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Application of Transfer Learning Using Convolutional Neural Network Method for Early Detection of Terry's Nail

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Abstract. Nails are one part of the fingers and toes, by observing the shape and the condition of the nails, health expert can find out information about a person's health. However, this sometimes not realized and ignored by society, even though many diseases that can be seen through the condition of the nails and the shape of the nails are one of the systemic diseases. This research was conducted to detect abnormalities in the nail based on digital images. The detected abnormalities are terry's nails in the hand which can represent systemic diseases, while the method used is the Convolutional Neural Network (CNN) method. This research uses Tensorflow Inception-V3 architecture model with the transfer learning method where the results of the experiments that have been done are obtained with 95.24% accuracy.
Keyword : Nail, Terry's nail, Convolutional Neural Network.

1. Introduction

Nail's are an important part of the fingers and toes. Nails function as protective fingers full of nerves and other sensitive parts. by observing the shape and the condition of the nails, health expert can find out information about a person's health, but this is sometimes not recognized and ignored by society, even though some changes in the shape of the nail can provide information about internal organ diseases such as systemic diseases.

Currently, health expert take some sample tests to determine systemic diseases from patients, but in the research has studied the analysis of systemic diseases through digital image processing methods based on color analysis of nails. It is enable to detect of diseases without painful sampling[1].

Terry's nail is one of the nail disorders that can indicate systemic diseases such as liver cirrhosis[2]. Meanwhile, according to the paper[3], Terry's nail can indicate systemic diseases such as hepatic failure, chirrosis, diabetes mellitus, congestive heart failure and hyperthyroidism.

Based on this, the study will detect the abnormalities of terry's nails by using other methods based on the color pattern in the nails

2. Methodology

In this study the method used was Convolutional Neural Network (CNN). The CNN method has been shown to provide good performance in many image classifications[4]. CNN method specially designed to recognize two-dimensional shapes with a high level of inversion to translation, scaling and other distortions.

CNN is included in the type of deep neural network because of the high network depth and much applied to image data[5]. Generally, Convolutional Neural Network is divided into two main parts, They are feature extraction layer and fully connected layer. feature extraction itself consists of convolutional layer, pooling layer and classification layer. However, there have been developments in various CNN architectures such as VGGNet, GoogleNet, ReLU, BN-Inception, Inception-v3 where the writing[6] has explained various differences of each existing architecture. Next, the experiment in this study will detect nail abnormalities with existing models such as the inception V3 architectural model.

2.1. Image Pre-Processing

Pre-processing is done to obtain images that are ready to be classified for the next stage. At this stage bitmap images obtained through the acquisition process are carried out by the process of cropping and resizing.

Cropping is the process of cutting or taking pictures in certain parts. The cut image is all parts of the nail which include cuticle, lanula, nail body to free edge. This process is done manually.

Table 1. Cropping Example

Before *Cropping*	After *Cropping*
Cropping Area	Output

Next process is resizing, In the process of resizing the nails the size of n x m pixels is changed to a size of 229x229 pixels. The resize process is done so that the computing process becomes faster. In addition, the size is a measure commonly used on digital image training.

Table 2. Resize Example

Before *Resize*	After *Resize*

2.2. CNN Concept

CNN is one of the deep learning methods that is often applied to two-dimensional image. This method has two main parts, that is Convolution Layer, Pooling Layer and Classification Layer[7]. In figure 1, convolution layer is the base layer that builds CNN networks, where in this layer convolution operations are carried out between the input image and a kernel at all points. This process can use discrete function equations $f(n, m)$ and $h(n, m)$ which is defined by:

$$y(x1, x2) = \sum_{n-1}^{Tn} \sum_{m-1}^{Tm} f(x1 + k2, m) h(n, m) \qquad (1)$$

the illustration of the equation above can be seen in the following picture:
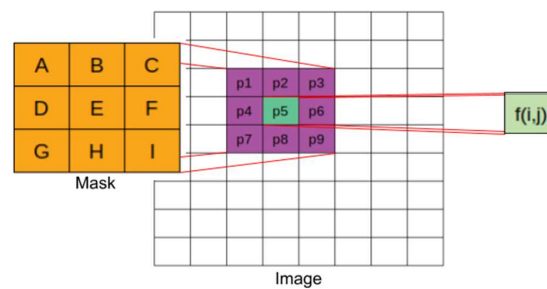
Figure 1. Convolution Illustration

