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Dermatological Disease Classification using ResNet50 and Inception V3

Apparna Allada[1], Assistant Professor, Seshadri Rao Gudlavalleru Engineering College,Department of CSE, Gudlavalleru, alladaaparna9@gmail.com
Gracy Chrysolite Bollarapu[2], Seshadri Rao Gudlavalleru Engineering College, Department of CSE, Gudlavalleru, bgracychrysolite@gmail.com
Sushmik Battu[3], Seshadri Rao Gudlavalleru Engineering College, Department of CSE, Gudlavalleru , sushmikb@gmail.com
Naveen Kumar Garre[4], Seshadri Rao Gudlavalleru Engineering College, Department of CSE,naveengarre9999@gmail.com
Aditya Shanmukh Dasari[5], Seshadri Rao Gudlavalleru Engineering College, Department of CSE, Gudlavalleru ,dasariinap@gmail.com

Abstract
Skin diseases are quite common and prevail in all age groups. Dermatological diseases such asacne and lesions not only affect the appearance of the skin but also have a greater impact on theirsocial and mental well-being. In the contemporary age, skin disease diagnosis relies on manual inspection and observation by physicians. Moreover, not all people have the courage to visit the doctor until it gets worse and unbearable. In addition, identification of distinction between different skin illnesses requires a significant deal of experience. So, the classification of the disease by a doctor is not always completely right and may result in misdiagnosis. The proposed system deals with the classification of the skin disease once the image of the infected skin is given as input. This task is carried out using image processing and deep learning models namely ResNet50 and Inception V3. While image processing is an essential phase to improve theaccuracy of diagnostic procedures, deep learning has made a significant contribution in the classification of disease using images. The Inception V3 model outperformed ResNet50 with a classification accuracy of 0.97. The results would aid in the diagnosis of dermatological problems and be helpful for both professionals and the public.

Keywords
Benign Keratosis, Vascular Lesions, Skin Cancer, Convolutional Neural Networks, ResNet50,Inception V3

Introduction

Skin being the largest organ in the human body, is exposed and is prone to many diseases. Dermatology is a branch of medical science that deals with the clinical and surgical aspects ofthe skin. Dermatological diseases are the conditions that affect the skin, which can be dangerous at times and may also lead to death. There are various conditions that are classified as dermatological. But, skin lesions can be considered a more prominent problem not only because of their abnormal appearance but also because it is proven that skin lesions can be both benign and malignant. Lesions are tumors or growths on the skin that are comparatively small. Malignant lesions often referred to as Melanoma or skin cancer have a high fatality rate and are one of the categories of diseases that cannot be treated and cured with ease. According to the American Skin Cancer Society, 7650 people are likely to die from skin cancer every year. Skin cancers such as Melanoma and Basal cell carcinoma which are the most commonly occurring cancers are usually identified by the lesions that appear on the skin. On the other hand, benign skin lesions are harmless and a common occurrence in people of all age groups.

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Benign lesions clinically present with symmetric shape, colour, structure, slow and stable evolution and absence of spontaneous bleeding. Moles, birthmarks, skin tags, freckles also fall under benign lesions but are considered primary skin lesions. They do not require medical attention unless they cause too much discomfiture. They are usually treated with creams, lotions or oral medication. Lesions that result from changes in primary skin lesions are considered secondary lesions. These changes could be because of itching, injury or an underlying condition. Treatment for secondary lesions include treating the underlying medical condition. Lesions could be identified by the patients themselves or could be found during examination by specialists. Dermatologists examine skin with tools such as magnifying glasses to determine the properties of the lesion. At times, other examinations such as blood tests, allergy tests and biopsies are recommended to eliminate any ambiguity in the diagnosis. This would help them diagnose if the lesion is benign or malignant. Conventional diagnosis involves the physical attributes and microscopic examination of the tissue of the lesion and the study of the subject's medical history. This requires a great deal of experience and knowledge. There are chances of misdiagnosis as it depends on many factors. Malignant lesions if diagnosed as benign lesions can be harmful and may lead to death as lesions would not be treated considering them harmless. Therefore, a misdiagnosis can cost a patient's life.

