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Pattern Analysis and Interpretation of subject images using Deep Learning Technique for Health Analysis

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***Abstract*—** Deep learning is becoming a prominent area for pattern analysis of large amount of data. Deep learning is a part of machine learning and its roots are from artificial neural network. In today's time data is increasing at a very fast rate and to deal with such huge data efficient techniques are required that work well with such large data. Deep learning works efficiently with the data in large quantity and its performance increases with the increase in data as compared to traditional algorithms. Deep learning models like recurrent neural networks and deep belief networks have been used in the fields like computer vision, speech recognition, natural language processing, audio recognition, social network filtering and bioinformatics where they have produced very satisfactory results. Convolutional Neural Network (CNN) is also one of the models of deep learning which has its application in image and video recognition. The research work uses deep learning technique for pattern analysis of nail images of humans for health analysis. Convolutional Neural Network one of the deep learning models is used for analyzing nail patterns for health analysis. Five nail categories are used in this work. The system used in this research work is divided into image acquisition section, the pre-processing section, the pattern analysis section and the result section. The pattern analysis is performed under the effect of various factors like learning rate, number of epochs, mini-batch size.

Keywords: convolutional neural network; deep learning; machine learning; pattern analysis.

I. INTRODUCTION

Health care is moving towards a new age where the biomedical data is available in huge amount and very accurate medicine decisions are needed to deliver the correct treatment to right patient at right time by properly analysing the patient's data. To handle such huge biomedical data good techniques are required [1].

Deep learning is a rising field with its roots from artificial neural networks, growing in recent years as a strong tool for machine learning. Deep learning is different from traditional neural networks as it uses many hidden layers like more than two. The outputs generated at different layers correspond to some features, the initial layers correspond to low level features and the layers at end correspond to higher level features. The higher level features are defined in terms of low level features. The network if trained well results in useful high-level abstractions of the images and these features provide an automatic feature set. In areas such as health informatics, the automatic feature extraction without any human interference has many advantages like in medical imaging; it can generate features that are more difficult to describe [2]. There are variant models for implementing deep learning and Convolutional Neural Network (CNN) is one of them.

Yann LeCun presented the concept of Convolutional Neural Network (CNN) in 19880s, where a neural network architecture comprises of two basic layers, respectively called convolutional layers (C layers) and subsampling layers (S layers). CNN for image recognition acquired the more attention when Hinton and his students incorporated a deeper Convolutional Neural Network to achieve the optimal outputs in the world on ImageNet in 2012 [3].

CNN structure comprises convolutional layers, pooling layers and fully-connected layers. CNN is different from traditional networks as it uses the concept of local receptive field and weight sharing. The convolutional layer involves convolution of filters around the input image and output produced represents some features. Thus layer is used for feature extraction. The outputs produced in convolutional layers are called activation maps or feature maps. The pooling layer involves dimensionality reduction. The fully-connected layer is same as in traditional neural networks [4]. After the feature extraction part there is output layer that comprises of classification part. The output layer provides the output. It provides the class of the input image. The arrangement of layers is defined by user. Different layer structures can be used to achieve good result. Figure 1 represents general CNN architecture.

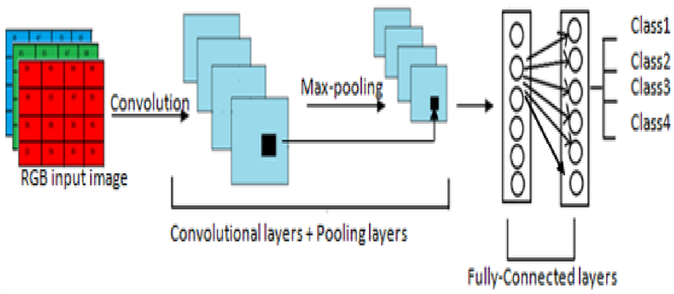

Fig. 1. General architecture of CNN

Pattern recognition involves finding patterns in things and then these patterns can be useful. Pattern is an entity or thing that can be given name. For example, patterns in flowers, manmade designs or a handwritten cursive word. Pattern recognition involves supervised classification or unsupervised

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classification. Analysis of patterns provides us information that can be very useful like in health area analysing patterns in patient's data provide information about health of patient [5]. There are different techniques that are used for patterns analysis like pattern recognition based on similarity measure [6] [7], nature based algorithms [8] [9] that are inspired from nature.

