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Original Article

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

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Abstract - *This study presents the development and evaluation of an AI-based system for detecting nail diseases using two models: Of them one was trained with Roboflow, and the other one was trained with YOLO. The Roboflow model was a multi-label classification of 7264 images of 11 nail conditions, and the accuracy of the model was 98.8%. In the YOLO model using medium and large variations, six particular nail diseases were distinguished with a total of 3,081 images. For the medium YOLO model, if each of the model sizes is trained for 20 epochs, the top-1 accuracy was 78.075% and the top-5 accuracy of 96.791%. At the same time, the large-sized model had a top 1 accuracy of 76.471% and a top 5 accuracy of 96.791%. Both models were trained based on the augmented datasets which assisted in improving the performance of the models. The Roboflow model was very good for some diseases, such as Acral Lentiginous Melanoma and Terry's Nails but was not so good for diseases like Lindsay's Nails, which are not very common. This research is in harmony with the current development in AI in dermatology and can be used to diagnose nail diseases at an early stage and a cheaper cost.*

Keywords - *Nail diseases, Artificial intelligence, Roboflow, YOLO, Deep learning, Early diagnosis, Medical imaging, Machine learning, Dermatology, Multi-label classification.*

1. Introduction

Artificial Intelligence (AI) is the branch of computer science that focuses on the ability to make machines smart enough to do what humans do. Arthur Samuel, one of the early workers in the field, defined AI as the study area that makes it possible for the computer to work on its own without being programmed [1]. AI is interdisciplinary and is connected with many fields, including computer science, data analysis, statistics, hardware and software engineering, linguistics, neuroscience, philosophy, and psychology [2]. In the business context, AI is mainly supported by ML and deep learning, which are essential for data analysis, prediction, forecasting, object classification, natural language processing, recommendation, and intelligent data search [3].

Artificial Intelligence has several subcategories, among which is Machine Learning, which involves creating systems that learn from several data sets. These systems can forecast, categorize, identify and handle data complexity with trends from historical data [4]. AI and ML are slowly phasing out human beings from the workplace – both the technical and the non-technical ones. According to the World Economic Forum, the AI and ML sector is projected to grow by about 40%, and this is expected to create about one million new jobs within the next five years [1]. This growth is a result of research and development and the number of start-ups and large tech companies that are adopting AI in their operations, thus providing employment for data scientists, analysts, AI researchers, and software developers [5].

The utility of ML in analyzing and processing a large amount of data with the help of historical data is applicable in different spheres, such as finance, healthcare, retail, and law [1]. For example, Amazon stores employ AI to improve the experience, and the STYL app employs machine learning to recommend clothes based on the customer's choice [3]. Moreover, the application of AI is also gradually promoted in different areas including legal review, fraud detection in finance, and prediction analysis [2].

1.1. Growing use of AI in Healthcare

AI has proven to be helpful in many fields of study, especially in the field of medicine. In medicine, AI has been used in a diverse number of avenues, whether it's diagnoses and personalizing treatment or developing drugs and improving gene editing. When it comes to diagnosing diseases, deep learning algorithms can see patterns the way doctors see them [6]. There being a huge problem in the demand and supply of medical experts in remote places, AI has made diagnostics cheaper and more accessible in cases of lung cancer based on CT scans, classification of skin lesions through image reading software, and identifying symptoms of diabetes retinopathy based on eye scans [7].

Machine learning algorithms can help make highly advanced risk assessment software that will, in turn, provide real-time health information for breast cancer patients [8]. Furthermore, AI can assist doctors in making much faster decisions while diagnosing patients. By comparing the patient's symptoms with historical databases, AI can prove to help patients in life-or-death situations [8]. As AI continues to evolve and give faster and more accurate results, it has the potential to bridge the socio-economic gap in places that can't afford medical experts and expensive medical equipment [6].

1.2. Growing Detection in Nail Diseases and Dermatology Field

Recently, dermatology has seen a sudden increase in medicinal research studies enhanced by the applications of artificial intelligence. The cause of this sudden increase can be attributed to the visual nature of dermatology and its comparatively easier access to a vast number of visual datasets that include clinical and dermoscopic images [9]. Integrating AI with normal clinical practices can help doctors make the diagnosis faster with very little margin of error. Hence enhancing both the efficiency and accuracy of the diagnosis. Furthermore, it would also be inexpensive. In the coming times, which is not that far from now, AI will inevitably replace humans in many decision-making and analysis jobs. Concerning artificial intelligence, this is also valid. According to the World Economic Forum's latest The Future of Jobs Report, machine learning is expected to eliminate about 85 million jobs by 2025 [10]. But human interactions and human–AI symbiosis will forever remain indispensable in clinical practices. The present study aims to use various tools to check which can help to improve the previous techniques being used. That is, introducing AI while respecting the human-AI symbiosis framework. Although AI still can't predict 100 percent accurate results, this integration of algorithms with physicians makes the whole process much more efficient. Therefore, it is foreseeable that AI will be a very important part of dermatology [10].

Onychopathies, which may indicate a systemic disease, are often difficult to identify with a high degree of certainty because of the current deficiencies in dermatological training and practice. Although nails are crucial in overall health, dermatology training may afford little opportunity to learn about diagnosing and treating nail disorders. For example, the curriculum of the American Academy of Dermatology provides inadequate coverage of nail examinations, melanoma, and biopsy.

This gap in training results in misdiagnosis of the conditions often, especially the non-fungal nail disorders that mimic fungal infections. Present diagnostic techniques are mostly dependent on clinical assessment and, as such, can lead to either delayed or wrong diagnosis. The use of AI and deep learning algorithms in dermatology can be seen as a solution to these challenges where tools that can improve diagnostic performance and facilitate the identification of nail disorders at an early stage are provided. Nevertheless, the use of AI in this field is yet to be fully developed, thus pointing out the need for more studies and innovations in enhancing diagnostic results for nail-related diseases.