In addition, there are a number of studies that present the classification of melanoma, acne and eczema which are the most observed diseases. Skin conditions such as benign keratosis and vascular lesions which are also most common do not have much work done on them. It was one of the main reasons behind considering these conditions for this work. Having a tool that diagnoses these kinds of diseases with a much higher accuracy and efficiency can be advantageous in the field of dermatology. It would reduce the possibility of misdiagnoses. Moreover, making use of deep learning models for the diagnostic tool in the time where technology is being used to provide solutions to a wide range of problems makes the classification more efficient in comparison with other machine learning models. The proposed system uses ResNet50 and Inception V3 models to perform the classification task. They are pre-trained models based on convolutional neural networks and are the two of the best performing algorithms in the ImageNet visual recognition challenge.

The reminder of the paper is structured as follows- A critical analysis of the literature is presented in the second section. Third section elucidates the methodology, the fourth section deals with the findings and the last section presents the conclusions and future scope of the study.

Literature Survey

Contemporary improvements in deep learning and the availability of huge datasets are resulting in algorithms outperforming medical staff in many tasks including the study of medical images and disease diagnosis. In addition, automated diagnosis is gaining prominence. This led to extensive research that involves making use of deep learning models in the medical field. This section discusses the work that has been done to integrate technology and medical sciences, specifically the field of dermatology.

K. V. Swamy [1] developed a model that diagnoses skin diseases by texture, colour and a combination of these attributes of the skin. The classification model uses machine learning techniques such as Support Vector Machine and Decision trees which are most preferred classification models. Support vector machine classifier classifies the images based on the

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support vectors or the data points closest to the hyperplane. On the other hand, decision trees classify according to certain criteria such as information gain or entropy. R. K. M. S. K Karunanayake [2] designed a model to classify the subtypes of acne by using support vector machine, Naive bayes classifier and convolutional neural networks. Of the three models, convolutional neural networks obtained the highest accuracy of 84%. Ozkan [3] designed a classifier that distinguished skin lesions into three categories - normal, abnormal and melanoma. The work uses four machine learning methods namely Artificial neural networks, support vector machine, K Nearest Neighbour and decision tree. Artificial neural network had the highest accuracy of 92% among the four classifiers. Although machine learning algorithms are conventionally used for classifiers, the increasing use of deep learning models for the classification tasks, especially that of images, revealed that they have a better accuracy.

R. Shaik [4] in 2022, designed a model that could provide the user with the details of the disease from which they are suffering and recommend the medication that treats the disease using MobileNetV2 which is an advanced model of Convolutional Neural Networks. T. A. Rimi [5] in 2020 has built a classification model that classifies eczema, dermatitis and ulcers using convolutional neural networks. The model has a classification accuracy of 73%. J. Rathod [6] classified the images of infected skin using convolutional neural networks in 2018. J. Alam [7] classified the images using deep learning models in 2021. The model had a classification accuracy of 85.14%. Despite the usage of neural networks for classification, the observed performance could be a result of the lack of availability of consistent and reliable data. In addition, traditional neural networks have their own drawbacks such as degeneration and vanishing gradient problems.

Shetty [8] proposed a convolutional neural network based model that classifies the skin lesions with a classification accuracy of 95.18%. The model was trained and tested using the HAM10000 dataset which is one of the few reliable datasets available of skin lesion images. Sah
[9]designed a classifier using VGG16 which is a pre-trained model based on convolutional neural networks with an accuracy of 76.3%. Dermnet dataset that has more than 23000 images is used to train and test the model. Kritika Sujay Rao [10] employed a convolutional neural network to design a multiclass classifier with an accuracy of 93.35%. Works that employed reliable and consistent datasets to train and test the models had a higher accuracy in comparison with the other models.