In this research work deep learning is used for pattern analysis of nail images of humans for health analysis. The trained network is analysed under different factors like learning rate, epoch and mini-batch size. Learning rate (Ƞ) is a hyper-parameter used during training neural network that controls the adjustments of the weights with respect the loss gradient. In neural network data is divided into smaller batches or parts and then these batches are passed to network. The number of training examples present in batch is called mini-batch size. Epoch means when an entire dataset is passed forward and backward through the neural network. Usually more than one epoch is used to get better results.

Nails are part of human body that depicts a lot about health if properly analysed. The nail matrix sometimes called the matrix unguis is the tissue which protects nails and is affected by each individual's general state of health. Different health conditions like illness, fever, surgical treatment, disturbance, life stressors, and any kind of nutritional deficiencies all have different impacts on the nails and their growth. Thus, nails are helpful in depicting health condition but it is very important to analyse them correctly.

In this research work five categories of nail patterns are studied and convolutional neural network is used for classification. The nail categories used in this work are melanonychia, dystrophy, normal, onychomycosis and onycholysis. Nail melanonychia shows the discolouration of finger or toe nail from brown to black. Nail dystrophy means poor nail formation due to the effects of trauma or infection. Onychomycosis is a fungal infection of the nail. Onycholysis is a nail disorder in which fingernail or toe nail separates from its nail bed. The pattern analysis of images is done under the effect of variant factors that are changed to obtain better results.

II. LITERATURE REVIEW

Riccardo Miotto et al. work presented the review on the deep learning technologies for the health care domain. Depending on the analysed work, they suggested that deep learning techniques could be used for translating big biomedical data into improved human health [1]. Ke Shan et al. have used deep convolutional neural network for automatic facial recognition. They used Japanese Female Facial Expression Database (JAFFE) and the Extended Cohn-Kanade Dataset (CK+) for their work and evaluated the recognition performance under the control of different factors like network structure, learning rate and pre-processing. They also provided result comparisons based on a K-Nearest Neighbor (KNN) algorithm and CNN [3]. Sneha Gandhat et al. have studied and analysed nail images of patients. The system developed by them for nail analysis uses similarity measures like Mean Square Error and Euclidian Distance [10].

Nityash Bajpai et al. have developed an automated prediction system for health analysis by analysing human palms and nails using image matching technique [11].

Ping Kuang et al. provided the preview on structures and algorithms of deep learning [12]. Rajivkumar Mente and S. V. Marulkar studied the various steps used to process the nail images for disease detection and the various steps are image acquisition, preprocessing, segmentation, feature extraction, comparison with database and result [13].

B. Nithya and V. Ilango have studied various prediction techniques and tools for Machine Learning in practice. They have also provided applications of machine learning in different domains mainly focusing on health area [14].

Vinayshekhar Bannihatti Kumar et al. have provided an approach to detect various kinds of dermatological diseases. They used a dual stage method which involves computer vision and machine learning. In the first stage, the image of the skin disease is subject to various kinds of pre-processing techniques followed by feature extraction. The second stage involves the use of machine learning algorithms to identify diseases based on the histopathological attributes observed on analysing of the skin [15].

Hardik Pandit and Dr. D M Shah proposed the system using the algorithm which automatically extracts only nails area from scanned back side of palm [16].

Arkadiusz Kwasigroch, Agnieszka Mikołajczyk and Michał Grochowski presented the results of research using Deep Neural Networks (DNN) for automatic classification of the skin lesions. They have used CNN in their work [17].

III. METHODOLOGY:

This segment provides view of pattern analysis system of nail images using CNN. The different steps performed in research work are image acquisition, pre-processing, pattern analysis, testing and result improvement. The diagrammatic representation of proposed work is given in figure 2.

