the model was trained. The model after the training gave an accuracy of 98.8%.
- After training the model was hosted using the streamlit software on the webapp CutiCure.
- The images are input on the webapp through the PIL image library and then fed into the trained model.
- The results are then printed on the webapp and confidence score is also printed.

Flip	Horizontal, Vertical
90° Rotate	Clockwise, Counter-Clockwise, Upside Down
Rotation	Between -15° and +15°
Shear	-15° and +15° Horizontal and Vertical
Hue	Between -15° and +15°
Saturation	Between -20% and+20%
Brightness	Between -20% and+20%
Exposure	Between -15% and+15%

For YOLO Model:

- Two variations of YOLO were used—**YOLOv8m-cls** (medium-sized) and **YOLOv8l-cls** (large-sized). Both models were trained to detect six specific nail conditions, using bounding boxes to identify and localize the diseases within the nail images.
- Both YOLO models were trained for 20 epochs using Ultralytics, a popular library that simplifies YOLO model training. During training, images were fed into the model, and it was trained to classify nails into one of the six disease categories or as healthy.
- The model used the PIL image library only to read the images.

Results and Discussion

Roboflow Model:

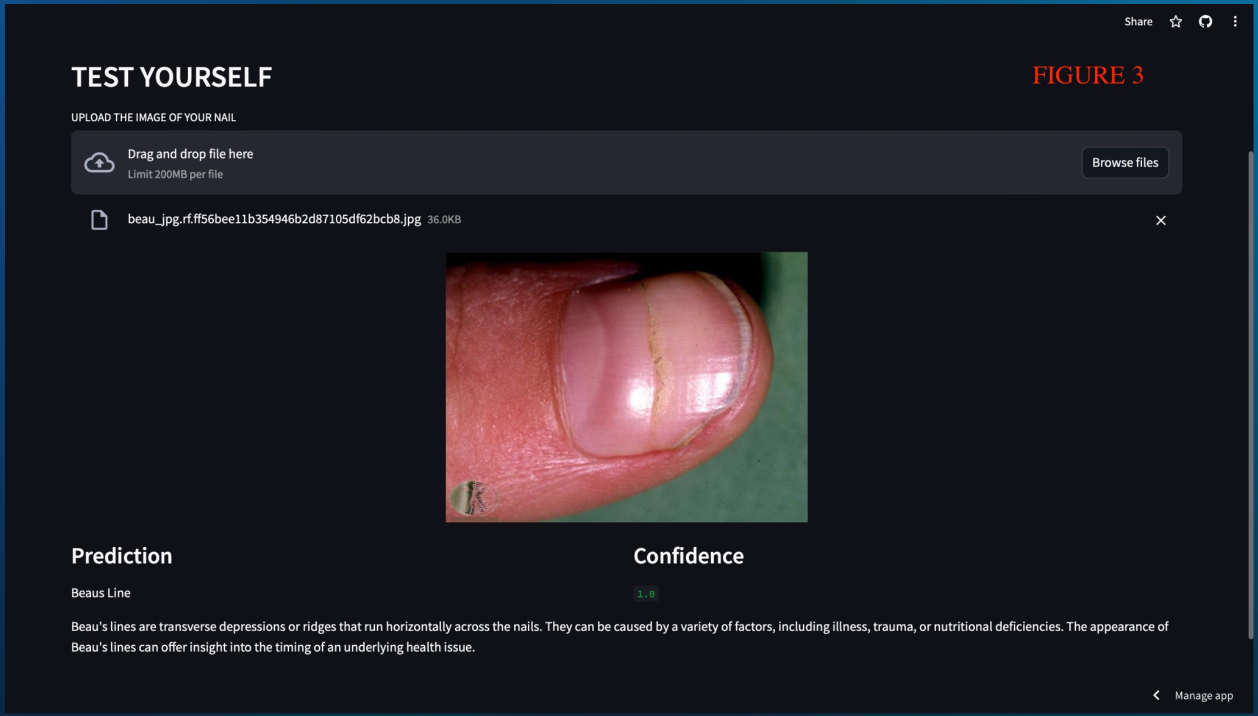
- Achieved **98.8% accuracy [4]**.
- 100% accuracy for **ALM**, **Blue Finger**, **Clubbing**, and **Terry's Nails**.
- Struggled with underrepresented conditions like **Lindsay's Nails** (0% accuracy).