Next, there is also a pooling process, where this process is used to convert the input image into a smaller size. It aims to reduce input spatially (reduce the number of parameters) with a down sampling operation. There are two pooling layer operations used in the Inception-v3 architecture, namely Max Pooling and Average Pooling. Max pooling is a mathematical operation that works by taking the largest value from a portion of the image with a certain size, while average pooling is a mathematical operation that works by taking the average value of a portion of the image with a certain size.
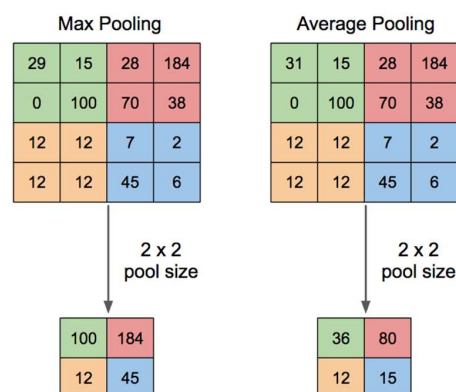

Figure 2. Illustration of Max Pooling and Average Pooling

Figure 2 above shows an example of max pooling operation and average pooling with a 2x2 pixel filter size from 4x4 pixel input. At max pooling, each filter is taken the maximum value, then arranged into a new output with a size of 2x2 pixels. While the average pooling value taken is the average value of the filter size.

Classification layer is a layer consisting of flattening, hidden layer and activation functions. Hidden layers in artificial neural networks is layers between input layer and output layer, where artificial neurons take a set of weight inputs and produce output through activation functions such as sigmoid[8], ReLU[9], or Softmax[10].
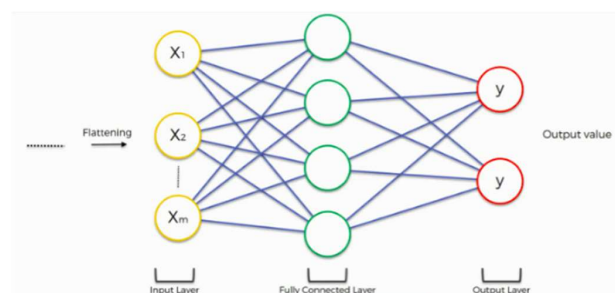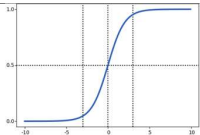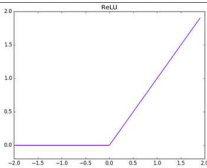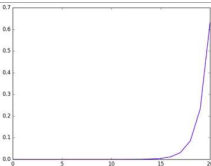

Figure 3. Hidden Layer

Table 3. Activation function

| Activation Function	Plot	Equation
Sigmoid[8]		$f(x) = \dfrac{1}{1 + e^{-x}}$
ReLU[9]		$f(x) = \left\{\begin{array}{l} 0, x < 0 \\ x, x \geq 0 \end{array}\right\}$
Softmax[10]		$f(x_j) = \dfrac{e^{x_j}}{\sum e^{x_i}}$

A. Transfer Learning

   Transfer Learning is the process of transfer knowledge from previous training to be used in new research so that training time will be completed faster. This is certainly different from the process of training on traditional machines that learn input data from the start and require long computational time. The workings of transfer learning are by keeping the parameters in the previous layer and removing the last layer of the model. Then retrain the last layer[10]. As for the learning transfer can be seen in the following picture:
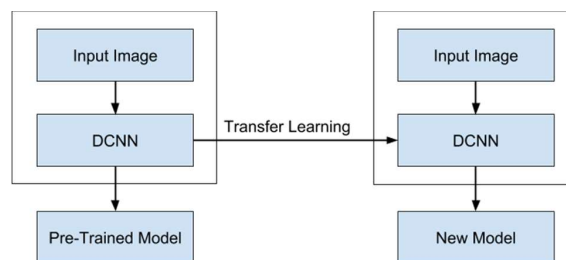