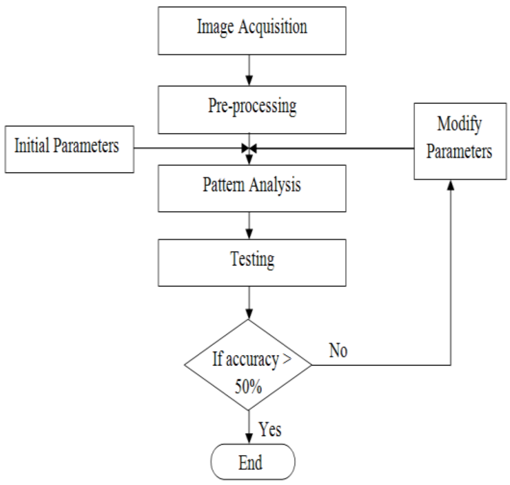

Fig. 2. Workflow

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A. Image Acquisition

The instigation of work is done with image acquisition. Images of different categories of nails are collected. Images are collected from internet. Five categories of images that are analyzed in this work are melanonychia, dystrophy, normal, onychomycosis and onycholysis. The details of images are given in TABLE I.

TABLE I. Nail images used for classification

Nail categories	Total images	Images for training	Images for testing
Melanonychia	2148	2000	148
Dystrophy	2500	2000	500
Normal	2500	2000	500
Onychomycosis	2500	2000	500
Onycholysis	2492	2000	492

B. Pre-processing

In pre-processing, images are processed using batch processing. All the images are then resized to same size according to requirement. All the images are grouped into training and testing classes. The image sharpening is performed on all images. The image normalisation is performed on images before starting the actual training phase.

C. Pattern Analysis

In pattern analysis phase CNN is used for feature extraction. CNN structure used in the proposed work comprises of mainly convolutional layers, pooling layers and fully-connected layers. ReLU is used as an activation function. After feature extraction part there is softmax layer and classification layer. The figure 3 represents the pattern analysis system. Here C1, C2 and C3 are convolutional layers. MP1 is max pooling layer. AP1 and AP2 are and average pooling layers. FC1 and FC2 are fully-connected layers. Pattern analysis involves training phase of nails images. The network is trained till classification accuracy is equal or greater than 50%. Different parameters like learning rate, epoch and mini-batch size are changed to achieve required accuracy. The complete detail of layers is given in TABLE II.

TABLE II. Layer description

Layers	Description
Image Input	32*32*3 images with 'zerocenter' normalization
Convolutional	32 5*5 convolutions with stride [1 1] and padding [2 2 2 2]
Max Pooling	3*3 max pooling with stride [2 2] and padding [0 0 0 0]
ReLU	ReLU
Convolution	64 5*5*32 convolutions with stride [1 1] and padding [2 2 2 2]
ReLU	ReLU
Average Pooling	3*3 average pooling with stride [2 2] and padding [0 0 0 0]
Convolution	64 5*5*64 convolutions with stride [1 1] and padding [2 2 2 2]
ReLU	ReLU
Average Pooling	3*3 average Pooling with stride [2 2] and padding [0 0 0 0]
Fully-connected	64 fully connected layer
Fully-connected	5 fully connected layer
Softmax	Softmax
Classification	Crossentropyex with 'dystrophy', 'melanonychia', ' normal', 'onychomycosis' and 'onycholysis' classes.

D. Testing

In this phase trained network is tested for new images which are not used during training. The output is and with its class. The images which are correctly classified have class title in green colour while the images which are not correctly classified have class title in red colour. After testing images confusion matrix for test images is obtained that tells how many images are correctly classified and how many are misclassified. Confusion matrix is used to obtain accuracy of network.

IV. Result Analysis

A. Performance Evaluation vs Learning Rate

Learning rate Ƞ is the used to determine change of parameter updating, its value is controlled between 0 and 1(0 < Ƞ <=1). The value of learning rate will affect the change of network parameters. Large value of Ƞ will result in sharp updating while small value of Ƞ will take more time to reach optimal state. For performance evaluation based on Ƞ, six different values of Ƞ are considered. The values are selected between 0-1 and the results in both are displayed in the Table III.