Table 1. The table lists all the nail diseases that the model can detect

Name of the Disease	What is the disease	How is it detected	Impact on the body
Acral Lentiginous Melanoma	Acral Lentiginous Melanoma (ALM) is a rare subtype of melanoma arising on the palms, soles, or under the nails [11]. It is also known as acral melanoma [11].	In the early stages, ALM often appears as a dark brown or black macule with a variegated colour and can be nodular and ulcerated in advanced cases [12].	If left untreated, Acral Lentiginous Melanoma can cause distal metastasis. This means that cancer will spread to the other organs and lymph nodes of the body [12].
Beaus Line	Beau's lines occur when nail growth is interrupted at the nail matrix — the place where your nail emerges from your finger [13].	Beau's lines are horizontal indentations, or ridges, that develop across the nails. They usually run straight across the nail [13].	Beau's lines can develop as a result of injuries, illnesses, or environmental factors. It can also be caused if a person is suffering from acute kidney failure, mumps, thyroid diseases, syphilis, endocarditis, pneumonia, scarlet fever, and [illegible]

Blue Finger	It is a benign and rare condition with an idiopathic etiology [14].	It is characterized by an acute bluish discoloration of fingers, which may be accompanied by pain [14].	Blue fingers can mean your organs, muscles, and tissues aren't getting the amount of blood they need to function properly. Many different
Clubbing	Nail clubbing is a change in the appearance and structure of your fingernails or toenails that can occur as a symptom of an underlying health condition.	If you have nail clubbing, your nails may feel soft and sponge-like. Feel warm to the touch. Form a rounded, bulging shape, giving the appearance of an upside-down spoon. It Looks red. Widen and wrap around the sides of your fingertips.	Nail clubbing is most often associated with diseases of the heart and lungs, like lung cancer, lung infections, interstitial lung disease, cystic fibrosis or cardiovascular disease.
Koilonychia	It refers to abnormally thin nails (usually of the hand) which have lost their convexity, becoming flat or even concave in shape. In a sense, koilonychia is the opposite of nail clubbing [16].	Spoon nails look like the center of your nail is scooped out. The nail becomes thin, and the outer edges turn up. The nail may crack, and the outer part may come out of the nail bed [17].	Some of the diseases associated with spoon nails are celiac disease, diabetes, heart disease, hemochromatosis, or too much iron, lupus, malnutrition, protein deficiency, psoriasis, Raynaud's syndrome, thyroid disorders, and vitamin B deficiency [17].
Lindsay's nails	Half-and-half nails (also known as Lindsay's nail") show the proximal portion of the nail white and the distal half red, pink, or brown, with a sharp line of demarcation between the two halves [18].	Half-and-half nails, or Lindsay nails, have sharp demarcation of nail beds: the proximal portion of each nail is whitish, and the distal portion, which occupies 20% to 60% of the nail length, is red, pink, or brown [19].	Half-and-half nails are seen in 15-50% of chronic renal failure patients. It has also been associated with yellow nail syndrome, hyperthyroidism, pellagra, HIV infection, Crohn's disease, Kawasaki disease, Behcet's disease, cirrhosis, and even in healthy individuals [18].
Muherckes Lines	Muehrcke's lines appear as double white lines that run across the fingernails horizontally [20].	Muehrcke's lines usually affect several nails at a time. There are usually no lines on the thumbnails. Some characteristics ofMuehrcke's lines are: White bands go across the entire nail from side to side. Lines are usually most clearly seen on the second, third, and fourth fingers. The nail bed looks healthy in between the lines. The lines do not move as the nail grows. The lines do not cause dents in the nail. When you press down on the fingernail, the lines temporarily disappear.	The lines have been linked to low levels of a protein called albumin. Albumin is found in the blood. It is made in the liver. Although low albumin level is most commonly linked to liver disease, many different systemic (body-wide) diseases can cause low albumin levels. Muehrcke's lines have been seen in people with: Cancer after chemotherapy; Kidney disease, including nephrotic syndrome and glomerulonephritis; Liver disease, including cirrhosis, An unbalanced diet that leads to an
Onychogryphosis	Onychogryphosis, also known as ram's horn nail, is a nail disorder resulting from slow nail plate growth. Onychogryphosis is a nail disease that causes one side of the nail to grow faster than the other [21].	It is characterized by an opaque, yellow-brown thickening of the nail plate with elongation and increased curvature. The nickname for this disease is ram's horn nails because the nails are thick and curvy, like horns or claws [22].	Ram's horn nails are especially prominent in older people, particularly those who live with or have had Poor circulation, Type 2 Diabetes, Bunions, Gout, and Ichthyosis. It can also be caused by trauma to the feet, caused by either foot injury or wearing poorly fitting shoes. While onychogryphosis is most common in the big toe, it can affect any of the toes on either

Pitting	Nail pitting may appear as depressions or dimples in your fingernails or toenails.	Nail pitting may show up as shallow or deep holes in your nails. The pitting can happen on your fingernails or your toenails. You may think the pitting looks like white spots or other marks. It might even look like your nails have been hit with an ice pick [24].	Nail pitting also may be related to alopecia areata — an autoimmune disease that causes hair loss [25].

3. Methodology

3.1. Research Aim

To detect nail diseases using Artificial Intelligence and testing it using the help of YOLO and Roboflow [27] [28].

3.2. Tools Used

3.2.1. Model 1 using Roboflow

The model was created by using ROBOFLOW. The app was made using the coding language Python. The PIL library was used to import images in the model and used to read them. The model of roboflow was inserted in the code, and then a dictionary was created to show the name of the most probable disease. The model was used in the code with the use of inference keywords. This keyword was used by the roboflow API, which was inserted in the code. API keys are revocable credentials used to integrate the Roboflow API into your application. Keys are used to perform inference on your models and upload images directly to your project from outside sources.

The entire code was hosted using the Streamlit software which provides the server to host the web app for free [27] [28].

