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An Overview of Deep Learning and Classification Algorithms

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Abstract: In recent years, deep learning made a tremendous growth in medical imaging for developinga new idea towards the real time applications. This field comes under the subset of Machine Learning (ML) and different methods are validated through Neural Network (NN), Convolutional Neural Network (CNN) and Deep Learning (DL). Basically, the entire categories are developed in Artificial Neural Network (ANN), which was inspired by biological neurons (or) node and ANN used to solve the actual problem and reduce network over fitting. Further, this paper represents an overview of deep learning, different types of classification and anatomical applications in the medical field.

Keywords: *Machine learning, Deep Learning, Artificial Neural Network, Convolutional neural network.*

I. INTRODUCTION

In past few decades the field of machine learning has created a new revolutionbetween various fields such as image processing, data mining, social network, text mining and big data analysis. The main objective of ML is that describe the pattern (or) regularities in several tasks in medical image analysis. These inhabitant patterns are drawn through shallow architecture that leads to limits their representation power of the system [7]. To overcome these obstacles, Deep Learning (DL) is an emerging technology for creating an outstanding application in every domain. The tremendous growth of DL is availability of data and remarkable adventurous in hardware technologies are tend to enhance the new ideas in DL. Whereas, it is a path of CNN because, it transform information among neurons to develop a multi layered models that leads to initiate many techniques for different kind of application such as natural language programming, visual data processing, speech and audio processing [1]. Thus the DL exhibits high performance in various fields including medical imaging.

In medical image processing, the DL network able to identify the abnormality of disease and easily classify them into different categories. The DL only achieves through by this following factors such as high technology CPU, GPU and big data analysis are the major development in learning algorithms [8]. It can able to perform a hierarchical feature extraction, lesion detection and CAD, also these methods are highly effective even a large number of images are sampled together. However, in medical imaging only (<1000) are taken because the limited number of samples leads to build a model without over fitting. To meet out these problems, researchers

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derived a various methods such as convert an image into 2D (or) 3D rather than taken full image as input. This leads to train a millions of data in a simplest step. Consequently, this paper organised as follows: Outline of Deep Learning (DL), how DL worked in Medical image processing and various anatomical applications towards DL networks

II. OUTLINE OF DEEP LEARNING METHODS

The goal of this section is to describe the introduction and fundamental concepts of
Deep Learning (DL) network which are related to medical image processing. It moves on several methods such as Neural Network (NN), Convolutional Neural Network (CNN) and Deep Neural Network (DNN).

Neural Network (NN):

Neural Network (NN) is a circuit of neurons, which was inspired by biological neurons (or) artificial neural network. The fundamental unit of neural network is

$$f\hat{}(x) = h(w^T x + w0) \quad (1)$$

Where, w0is a bias function and w = (w1,……wn) as a parameters of weight function using nonlinear activation function h(x)[2]. Hence, it is a comprised form of neurons with activation function a and parameters$\theta = [w, b]$, where w is a weight and b is set of biases as following the transfer function equation given as

$$a = \sigma (w^T x + b) \quad (2)$$

Generally, the sigmoid and hyperbolic are the transfer function of fundamental neural network as well as it have several types of transformations using Multi-Layer Perceptron (MLP) in traditional Neural Network.

$$f\hat{}(x, \theta) = \sigma (w^L \sigma (w^{L-1} \ldots . \sigma w^0 x + b^0) + b^{L-1}) + b^L) \quad (3)$$

Here, the symbol of n indicates number of current layer and L is a final layer. Thus, the layer between the respective input and output are known as hidden layer as shown in the fig. 1.

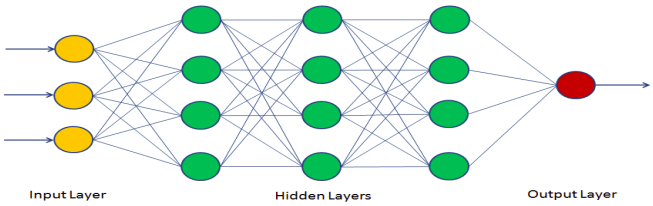

Fig. 1 Neural Network

According to that, a neural network which consists of multiple hidden layers is known as ‘deep’ neural network and hence it is called as Deep Learning (DL). The term DL has been trained a network through layer by layer in an unsupervised (pre-defined) model, followed by supervised learning of fine-tuned method that gives high performance to the system model. Nowadays, there are many popular models to simplify the training process in multi layered network. Thus the popular models are Convolutional Neural Networks (CNN), Recurrent Neural Network (RNN) and Deep Neural Network (DNN) is explained in the following sections which are currently used in the medical image analysis.

Convolutional neural network:

The Convolutional Neural Network (CNN) is a network with multiple processing stages which consists of two layers namely convolutional layer and non-linear sub sampling layer. For medical images, the information among neighbouring pixels are very important, but during vectorization it destroys some structural and feature information in images. In CNN the respective images are taken as 2D and 3D images, which are designed for better utilization of spatial and feature extraction. Generally, CNNconsists of pooling layers followedbyfullyconnectedlayers with multi-layerneuralnetwork.