Figure 4. Transfer Learning Illustration

B. Inception-v3 Architecture

   Inception is an architecture developed based on Convolutional Neural Network (CNN). Inception-v3 is one of the pretrained models in Tensorflow[11]. This architecture consists of several convolution squares which are interconnected. The inception module is as follows like this.
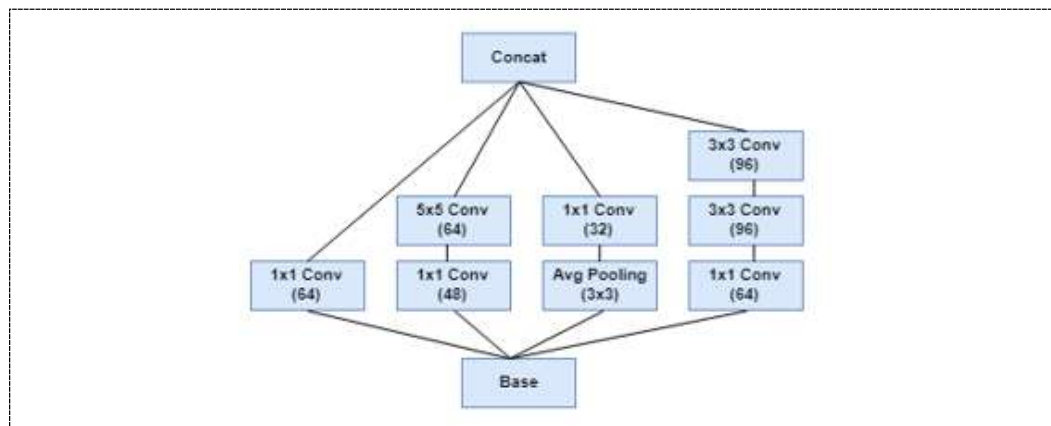
Figure 5. Inception Module A[6]
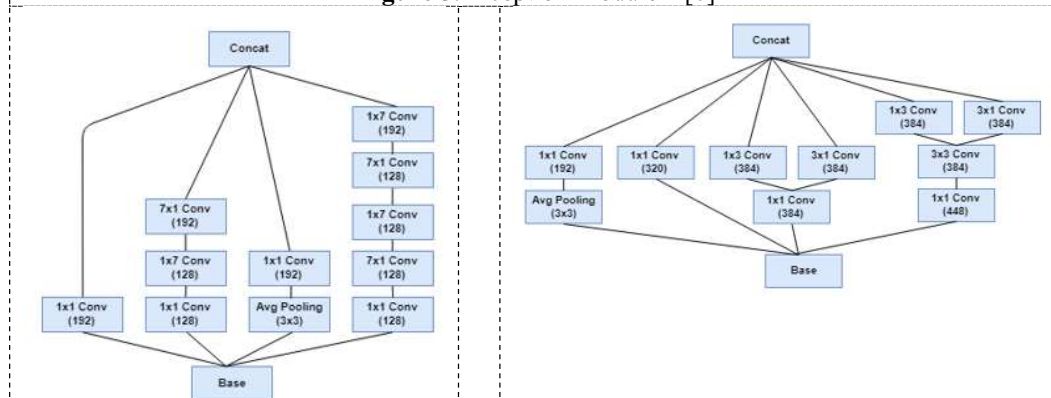
Figure 6. Inception Module B[6]

Figure 6. Inception Module c[6]

Then the module is interconnected so that it forms an architecture like this:
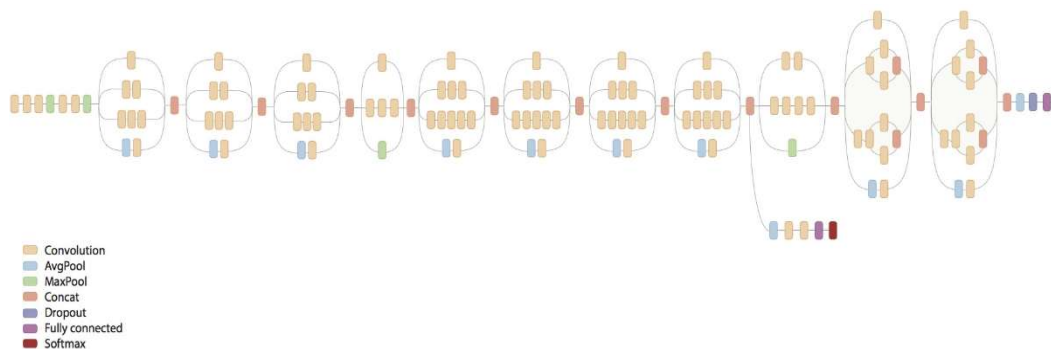
Figure 7. Inception-V3 architecture[6]

Previously, this architecture could not see the difference between healthy nails and terry's nails, so it needs to be retrained by using transfer learning techniques. The result is a new model that can predict healthy nails and terry's nails.

3. EXPERIMENT

3.1. Image Prepocessing

Before the classification process, simple image processing techniques are applied automatically to all images in the dataset. Each image class is encoded with numbers 0 and 1, where 0 represents healthy nails and 1 represents terry's nails. Next, all nail images are resized in 224x224 pixels. Then the image is divided into training data, testing data and data validation.

3.2. Dataset

The dataset used in this study consists of two types of nails, they are terry's nails and healthy nails. 115 terry's nails were taken from google image and dermatology website. While 100 healthy nails were taken from the Telkom University environment. The nails were previously validated to the hospital of Al-Islam Bandung to ensure which ones are the right terry's nails and which ones are the right healthy nails.