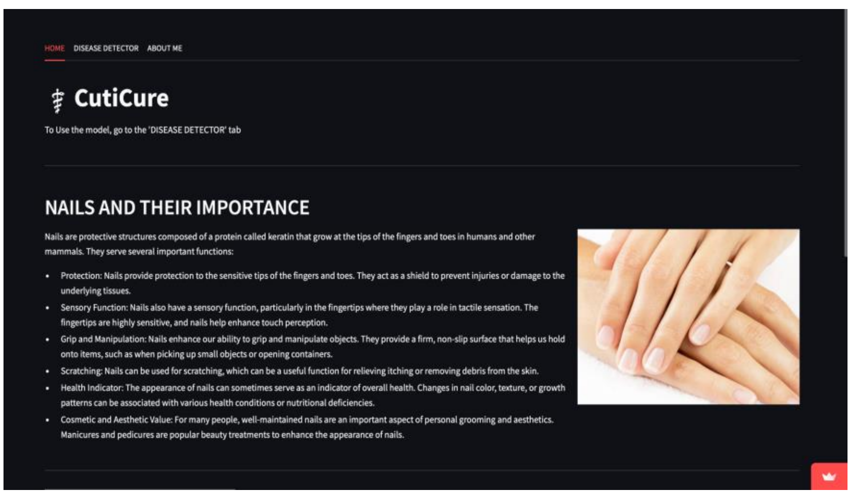

Fig. 1 Home page of the Webapp- CutiCure On the homepage, nails and their importance have been explained as well as the diseases being detected by the model.

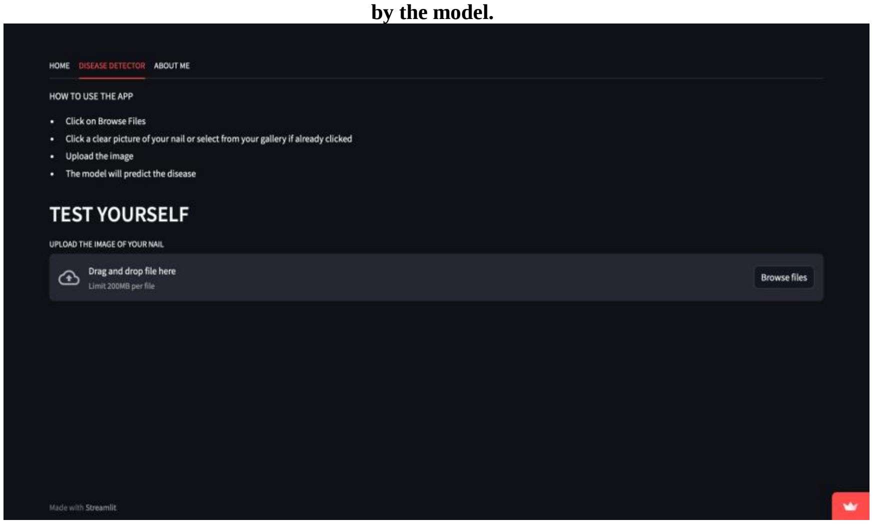

Fig. 2 The disease detection page of the Webapp

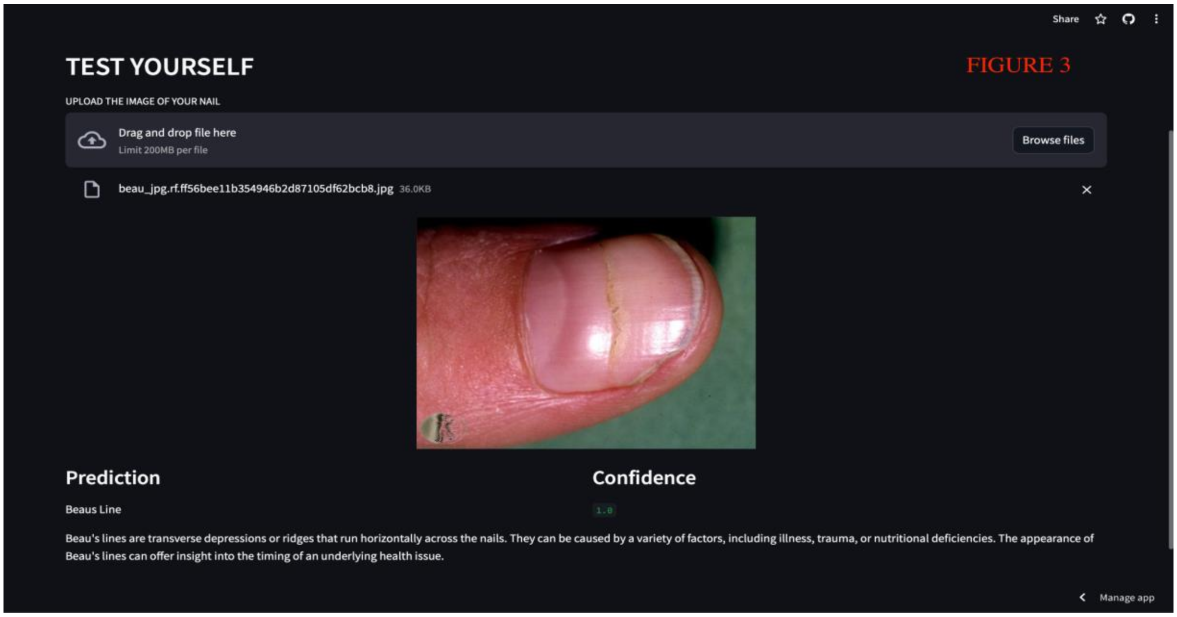

Fig. 3 The figure shows how the output is printed after we input an image

Figure 2 shows the page on which the model is present. Here, a person has to upload the image, and the model will give the result.

Figure 3 shows how the prediction is printed on the page. The result predicted by the model is printed under prediction, and the confidence level is printed under confidence. Below the image is a description of the disease.