YOLO Model:

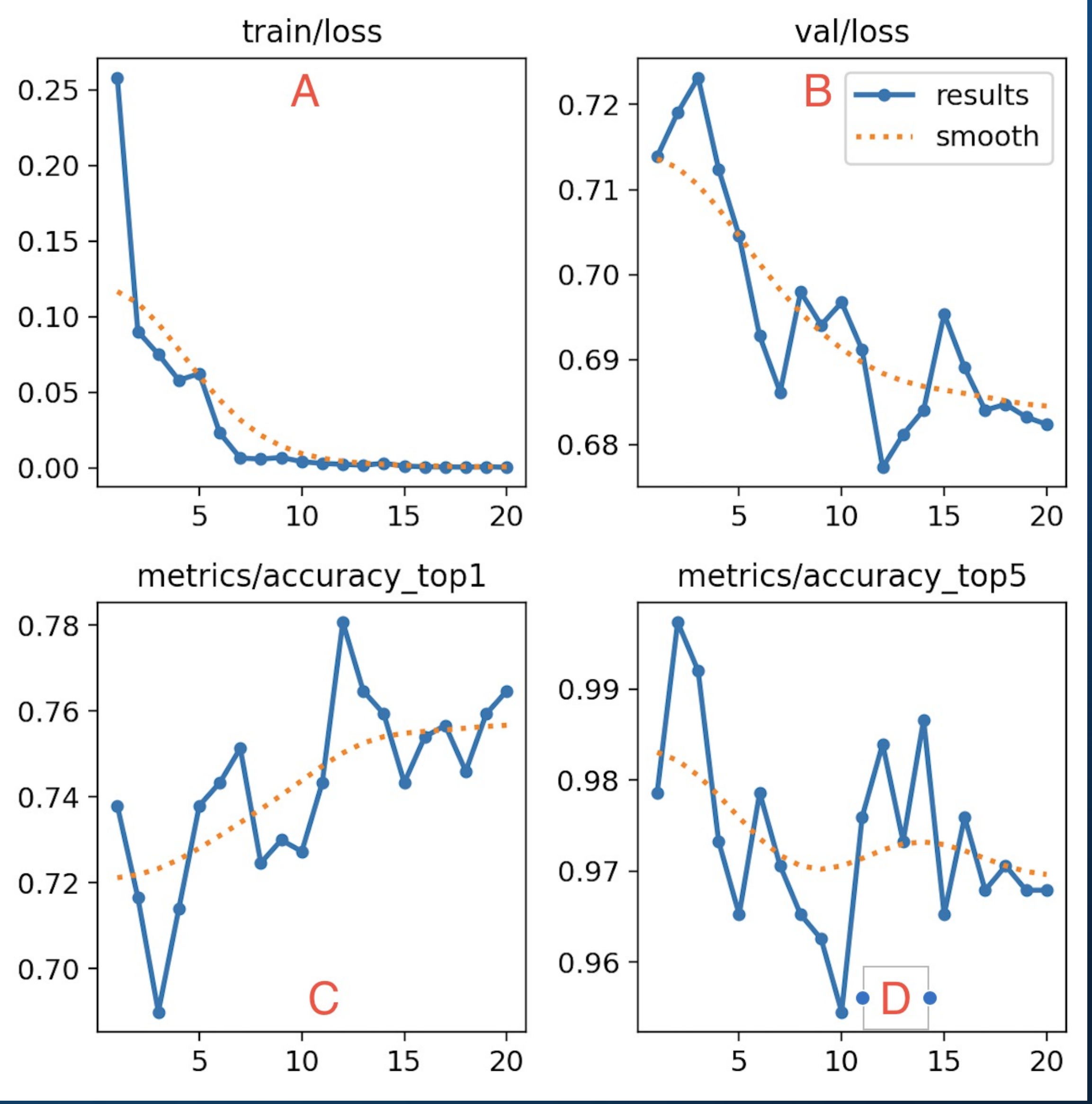
- **Top-1 accuracy**: Medium model **78.075%**, Large model **76.471% [4]**.
- **Top-5 accuracy**: **96.791%** for both models [4].
- Performs well in real-time diagnosis by listing top-5 disease predictions.