Methodology:

Skin Conditions:

Benign Keratosis is often referred to as seborrheic keratosis. These are the most commonly occurring skin tumors that occur on the upper layer of the skin which is the epidermis. As shown in Figure 1 these are often dull and waxy surfaces that are mostly in the colours brown, yellow or gray. These usually are not required to be treated, as most of the time they are benign. But their appearance overlaps with the appearance of cancerous or malignant conditions which must be diagnosed and treated. Hence, differentiating and classifying benign tumors are crucial. There are many underlying factors that cause this condition including inheritance and proliferation of immature keratinocytes. These tumors might grow at a leisurely pace and their thickness increases with time. People of age over 50 years are the most vulnerable to this condition and the frequency of occurrence of the condition increases with increasing age. Also, the condition can be typically observed in people with fair complexion. These tumors do not occur on palms or soles and are conventionally diagnosed by their visual appearance.

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Any ambiguity in the clinical diagnosis is further clarified by skin biopsy and histological pattern examination. Though they do not require treatment, people seldom prefer to get them treated or removed as they can be a cause of irritation and discomfort. This condition can be treated in the following ways – cryotherapy (uses liquid forms of Nitrogen or Carbon dioxide to freeze or thaw the target cells leading to their death. The number of times it is suggested to the subject differs based on the thickness of the tumor), shaving (extraction using a scalpel which is a special blade that is often used to remove a thin slice of tissue containing the lesion), electrodesiccation, usage of Hydrogen Peroxide and laser therapy (non surgical alternative).

Figure 1 Benign Keratosis

Vascular lesions are the most common growths on the skin. As shown in Figure 2 these include moles or birthmarks that appear on the skin. Like keratosis, vascular lesions also have benign and malignant variants. Vascular lesions are a result of the malformation of the veins which could appear at the time of birth or later in the life of a person. These can be of varied sizes, colours and occur on any part of the body. While lesions with usual colours such as brown or gray do not have much impact, deeper coloured lesions such as those in deep purple or reddish purple would have a significant impact on the mental well-being of the person especially when they are on the areas of skin that are exposed such as arms and feet.

Figure 2 Vascular lesions

Data Collection:

The dataset used for the classification is an ISIC (The International Skin Imaging Collaboration) dataset that has been collected from Kaggle. The International Skin Imaging Collaboration is an industry partnership that facilitates the application of digital skin imaging. It provides users with a vast library of images that are of a wide range of skin diseases from acne to skin cancers. Theseimages can be used to educate both professionals and the public in the recognition, and diagnosis of various skin diseases through teledermatology and automated diagnosis. The considered ISIC dataset conventionally had nine classes of skin diseases including actinic keratosis, basal cell carcinoma, dermatofibroma, melanoma, nevus, pigmented benign keratosis, squamous cell carcinoma

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and vascular lesions. Of these, two classes as shown in Figure 3 – benign keratosis and vascular lesions have been considered to train and test the classification model. The total number of images in the two classes are around 2300.

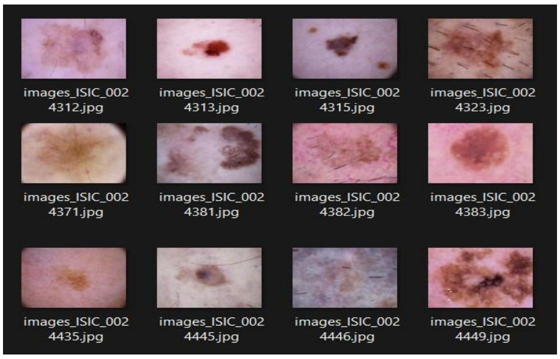

Figure 3 ISIC dataset

ResNet 50:

Since both the models used, ResNet50 and Inception V3 are pre- trained versions of the traditional Convolutional Neural Networks, they perform similar operations as those performed by the convolutional neural networks. These operations include convolution, pooling and flattening. Firstly, the convolution layer of the neural network performs convolution which is primarily a mathematical operation that attempts to merge or concatenate information. It produces a feature map which can be thought of as a matrix of features combined. It makes useof filters or kernels of certain dimensions to produce the feature maps. The layer that is often found after the convolution layer is the pooling layer. The feature map obtained after theconvolution operation is given to the pooling layer which as suggested by its name attempts to reduce the dimensions of the feature map thereby enhancing the efficiency of the classification model and cutting off the computational power. The pooling operation can be of two types – max pooling and average pooling. Max pooling operation considers the most important feature of the feature map and produces it as output. On the other hand, the average pooling operation considers the average of a subpart of the feature map to produce a feature map of reduced dimensions. Lastly, the flattening operation transforms the feature map of reduced size produced by the pooling layer into a single column which makes it easier to obtain the output.