3.2.2. Model 2 using Yolo

The model was developed with the help of YOLO which is an acronym for You Only Look Once, an algorithm that is commonly used for real-time object detection. YOLO makes what was a complex process of using several neural networks to perform object detection and bounding box prediction into a single neural network. The model was first trained with the medium-sized yolo model, that is, "yolov8m-cls". We used 20 epochs to train the model. The model was again trained using YOLO, but with a large-sized model, that is, "yolov8l-cls". The number of epochs was again 20 in the training of this model. The YOLO model was imported using Ultralytics and also imported PIL from the Image library. The PIL was used to read the image and use it to insert it into the model [27] [28].

Data

The total number of images used to train the model was 7264. Out of these, there were 1017 images of Terry's nails, 895 for clubbing, 859 for ALM, 789 for Onychogryphosis, 750 for pitting, 700 for blue finger, 617 for koilonychia, 522 for beaus' line, 383 forMuehrcke's lines, and 2 for Lindsay's nails. To teach the model about healthy nails, there were 726 images. The model type used by Roboflow to predict the images is Roboflow 2.0 Multi-label Classification.

The model trained using YOLO could detect 6 diseases. These included Acral Lentiginous Melanoma, Beau's Line, Blue finger, Clubbing, Eczema, and Onycholysis. The dataset had 822 images for ALM, 377 for Beau's Line, 304 for Blue Finger, 354 for Clubbing, 66 for Eczema and 306 for Onycholysis. To teach the model about healthy nails, there were 852 images. In total, there were 3081 images in the entire dataset.

3.3. Model Preparation

A version was created in which the images for training were prepared. There were 11 classes created to train the model. These included ALM, Terry's Nails, Beau's Line, Blue Finger, Clubbing, Koilonychia, Lindsay-s Nail, Muehrcke's Lines, Onychogryphosis, Pitting, Terry-s Nail, and Healthy Nails.

The training set had 6,400 images, 87% of the total images, and these images were used to train the model. The validation set had 603 images, 8% of the total images, which were used during the training to adjust the parameters for the best possible result. The testing set had 311 images, 4% of the total images, these were used to check the accuracy of the model after it had been trained.

The images were then pre-processed, which means that the size of the images was modified to reduce the running time and increase performance. In the pre-processing, the images were resided to 416X416 and had black edges to fill out the empty space. The images were then augmented too, this can create different versions of the same images to provide the model with a large number of images to train from. These augmentations resulted in increasing the training set to 19,990 images.

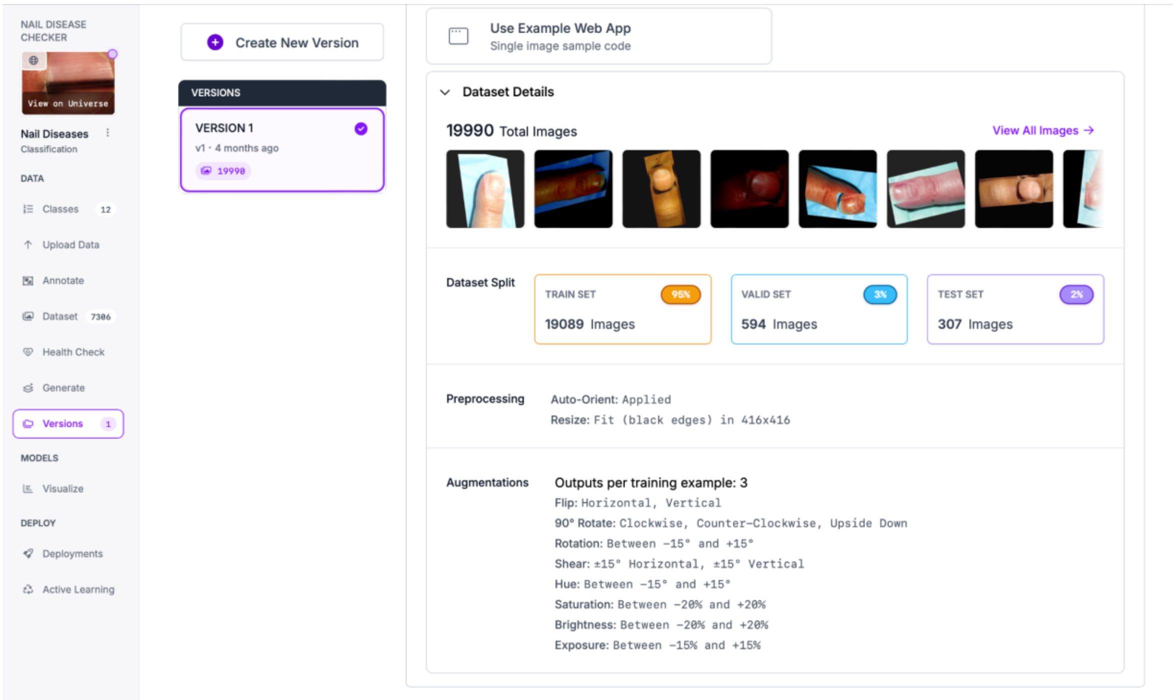

Fig. 4 The figure shows the size of the dataset after the augmentations were applied

Table 2. The table shows the augmentations that were applied

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%

Table 3. The table shows the number of images in each of the sets before the augmentations were applied.

Train Set	6400
Valid Set	603
Test Set	311

Before the augmentations were applied, the number of images in each of the sets is given in the table above.

Table 4. The table shows the number of images in each of the sets after the augmentations were applied

Train Set	19089
Valid Set	594
Test Set	307
Total Images	19990

After the augmentations were applied, the number of images increased, and this table shows the increase in each of the sets.

4. Data Analysis

4.1. Model 1 using Roboflow

For the training of the model, Roboflow utilized ImageNet which is a large image database organized according to the WordNet taxonomy and which contains only nouns. Each of these nodes contains hundreds, if not thousands, of images. ImageNet has been very instrumental in the development of research in computer vision and deep learning.

The data is open for public use for research purposes and not for commercial use. It is used in training and evaluating different machine-learning algorithms for different tasks such as image classification, object detection and object localization.