Figure 8. Healthy Nail	**Figure 9**. Terry's Nail

3.3. Experimental procedure

First, image must be change into the size of the image set in 229x229 pixels in all datasets, then it is purchased label after the image class. In addition, the size of the hyper parameter is adjusted according to computer capabilities and image size. In this study the parameters used consisted of batch size, epoch, learning rate, amount of training data and number and test data. batch size is the number of training data in one batch, epoch is when the entire dataset has gone through the training process on Neural Network until it is returned to the beginning for a single round, the learning rate is the value used to control controls how much we adjust our network weight to value loss.

Table 4. Hyper Parameter Value

Hyper Parameter	Value
Batch Size	8, 64, 128, 512
Epoch	100
	400
	600
Learning rate	0.01
Data comparison	90% training, 10% testing
	80% training, 20% testing
	70% training, 30% testing
	50% training, 50% testing

The size of the batch size is set according to the computer's memory capacity which increases the size of the batch size requiring more memory so that it needs to be adjusted to the specifications of the existing computer.

4. RESULT AND ANALYSIS

Figure 10 showing the accuracy of the training that has been done, and the figure 11 showing the value of loss during the training process.
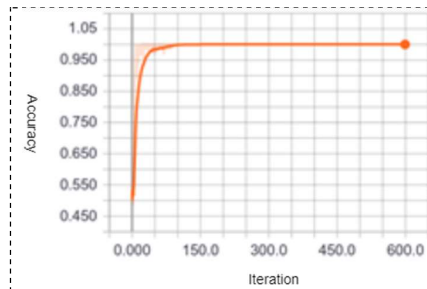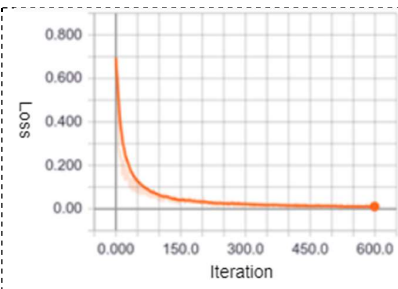

Figure 10. Training accuracy   **Figure 11**. Training loss

Figure 12 shows the validation value during the training while the figure 13 shows the validation loss value.
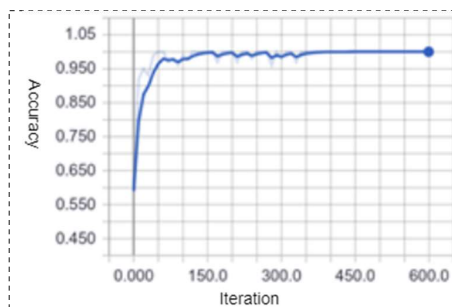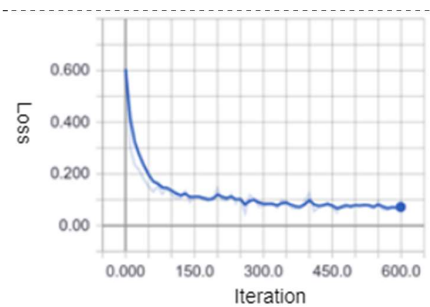

Figure 12. Validation Accuracy   **Figure 13**. Loss Accuracy

Table 5 below shows the difference in accuracy, precision and recall obtained based on the difference in the number of partition data between training data and testing data

Table 5. Training Result

Experiment	Parameters	Result (%)
Training 50%, Testing 50%	*Accuracy*	94.39
	Precision	98.00
	Recall	90.74
Training 70%, Testing 30%	*Accuracy*	89.23
	Precision	100.00
	Recall	78.13
Training 80%, Testing 20%	*Accuracy*	93.02
	Precision	100.00
	Recall	86.36

Experiment	Parameters	Result (%)
Training 90%, Testing 10%	*Accuracy*	95.24
	Precision	100.00
	Recall	90.91

The testing process was implement on the test data. The result shows that the comparison of test data is 90% and training data of 10% has good results. Table 4 is a summary of the minimum loss value during training.

Table 6. Testing Result

Batch Size	Epoch	Minimum Loss
8	100	0.039395846
	400	0.013392279
	600	0.00655178
64	100	0.097544082
	400	0.049845323
	600	0.030631069
128	100	0.122955941
	400	0.051219061
	600	0.040414054
512	100	0.136599451
	400	0.59462547
	600	0.44304498

5. CONCLUSION

In this paper, based on the inception-v3 architectural model we use transfer learning technology to detect terry nail abnormalities the first thing to do is pre-processing by doing cropping and resizing. The results are the best accuracy obtained with training data 90% and 10% validation data with values of accuracy, precision and memory, each of which is worth 95.24%, 100%, and 90.91%. This is in accordance with other studies where more and more training data then the information received by the computer as much so that the accuracy results are getting better. Next best loss value is obtained when the minimum batch size is 8 and the maximum age is 600 with a value of 0.00655178.

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