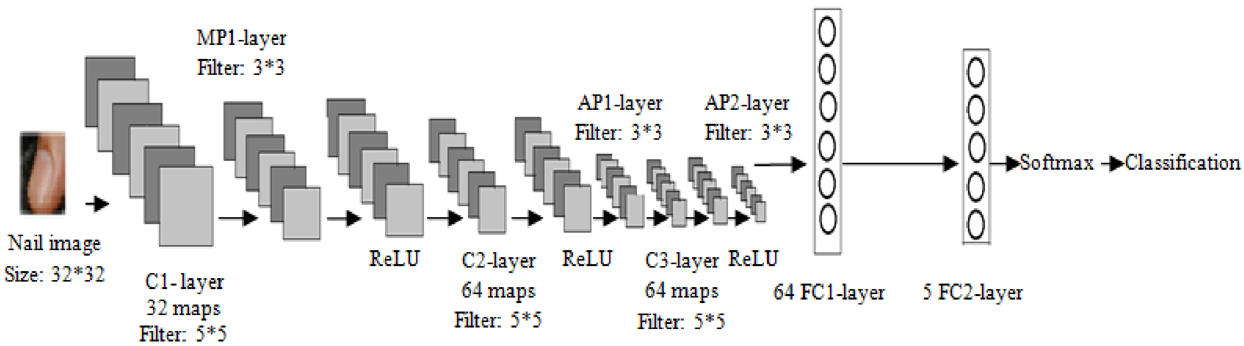

Fig. 3. Pattern analysis system

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TABLE III. Recognition accuracy on different learning rates

η	Accuracy
0.001	55.33%
0.002	52.49%
0.003	53.36%
0.004	50.61%
0.01	20.00%
0.02	20.00%

B. Performance Evaluation vs Pre-processing

The recognition performance for the pre-processing is discussed here. Image pre-processing involves various steps. Training is done for sharpened images and images which are not sharpened. The result is shown in Table IV.

TABLE IV Recognition accuracy before and after pre-processing

η / Sharpening	0.001	0.002
Before	52.45%	51.61%
After	55.33%	52.49%

C. Performance Evaluation vs Noisy data

The recognition performance is evaluated for noisy data. Gaussian noise is introduced in test images and the result is shown in table V.

TABLE V. Recognition accuracy before and after noise

η / Noise	0.001	0.002	0.003	0.004
Before	55.33%	52.49%	53.36%	50.61%
After	47.31%	44.51%	43.59%	45.55%

D. Performance Evaluation vs CNN structures

The recognition performance is evaluated under different CNN structures. The filters in first two convolutional layers are changed. Different combination of these two layers is taken and the results obtained are shown in table VI.

TABLE VI. Recognition accuracy for different CNN structures

C2 / C1	32	64
32	50.79%	53.36%
64	52.96%	50.92%

E. Performance Evaluation vs Mini-Batch size

The recognition performance is evaluated different mini-batch size. Value of learning rate is 0.001%. The result is shown in table VII.

TABLE VII. Recognition accuracy for different mini-batch size

Mini-Batch size	Accuracy
25	55.33%
30	54.16%
50	53.76%

V. CONCLUSION

In this paper, CNN is used for pattern analysis of nail images for health analysis. The system comprises of input section, pre-processing section, pattern analysis section and testing section. CNN is analysed under different parameters to evaluate its performance. The different parameters are learning rate, pre-processing, noisy data, CNN structures and mini-batch size. CNN used in research work shows maximum accuracy at 0.001 learning rate and when the value of learning rate is increased its accuracy decreases. The effect of pre-processing has also been analysed, after pre-processing the accuracy has been improved that shows pre-processing helps increasing the performance of CNN. The effect of different layers of CNN has been analysed. The different combination of first two layers has been analysed and the result shown the variation in number of filters used in CNN affects its performance.

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