110 random images for each disease were picked up from GOOGLE. The images were tested on the model to find the disease-wise accuracy of the model. These were used to check the accuracy of the Roboflow model [27] [28].

4.2. Model 2 using Yolo

The page for the disease detection was made as tab 2. The streamlit function cache_resource was used to prevent the web app from calling the model again and again. It will help in saving the CPU storage from calling the model repeatedly. A function called "LoadModel" was created to load the model made to detect the diseases.

In this function, a variable was created to load the model. The trained model was stored in a file called "File_nail.pt". So, this trained model was stored in the variable "mod". Then, an if condition was created that if there is some image imputed then only the predictions will be carried out. The model was again stored in a variable called "model". A variable called "res" was created to store the results after the model read the image. The confidence and the top 5 predictions were stored in separate variables and printed on the web app.

5. Results and Discussion

This section mentions the results that were received after testing and while the model was being trained.

The accuracy of the Roboflow model with the given images and the augmentations is 98.8%. The underrepresented class is Lindsay's Nails, as the number of images that were uploaded for Lindsay's nails was only 2. After testing 110 images on the model, the results received were as follows: For Acral Lentiginous Melanoma, Blue Finger, Clubbing, and Terry's Nails, the model has 100% accuracy. This means that it predicted all the images correctly. For Beaus Line, the model showed 60% accuracy.

This meant that it only predicted 6 out of 10 images correctly. For Koilonychia, the model depicted 30% accuracy, as it predicted 3 out of 10 images correctly. For Lindsay's Nails, the model showed 0% accuracy as it is an underrepresented class, thus, the model could not be trained about this disease. ForMuehrcke's Lines and Onychogryphosis, the model showed 80% accuracy. This means that it predicted 8 out of 10 images correctly. For pitting, the model had 90% accuracy as it predicted 9 out of 10 images correctly.

The overall accuracy of all the diseases after the testing comes out to be 71.81%

The medium model had an accuracy of 78.075% under the top 1 and an accuracy of 96.791 under the top 5 accuracy. The large model had an accuracy of 77.273% under the top 1 and had an accuracy of 95.455% under the top 5 accuracy.

Table 5. The table mentions the disease-wise accuracy obtained after testing

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%

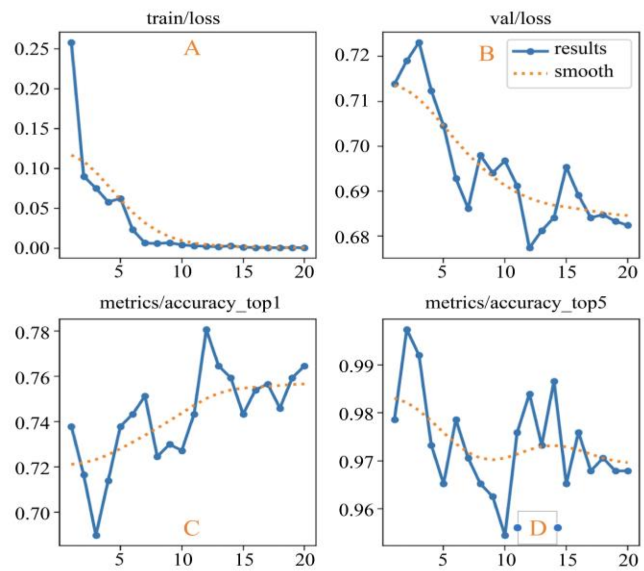

Fig. 5 This figure shows the graphs of the medium-sized model

Figure 5 shows the train/loss(A), top1 accuracy(C), top5 accuracy(D) and val/loss(B) graphs.

The A graph is the train/loss graph. The training loss graph shows how the errors on the training dataset change after each epoch. It is basically a progression of a model's errors overtime. It shows how well the model is learning the training data, which is improving during training. Thus, the train/loss should decrease if the model is learning effectively. It depicts that the errors were almost reduced to 0 after the training. The B graph is the val/loss graph. 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, which is different from the testing set. The loss is plotted over epochs; thus, it shows how the model's performance improves over time. It shows that in the start it was 0.713 and by the end it is 0.683.

The C graph shows the top 1 accuracy. Top-1 accuracy measures the proportion of times the model's top prediction (i.e., the class with the highest predicted probability) is correct. It is the ratio of the number of correct predictions to the total number of predictions.

The D graph shows the top 5 accuracy. Top-5 accuracy measures the proportion of times the true class is within the top 5 predictions provided by the model.

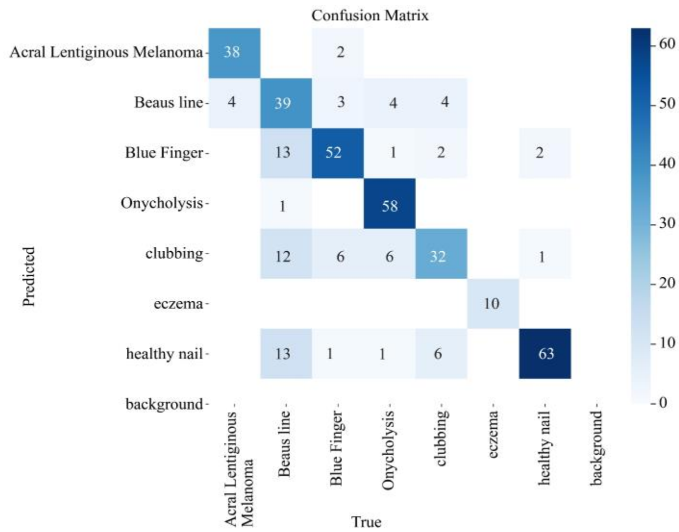

Fig. 6 The figure shows the confusion matrix of the medium-sized model

The confusion matrix depicts the confusion of the model in detecting various diseases. It gives the number of images guessed correctly for a model and the number of images which the model guessed incorrectly and for which disease.