DISEASE	ACCURACY OF THE MODEL
Acral Lentiginous Melanoma	100%
Beaus Line	60%
Blue Finger	100%
Clubbing	100%
Koilonychia	30%
Lindsay's Nails	0%
Muehrckes Lines	80%
Onychogryphosis	80%
Pitting	90%
Terry's Nails	100%
No Disease	50%

The table shows the accuracies that were achieved for the Roboflow model after the testing was done for total of 110 images.



The image shown above shows how our web app CutiCure prints the result after an image is inout in it.



MEDIUM MODEL

- The figure above shows the train/loss(A), top1 accuracy(C), top5 accuracy(D) and val/loss(B) graphs.
- A: Training loss graph shows how the errors on the training dataset changes after each epoch. It shows how well the model is learning the training data, that is improving during training. Thus the train/loss should decrease if the model is learning effectively.
- B: The validation loss graph helps to measure the model's performance on unseen data and can be an indicator of how well the model generalizes results on new data. The loss is computed on a separate validation set.
- C:. Top-1 accuracy is the ratio of the number of correct predictions to the total number of predictions.
- D:Top-5 accuracy measures the proportion of times the true class is within the top 5 predictions provided by the model.

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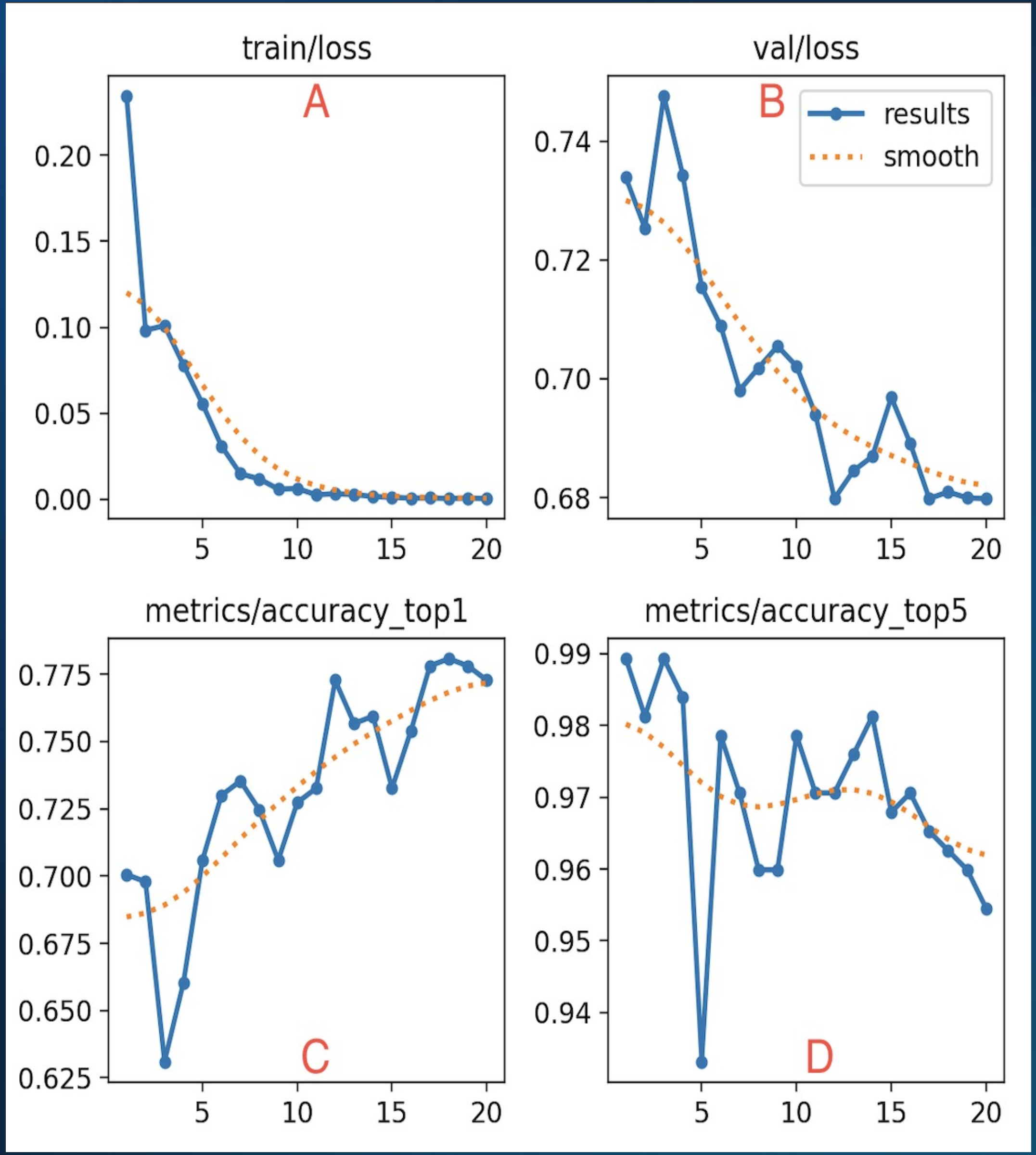

LARGE MODEL

Conclusion

- This study highlights the effectiveness of AI models—Roboflow and YOLO—in diagnosing nail disorders with high accuracy. The Roboflow model achieved 98.8% accuracy, particularly excelling in detecting common conditions such as Acral Lentiginous Melanoma and Terry's Nails [4]. The YOLO models showed strong top-5 accuracy (~96.8%), proving useful for real-time diagnostic assistance [4].