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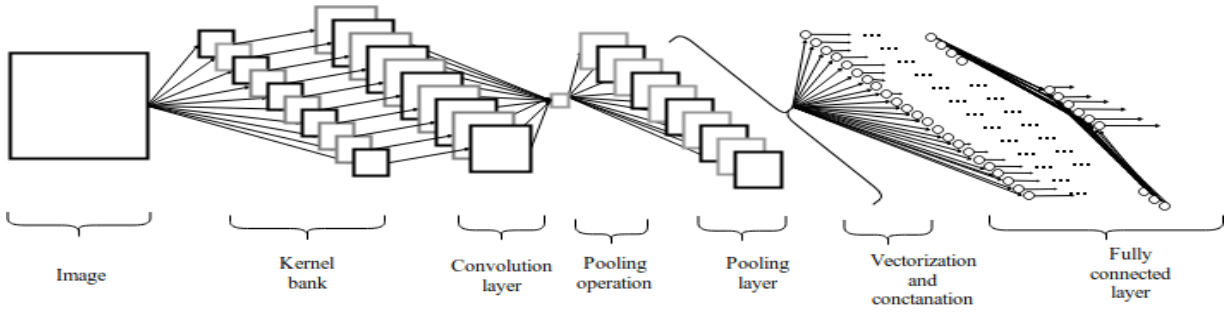

Fig. 2 Architecture of Convolutional Neural Network

Xk(j) = σ ($\sum i\epsilon\Omega$(j) Xk-1(i)*Wk(i,j)+bk(j)) (3)

Here, (i,j) are the input and output location of weight Wk and bias bkin orderto reduce the computational resources in the CNN architecture as shown in fig. 2.The modules that could extract multi scale features from the input feature maps and could efficiently reduce the number of parameters. The recent version of the inception module was created to have a more uniform simplified architecture than previous versions and thus could achieve top performance in large-scale image classification tasks.

Non-linearity layer:

The Non-linearity isachieved using a specific family of functions called activation functions. These activation functions ensure that the representations in the input are mapped to a scattered one and, hence achieving data variability and efficient representation for computational process.

Pooling and sub-sampling layer:

Typically, the CNN layers consist of three steps. At first, the layer performs several convolutions to produce feature maps. Second, non-linear activation functions are used on the resulting maps. Third, the output is modified by the pooling layer before reaching the next convolutional layer. The idea of a pooling function is to extract a summary statistics of non-overlapping neighbourhoods usually to reduce the number of parameters in the following layers, control over-fitting, and achieve slight translation invariance. Thus, the max pooling and average pooling are widely used because, their operations are common except than that of activation function.

Fully connected layer:

The Fully Connected layer (FC) has a full connection to all of the units in the previous layer. This layer changes the previous features of 2D structure into a predefined one dimensional feature vector. The implementation of FC layers require a large number of parameters compared to other layers as each cell of a feature map is fully connected to all elements in the previous layer. Besides, it consists of several drawbacks such as it produce only a single output for multi layered network, and it accepts only a fixed-size inputs. Thus the proper solution to these problems is that the FC layers can be converted to convolutional layers of 1 × 1 kernels (1 × 1 × 1 kernels in case of 3D).In this way, it keeps the model fully connected layer while it accepts the image input size and making huge predictions for analysis.

Recurrent Neural Network (RNNs):

Recurrent neural network (RNN) is a class of Artificial Neural Network (ANN)RNNs have traditionally used for analysing sequential data, such as the words in a sentence. Due to their ability RNN have been employed in text analysis

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tasks, like machine translation, speech recognition, language modelling, text prediction and image caption generation. Thus the output layer of RNN is added to the next input layer and this is fed back into the layer called feedback network for resulting in a contextual memory as well as significant performance [7].

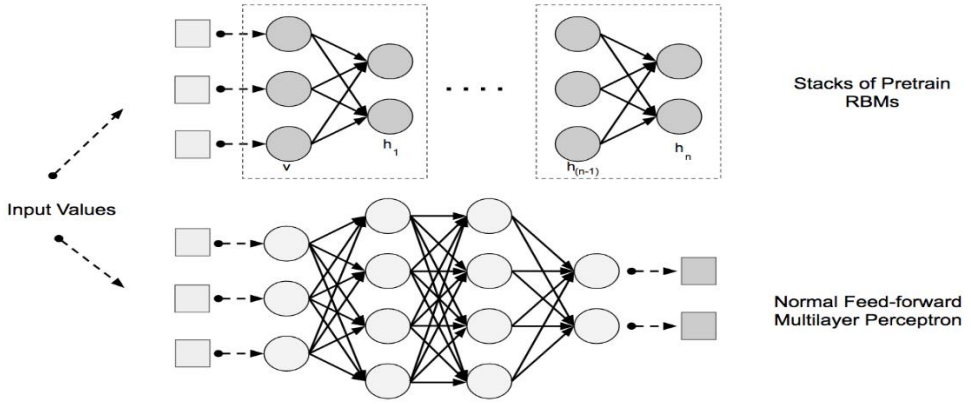

Fig. 3 Deep Neural Network

Deep Learning Neural Network (DNN):