Table 6. The table shows the accuracy of the model after each epoch was trained. It also shows the train/loss value as well as the val/loss value. This is for the medium model

epoch	train/loss	metrics/accuracy_top1	metrics/accuracy_top5	val/loss
1	0.25823	0.73797	0.97861	0.71388
2	0.09028	0.71658	0.99733	0.71905
3	0.07518	0.68984	0.99198	0.72318
4	0.05803	0.7139	0.97326	0.71238
5	0.06239	0.73797	0.96524	0.70452
6	0.02302	0.74332	0.97861	0.69276
7	0.00653	0.75134	0.97059	0.68615
8	0.00584	0.7246	0.96524	0.69795
9	0.00688	0.72995	0.96257	0.69405
10	0.00415	0.72727	0.95455	0.69671
11	0.00292	0.74332	0.97594	0.69111
12	0.00239	0.78075	0.98396	0.6773
13	0.00174	0.76471	0.97326	0.68116
14	0.00306	0.75936	0.98663	0.68405
15	0.00117	0.74332	0.96524	0.69534
16	0.00076	0.75401	0.97594	0.68902
17	0.00064	0.75668	0.96791	0.68403
18	0.00052	0.74599	0.97059	0.68472
19	0.00077	0.75936	0.96791	0.68322

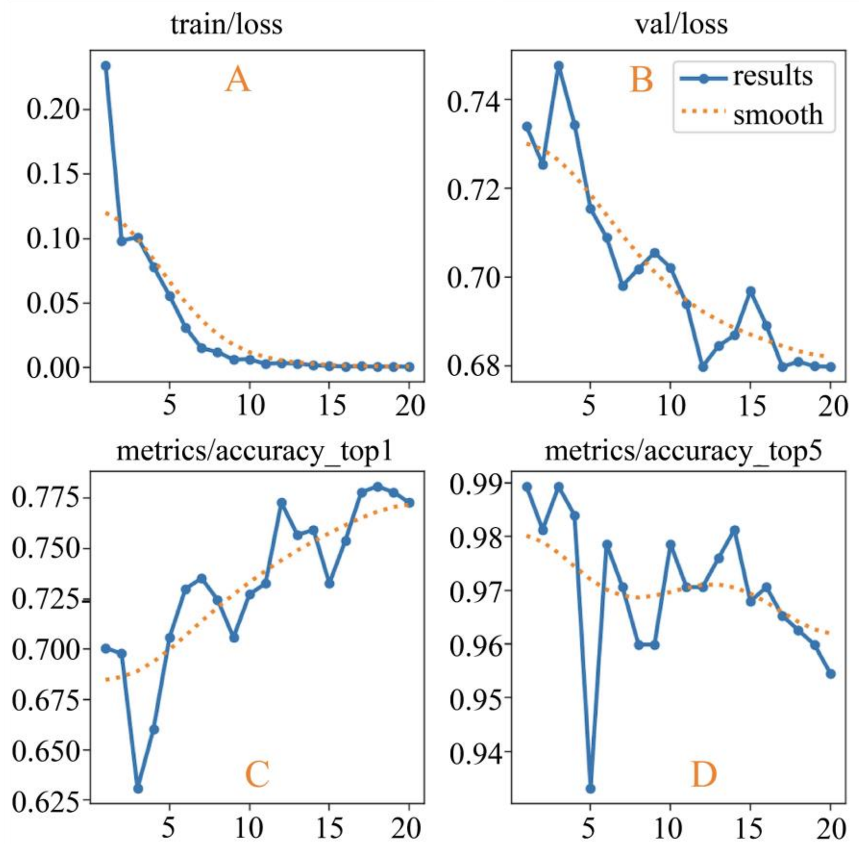

Fig. 7 This figure shows the graphs of the large-sized model

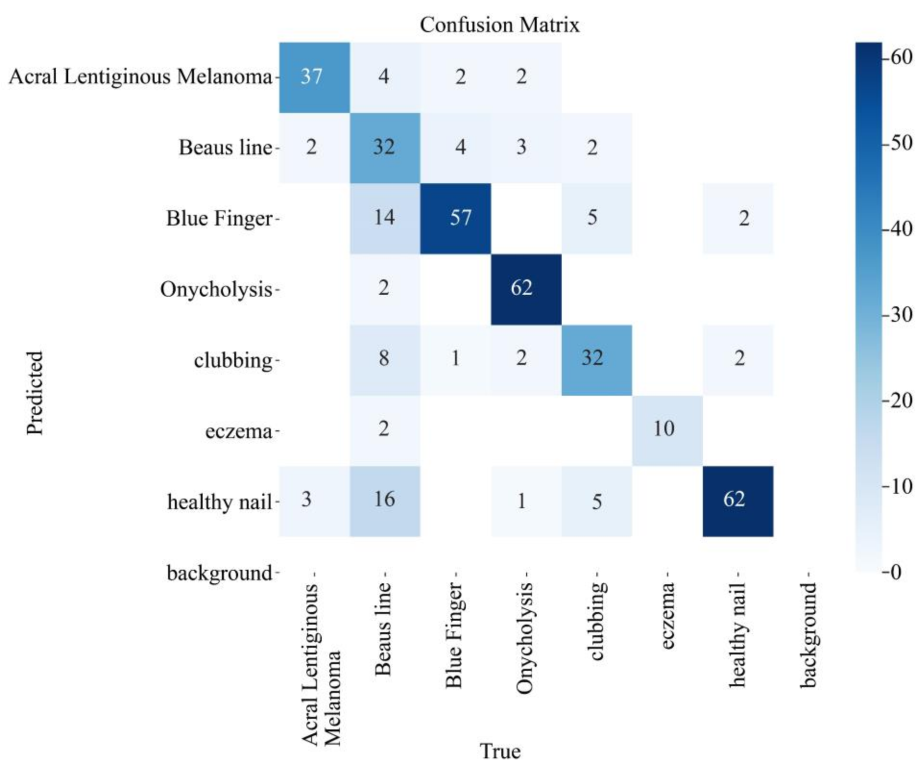

Fig. 8 This figure shows the confusion matrix for the large model

Figure 7 shows the train/loss(A), top1 accuracy(C), top5 accuracy(D) and val/loss(B) graphs.