- These results demonstrate the potential of AI in improving nail disease diagnosis and making healthcare more accessible, especially in resource-limited settings. With further refinement, AI could become an indispensable tool in dermatology.

Limitations

- **Underrepresentation of rare diseases**: The models struggled with conditions like Lindsay's Nails due to a lack of sufficient data.
- **Inability to detect comorbidities**: The models were limited to diagnosing only one disease at a time.
- **Clinical integration challenges**: Implementing AI in practice requires changes in infrastructure, workflow, and staff training.

Implications

- **Improved Diagnostic Accuracy**: The AI models, especially Roboflow and YOLO, reduces human error and helps early detection of melanoma and other serious conditions.
- **Accessibility in Healthcare**: AI tools can be deployed in remote and underserved areas thus bridging the healthcare gap by offering fast, reliable diagnoses without the need for specialized equipment or personnel.
- **Reduced Healthcare Costs**: By minimizing the need for extensive tests and specialist consultations, providing a more affordable alternative for patients.
- **Support for Medical Professionals**: Assist dermatologists in managing large patient volumes by providing preliminary diagnoses, allowing doctors to focus on complex cases, thus increasing efficiency in clinical practice.
- **Future AI Integration**: The research paves the way for further integration of AI into dermatology, encouraging the development of more comprehensive models that can diagnose a wider range of conditions and detect multiple disorders simultaneously.

References

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Thank You