The Deep Neural Network (DNN) constructed by using an artificial neurons that trying to intimate the behaviour of human brain which are the basic components of Artificial Neural Network (ANN). The fundamental computation of neuron called as node that receives information from the input from external sources. It consists of several internal parameters such as weight and bias which produce an output towards a network model. Thus the ANN consists of Multi-Layer Perceptron (MLP) with huge number of hidden layers [1]. Further, in deep learning the pre-processing and feature extraction are an automated process directly from the raw data with the help of feature learning (i.e, Learning approaches are done automatically). This is the major difference between the deep learning and machine learning. Thus the pre-processing and feature identification are merge into each other at the same time it can improve the entire training process to the system. In medical image processing, the deep learning is mostly activated by CNN because it is a powerful way to learn the representation of images are either 2D (or) 3D and structural data format [3].

III. CLASSIFICATION ALGORITHM OF DEEP LEARNING

In this section, several classification methods are examine with deep neural network including the convolutional layer, sub sampling layer, pooling layer and softmax layer. Here, some of the models are discussed with respective architecture such as Alex Net [13],VggNet [10], GoogleNet [14] and DenseNet [15] are most popular architecture for object recognition. Out of all, for large data analysis the GoogleNet and ResNet are considered as general architecture [1].

Alex Net:

Alex Net was developed by Alex Krizhevesky in 2012, it is a significant deep architecture and wider CNN model than LeNet, which consists of five convolutional layers and three fully connected layers as in [1]. Further, it has a fixed input image (227*227) image, the network would repeatedly convolve and pool the activations, then forward the results in to the fully-connected layers. Thus, the network was trained on Image Net and integrated various regularization techniques, such as data pre-processing, dropout. The Alex Net and set the tone have more interest

in deep convolutional neural network architectures. It consists of 11x11, 5x5, 3x3, convolutions, max pooling, dropout, data augmentation, ReLU activations, SGD with momentum. It attached ReLU activations after every convolutional and fully-connected layer. Alex Net was trained for 6 days simultaneously on two Nvidia GeForce GTX 580 GPUs which is the reason for why their network is split into two pipelines.

Vgg Net:

The Visual Geometry Group is known as VggNet, it was established in 2014 ILSVRC
[10]. The main objective of this classification is that it shows the depth of anetwork to achieve betterrecognition or classification accuracy in CNNs. It consists of two convolutional layers as well as ReLU activation function. Following that, activation function and ReLU are used as max pooling layer and fully connected layers. At, the final layer is a Softmax layer for furtherclassification. It was similar to Alex Net with only 3x3 convolutions, but associate with lot of filtersas shown in fig. 5. Nowadays, it is currently the most preferred for extracting features from images and the weight configuration of VggNet is available and has been used in many other applications and challenges as a baseline feature extractor [1].

Google Net:

GoogLeNet, was proposed by Christian Szegedy in ILSVRC 2014 [11]. It is used reduce the complexity between computational times when compared to CNN. Further, it is incorporate through Inception Layers which has variable receptive fields that are created by different kernel sizes. These receptive fields created operations that captured sparse correlation patterns in the new feature map stack. While, it gives better accuracy than human level performance and this module is based on several very small convolutions in order to drastically reduce the number of parameters. Their architecture consisted of a 22 layer deep CNN but reduced the number of parameters from 60 million (Alex Net) to 4 million.

Residual Network (ResNet):

Residual Network (ResNet), it was developed in 2015by Kaiming He. It is a traditional feed forward network with residual connection, fordesigningaultra-deep neural networks with different numbers of layers such as 34, 50,101, 152, and 1202. At the end of the network, the popular ResNet50 contained 49 convolution layers and one fully connected layer. It consists of several blocks with different architecture of ResNet and the wider version was proposed by Zagoruko el at. [15]. Also further transformation are analysed with both inception and residual units [1]

Densely Connected Network (DenseNet):

DenseNet developed by Gao et al. in 2017, which consists of densely connected CNN layers, the outputs of each layer are connected with all successive layers in a dense block [12]. Therefore, this concept is efficient for feature reuse, which dramatically reduces network parameters. It consists of several dense blocks and transition blocks were each layers are mapped with respective input layers, which are placed between two adjacent denseblocks.

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Table. 1 Comparison of Classification algorithms [1]

Methods	Top-5 errors	No.of.convolutional layers	Weights	No. of FC layers
AlexNet	16.4	5	2.3M	3
VggNet	7.4	16	14.7M	3
GoogleNet	6.7	21	6.0M	1
ResNet	5.3	50	23.5M	1

IV. CONCLUSION

In recentyears, thedeeplearningplays an important rolein the development ofmedical image analysis by determining the internal and external morphological patternsand feature selection from the images in given datasets. Thus, the deep learning is a state-of-art performance beyond different applications like robotics, cyber, natural processing and medical applications. Finally, this paper concluded the overview of deep learning and compares the classification algorithm for future results.

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