ResNet50 or the Residual Neural Network is an advanced version of convolutional neural networks which is 50 layers deep and is pre-trained using the ImageNet dataset which implies that it uses the same weights as used for the ImageNet dataset to train the model and perform the classification. The unique feature incorporated by the ResNet50 model is the use of skip connections. Skip connections are connections to the previous layers or the input itself. They help in overcoming the vanishing gradient as well as the degradation problem which are the drawbacks of a traditional neural network. As the network is built deeper and more layers are added, the gradient or the error approaches zero which makes the training process arduous and the accuracy of the model tends to get saturated which implies that despite the increase in the number of epochs or the number of times the model is trained, the accuracy remains constant.

These conditions are referred to as the vanishing gradient problem and the degradation problem, respectively. Getting over these problems not only allows the residual neural network to build deeper networks with more layers but also increases the efficiency of the model.

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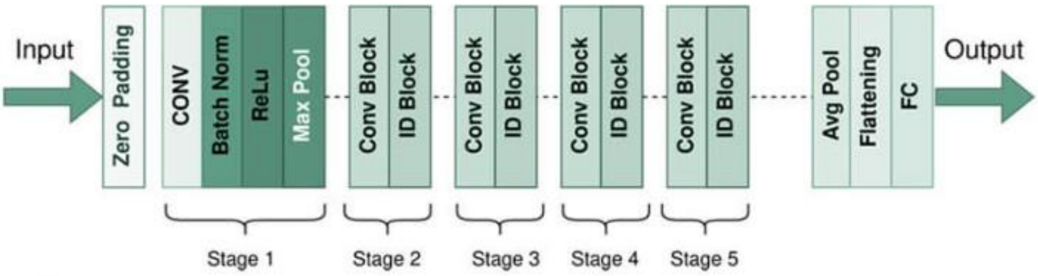

Figure 4 ResNet50 architecture

The ResNet50 architecture as shown in Figure 4, fundamentally consists of similar blocks namely convolution blocks and identity blocks. These blocks comprise a series of convolution and pooling operations along with the skip connections. The most significant difference between the two blocks is the operation performed by the skip connection. In the convolution block, the skip connection performs convolution and batch normalization operations to the input before merging it with the output. On the other hand, skip connection in the identity block directly connects the input to the output without performing any intermediary operations. The skip connections in the convolution block and identity block are shown in Figure 5 and Figure 6 respectively. The model also includes batch normalization layers. Instead of performing normalization on the raw data, batch normalization considers batches of small size at a time and performs normalization. Normalizing the data allows the model to train faster and easier. It also has a fully connected layer which makes sure that all the input nodes are connected to all the output nodes.

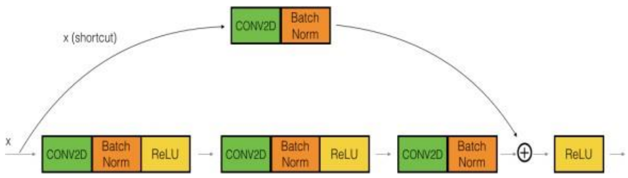

Figure 5 Convolution block

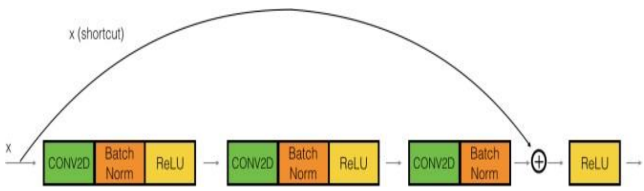

Figure 6 Identity block

Inception V3:

Inception V3 which is a 42-layer deep neural network is another revolutionary step in improvising the traditional convolutional neural networks. It was initially incorporated as a module in GoogleNet which was developed by Google. It was named based on its ability to allow users to make use of varied sizes of filters, unlike the usual convolutional neural networks that can only employ filters of single dimensions. While all the variants of the convolutional neural network attempt to build deeper networks, a distinctive aspect of the inception model is that it tries to make the networks wider. To achieve this, the model performs more than one operation in a layer and then merges the results and this combined result is given as the input to the next layer which performs similar kinds of operations.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, Dec 2022

In addition to the attempt in building wider networks, the inception model has multiple characteristics that make it exceptional. These characteristics include the use of smaller convolutions, asymmetric convolutions and auxiliary classifiers. Smaller convolutions as shown in Figure 7 employ filters of smaller dimensions in the place of larger filters. Asymmetric convolutions on the other hand use filters with dimensions in the form of n by 1 as shown in Figure 8. Auxiliary classifiers are small sized convolutional neural networks used in the model that act as regularizers, controlling the complexity of the model by reducing the number of parameters considered. They also help in combating the vanishing gradient problem. The usage of these makes it computationally efficient and reduces the time taken by the model to train.

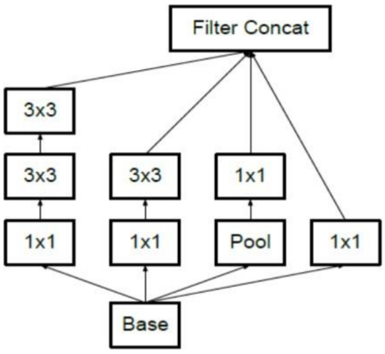

Figure 7 smaller convolutions

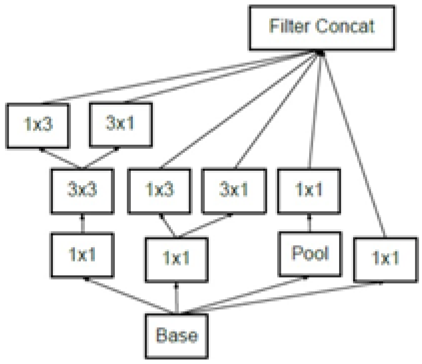

Figure 8 Asymmetric convolutions

Results:

The metric used for the evaluation of the performance of classification models is accuracy. Accuracy can be defined as the number of correct predictions made by the classifier. In machine learning, accuracy can be calculated as the total number of correct predictions per total number of predictions.

Table I presents the classification accuracies obtained by both the models used. Both ResNet50 and Inception V3 have obtained considerable accuracies but the Inception model outperformed the ResNet50 model with an accuracy of 97.88%.

Table I Classification Accuracy

Classification model	***Accuracy***
ResNet50	93.97%
Inception V3	97.88%

The work allows the users to upload the image through the user interface as shown in Figure 9 and Figure 10. The provided image is then given to the classifier and the prediction is displayed back through the same interface to the user.

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Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, Dec 2022

Figure 9 User interface

Figure 10 Classification

Conclusion

The dermatological disease classification model allows the users to select an image of the skin with either of the two considered conditions – Benign keratosis and Vascular lesions and classifies the image into its respective class of disease. The model makes use of two pre-trained convolutional neural networks ResNet50 and Inception V3 where a significant aspect of the study is to compare the performance of these classification models. From the results obtained after training and testing the model using the ISIC (International Skin Imaging Collaboration) data, the Inception V3 model transcends the performance of ResNet50.

The model focuses on the classification of two diseases. However, this can be further improvised into a model that classifies several skin diseases and their subtypes. For example, benign keratosis has the following subtypes: acanthotic lesions, clonal lesions, hyperkeratotic lesions, adenoid lesions, irritated lesions and melanoacanthoma. Also, a mobile application could be developed that not only employs these classifiers but also can make use of natural language processing to classify the diseases based on the symptoms provided by the users. Although there is a plethora of data available, the efficiency of the classification models can be improved if the data available is more consistent and reliable. Having such a diagnostic tool at hand not only makes it more accessible to the users but also proves to be cost-effective.

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