The A graph is the train/loss graph. The training loss graph shows how the errors on the training dataset change after each epoch. It is basically a progression of a model's errors over time. It shows how well the model is learning the training data, which is improving during training. Thus, the train/loss should decrease if the model is learning effectively. It depicts that the errors were almost reduced to 0 after the training.

The B graph is the val/loss graph. 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, which is different from the testing set. The loss is plotted over epochs; thus, it shows how the model's performance improves over time. It shows that in the start it was nearly 0.713 and by the end it is 0.682.

The C graph shows the top 1 accuracy. Top-1 accuracy measures the proportion of times the model's top prediction (i.e., the class with the highest predicted probability) is correct. It is the ratio of the number of correct predictions to the total number of predictions.

The D graph shows the top 5 accuracy. Top-5 accuracy measures the proportion of times the true class is within the top 5 predictions provided by the model.

The confusion matrix depicts the confusion of the model in detecting various diseases. It gives the number of images guessed correctly for a model and the number of images which the model guessed incorrectly and for which disease.

Table 7. The table shows the accuracy of the model after each epoch was trained. It also shows the train/loss value as well as the val/loss value. This is for the large model

epoch	train/loss	metrics/accuracy_top1	metrics/accuracy_top5	val/loss
1	0.25823	0.73797	0.97861	0.71388
2	0.09028	0.71658	0.99733	0.71905
3	0.07518	0.68984	0.99198	0.72318
4	0.05803	0.7139	0.97326	0.71238
5	0.06239	0.73797	0.96524	0.70452
6	0.02302	0.74332	0.97861	0.69276
7	0.00653	0.75134	0.97059	0.68615
8	0.00584	0.7246	0.96524	0.69795
9	0.00688	0.72995	0.96257	0.69405
10	0.00415	0.72727	0.95455	0.69671
11	0.00292	0.74332	0.97594	0.69111
12	0.00239	0.78075	0.98396	0.6773
13	0.00174	0.76471	0.97326	0.68116
14	0.00306	0.75936	0.98663	0.68405
15	0.00117	0.74332	0.96524	0.69534
16	0.00076	0.75401	0.97594	0.68902
17	0.00064	0.75668	0.96791	0.68403
18	0.00052	0.74599	0.97059	0.68472
19	0.00077	0.75936	0.96791	0.68322
20	0.00037	0.76471	0.96791	0.68236

6. Conclusion

Both the models had different accuracies. The Roboflow model was a multi-label classification of 7264 images of 11 nail conditions, and the accuracy of the model was 98.8%. In the YOLO model using medium and large variations, six particular nail diseases were distinguished with a total of 3,081 images. For the medium YOLO model, if each of the model sizes is trained for 20 epochs, the top-1 accuracy was 78.075% and the top-5 accuracy of 96.791%. At the same time, the large-sized model had a top 1 accuracy of 76.471% and a top 5 accuracy of 96.791%. The Roboflow model can help us to detect certain diseases very accurately while diseases such as Lindsay's nails inaccurately.

All the people who suffer from any nail disease can use the model and detect any disease they might be suffering from. This can be applied in the clinics and help the doctors manage the overflow of patients in the clinics. For a person with financial issues or any place where a doctor might not be available, the model can be used to check whether a person has any disease or not. The AI model can be used in clinical workplaces to check diseases in case of an overflow of patients. The AI model can be used in rural areas where the patients are not able to get their diseases detected. This could help dermatologists identify conditions more quickly and accurately, especially in cases of nail diseases where visual data is abundant.

Limitations

But, it is important to realize that the use of AI in diagnosing nail diseases is still in its infancy, and there is much learning that has to be done. It is thus crucial to know how these limitations can be addressed to permit the safe use of AI in clinical practice [9].

One of the most significant challenges is that if there are two diseases present on a nail at the same time, the model is not trained to interpret it. This is due to the fact that the model has been trained to detect only one disease at a time. If there is co-morbidity of diseases, it cannot detect it.

For rare diseases, the dataset is very scarce, and it is not easy to find the dataset. Integrating the AI models with the existing clinic workplaces is quite challenging and requires changes in their workflow and infrastructure. Moreover, training the staff on how to use the model would also require training. The use of AI software raises many ethical and legal concerns [9].

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Appendix

```
import streamlit as st
from PIL import Image
from ultralytics import YOLO

st.set_page_config(page_title="NAIL DISEASE DETECTOR", page_icon=":medical_symbol:", layout="wide")

tb1, tb2, tb3 =st.tabs(“HOM”,“DISEASE DETECTO”,“ABOUT M”])

with tb1:
    st.title(":medical_symbol: NAIL DISEASE DETECTOR")
    st.write("To Use the model, go to the 'DISEASE DETECTOR' tab")
    st.write("---")
    st.header("NAILS AND THEIR IMPORTANCE")
    cl1=st.columns([0.7,0.3])
    cl1[1].image("Nails.JPG")
    cl1[0].write(
        """
        Nails are protective structures composed of a protein called keratin that grows at the tips of the fingers and toes in humans and other mammals. They serve several important functions:
    - Protection: Nails provide protection to the sensitive tips of the fingers and toes. They act as a shield to prevent injuries or damage to the underlying tissues.
    - Sensory Function: Nails also have a sensory function, particularly in the fingertips, where they play a role in tactile sensation. The fingertips are highly sensitive, and nails help enhance touch perception.
    - Grip and Manipulation: Nails enhance our ability to grip and manipulate objects. They provide a firm, non-slip surface that helps us hold onto items, such as when picking up small objects or opening containers.
    - Scratching: Nails can be used for scratching, which can be a useful function for relieving itching or removing debris from the skin.
    - Health Indicator: The appearance of nails can sometimes serve as an indicator of overall health. Changes in nail color, texture, or growth patterns can be associated with various health conditions or nutritional deficiencies.
    - Cosmetic and Aesthetic Value: For many people, well-maintained nails are an important aspect of personal grooming and aesthetics. Manicures and pedicures are popular beauty treatments to enhance the appearance of nails.
        """
    )
```

```
    st.write("---")
    cl2=st.columns([0.3,0.7])
    cl2[0].image("Disease.JPG",width=340)
    cl2[1].header("WHY IS IT IMPORTANT TO DETECT THEM")
    cl2[1].write(
        """
        - Early Intervention: Detecting nail diseases early can lead to more effective treatment and better outcomes. In many cases, early intervention can prevent the condition from worsening or spreading to other nails.
    - Underlying Health Issues: Changes in nail appearance can sometimes be a sign of underlying health conditions, such as fungal infections, psoriasis, or nutritional deficiencies. Identifying these signs can prompt further medical evaluation, which may lead to the diagnosis and treatment of other health problems.
    - Prevention: Identifying and treating nail diseases can help prevent complications. For example, fungal nail infections can lead to secondary bacterial infections or the spread of the infection to other parts of the body if left untreated.
    - Quality of Life: Nail diseases can be uncomfortable, painful, or unsightly. Addressing these conditions can improve a person’s overall quality of life, reduce discomfort, and enhance self-esteem.
    - Infection Control: Some nail diseases, such as fungal infections, can be contagious. Prompt detection and treatment can help prevent the spread of these infections to others.
    - Avoiding Complications: Certain nail conditions, if left untreated, can lead to complications, such as cellulitis (a skin infection), abscesses, or chronic pain. Addressing these issues promptly can prevent these complications.
    - Monitoring Chronic Conditions: For individuals with chronic skin conditions like psoriasis or eczema, monitoring the nails is essential as they can be affected. Catching nail-related symptoms early allows for better management of the underlying skin condition.
    - Personal Grooming and Well-Being: Many people take pride in their personal grooming, and healthy nails are a part of that. Maintaining the health and appearance of nails can contribute to a person’s overall well-being and self-confidence.
    """
    )

with tb2:
    st.markdown(“““HOW TO USE THE APP
- Click on Browse Files
- Click a clear picture of your nail or select from your gallery if already clicked
- Upload the image
- The model will predict the disease
 """)
    dic={

"Fungal Nail Infections (Onychomycosis)": "Fungal nail infections are common and can affect one or more nails. They often appear as discolored, thickened, and brittle nails. Dermatophytes, yeast, or molds typically cause fungal infections. Treatment may include topical or oral antifungal medications."
"Psoriasis": "Psoriasis is a chronic skin condition that can also affect the nails. Nail psoriasis can cause pitting, discoloration, and separation of the nail from the nail bed. It is often associated with skin psoriasis and can be treated with topical steroids or other psoriasis medications."
"Eczema (Dermatitis)": "Eczema can affect the skin around the nails, leading to redness, swelling, and peeling of the skin. This condition may be associated with itching and discomfort. Managing eczema with moisturizers and topical corticosteroids can help alleviate symptoms."
"Ingrown Nails (Onychocryptosis)": "Ingrown nails occur when the edges of the nails grow into the surrounding skin, causing pain, redness, and inflammation. Proper nail trimming and avoiding tight-fitting footwear can help prevent ingrown nails. In severe cases, minor surgical procedures may be required."
"Beaus Line": "Beau's lines are transverse depressions or ridges that run horizontally across the nails. A variety of factors, including illness, trauma, or nutritional deficiencies, can cause them. The appearance of Beau's lines can offer insight into the timing of an underlying health issue."
"Yellow Nail Syndrome": "Yellow nail syndrome is a rare condition that can cause nails to thicken, yellow, and grow more slowly. It may be associated with lymphedema and respiratory issues. Identifying and managing the underlying causes of the syndrome is crucial."
```

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"Clubbing": "Nail clubbing is characterized by an enlargement of the fingertips and a downward curving of the nails. It can be associated with various lung and heart conditions. If clubbing is observed, it is important to consult a healthcare professional to identify and address the underlying issue."
"Koilonychia": "Koilonychia is a condition where the nails become concave or spoon-shaped. It can be a sign of iron-deficiency anemia or hemochromatosis, among other conditions. Treating the underlying cause is essential."
}
    st.header("TEST YOURSELF")
    img=st.file_uploader("UPLOAD THE IMAGE OF YOUR NAIL")
    if img is not None:
        col=st.columns(3)
        col[1].image(img)
        #img1=img.getvalue()
        img2=Image.open(img)
        import inference
        model = inference.get_model("nail-diseases-wnxuv/1")
        pred=model.infer(image=img2)
        name = (pred[0].predicted_classes[0])
        con = pred[0].predictions.get(name)
        col = st.columns(2)
        with col[0]:
            st.subheader('Prediction')
            st.write(name)
        with col[1]:
            st.subheader('Confidence')
            st.write(con.confidence)
        st.write(dic.get(name))

with tb3:
    st.header("ABOUT THE CREATOR")
    col = st.columns(3)
    col[1].image("My.jpg")
    st.write(
        """
        Greetings! I'm Krishiv Mahajan, a passionate grade 11 student at Sat Paul Mittal School with a profound love for computer science and an unwavering desire to make a positive impact in people's lives. As I embark on this journey, my mission is crystal clear - to combine the power of technology with a heartfelt commitment to your well-being.
    In a world where health takes precedence, I've set out to create a dedicated space where your nail health is at the forefront. Nails are often the silent messengers of underlying health issues, and my aim is to empower you with the tools to detect diseases early and take control of your well-being.
    My dedication to the world of computer science fuels my pursuit of innovation and excellence. I believe that technology can be a force for good, and together, we can harness its potential to revolutionize how we care for our nails and, in turn, our overall health.
    With the Nail Disease Detection website, I aspire to provide a valuable resource for everyone. Whether you're seeking answers to your nail-related concerns or simply want to stay informed about your health, you'll find a supportive community here.
        """
    )
```