A Profound Interpretation On Medical Image Classification Using Deep Neural Networks

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Abstract: Healthcare industry is in high priority compare to others, since people need an accurate, high quality of care and services regardless of cost. Symptomatic diseases have an influential impact on the continuum of care and on early diagnosis when it comes to screening, Diagnosis at a foregoing disease stage aid in patient prognosis and in Treatment Decisions. Deep learning algorithms, exceptionally convolution neural networks swiftly became a handpicked methodology to assay medical images in healthcare industry. This survey covers major Convolutional neural network architectures and we tried to include major deep learning concepts precise to medical image classification and various improvement to the field, also a brief overview provided on study of diabetic retinopathy from past three years. We confine with the prospectus of the nonce state-of-the-art, challenges and navigation for subsequent research.

Index Terms: Deep Learning (DL), Neural Networks, Medical Image Classification, Convolution Neural Network (CNN)

1 INTRODUCTION

Gone are the days where healthcare Information Technology was too small and medical image study was compassed with applications which make use of low-level pixel processing i.e. filters for detection of edge and line and other mathematical models i.e. using lines, eclipses and circles to compose a decree based system that deal with specific function. Initially, systems were designed completely by humans to produce results and predictions which can cause some errors. Now we are in a stage with high performance computing, where system is skilled by computers using data examples to extract element vectors to be able to deal with a big medical image data for authentic and efficient diagnosis. The very important step in developing such systems are to extract main features from the images. Next task is to determine features that most appropriately represent the data for a problem we hold. This can be attained by using deep learning algorithms. Deep learning helps to extract features and create contemporary ones, furthermore,it doesn't solely diagnose the unwellness however additionally estimate the prophetic rate to help doctors efficiently. There will be networks (models) framed of many layers that remodel given system file (images, videos, text) to outputs (At risk/low risk, sickness present) in parallel learning progressively more advanced level features. The most productive kind of networks for image classification till date is CNN. They contain several layers that remodel their input file with convolution filters. CNN determines its features directly from the image data, therefore eliminating manual feature extraction[6]. The first real world application in deep learning was developed by LeCun et al. called LeNet [5] to recognize hand written digits in 1998, which was also implemented in many banks to identify cheques with 32x32 input images. It took almost ten plus years to get a momentum in deep learning after the first success. In 2012, Krizhevsky et al. The described CNN, called AlexNet has won that contest in Image Net Challenge [7]. It has been a hot topic since last two years, many advancements are happening in this field specific to medical imaging to get more and more efficient systems. The reason behind the survey is to show how deep learning techniques are used in medical image classification, recognize the challenges of successful applications in Deep Learning to Medical Image Classification.

This paper presents an overall survey done on different applications of image processing which used DL techniques. Various DL methods including the activation functions used in CNN were discussed in second section . The third section focuses mainly on DL techniques which can be applied in the domain of Medical Image Analysis. Conclusion is mentioned in the section IV.

2 DEEP LEARNING METHODS

Deep Learning is an analogy to the functioning of human brain [8]. In deep learning, networks identifies the patterns, without human interference of artificial neurons by analyzing large dataset. Deep Neural Networks is a branch of Machine Learning and Artificial Intelligence. Machine learning uses a set of rules for acquiring a model of an object from data examples. A model or structure can be used to predict the unknown data using many forms as follows.

Decision tress
Linear regression
Neural Network weights

Decision trees predict the data by creating set of rules represented as a tree , In Linear Regression input data denoted by set of parameters and Neural networks have a parameter vector representing the weights on the connections between the nodes in the Neural Network. Below figure 1, explains the architecture of basic Neural Network which has one input layer, a hidden layer and an output layer. Each neuron in the Neural Network adds the data which is provided as input and apply an activation function to the added data and finally gives the output which will be delivered to the next layer. We can also add more hidden layers to solve complex problems by capturing non-linear relationship which is knows Deep Neural Network.

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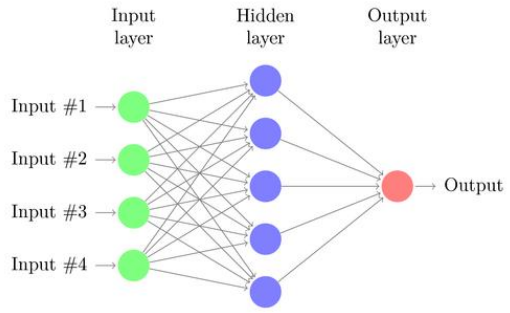

Fig 1: *Neural Network Architecture*

2.1 Learning Algorithms

Generally, Machine Learning techniques are categorized into two types such as Supervised Learning and Unsupervised Learning. Supervised learning have input variables (X) and an output variable (G), from input to output we use algorithm to learn the mapping function G= f(X). If the mapping function is well-defined, it is easy to predict the output variable 'G' whenever we give input (X). Simply we will have a training data set to predict the output. Here training data set supervises the learning process. This process will continue till we achieve an expected performance from the algorithm. Classification and Regression are the two main problems in supervised learning. If the prediction value is a category i.e. (blue or red, At Risk or Low Risk) then we call it classification. If the prediction value is a real value like (weight or rupees) then we call it as regression problem. In unsupervised learning, we will have input data 'X', but there will not be any output variables. The main objective of unsupervised learning is to determine the hidden patterns from unlabeled data. Clustering and association are the two types of unsupervised learning. If we want to identify inherent groups in data like customers purchasing behaviors, then it is a clustering problem. If the user wants to identify new expectations that describes a patterns like customer consuming a product A have the tendency to buy a product B.

TABLE 1
TOP 6 PERFORMING ACTIVATION FUNCTIONS

Name	Function
Sigmoid	$f(X) = \sigma(X) = 1/(1 + e^{-X})$
Swish	$f(X) = X \cdot \sigma(X)$
maxsig	$f(X) = \max\{X, \sigma(X)\}$
cosid	$f(X) = \cos(X) - X$
minsin	$f(X) = \min\{X, \sin(X)\}$
arctid	$f(X) = \arctan(X)\ 2 - X$
max	$\tanh f(X) = \max\{X, \tanh(X)\}$

2.2 Convolutional neural networks

CNNs are first introduced by LeCun in 1998 and used in so many applications today, from image classification to audio features. It is a unique kind of neural network for processing data with grid or image like communication network which can be either one or multi-dimensional data. CNNs have three important features that reduces the parameters in neural network.

Sparse Interaction
Parameter Sharing
Equivariant Representation

In typical feed forward neural network, every neuron in each layer is connected to the other in the next layer, which can further cause many problems like learning or training the network becomes too complex with the increase in convergent time. CNN's, reduce it through indirect interactions or sparse interaction, if the layer run deep we don't need every neuron to relate to other in the next layer to carry information throughout the network. After convolution of an image, in the next layer spares are created using same set of shared parameters which extremely reduces the parameters to learn from an artificial neural network. Convolution is equivariant with respect to translation, convolving an image and translating will give the same result, even if we first translate and convolving it next. An activation function is used on each layer to process a given input on layer to next hidden layer as a output. There are many activation functions available some of them are mentioned below. It is important to have an activation function to increase the performance of the network [18].

2.3 Hardware and Software

Hardware is one of the reasons to improvement of deep learning technology with the availability of fast computing, GPU (Graphics Processing Unit) and its libraries like Open CL, CUDA. GPU has fast processing engine with more number of execution threads than CPU (Central Processing Unit), With this deep learning on GPU is 20 - 30 times faster than CPU. Along with the hardware, open source software packages made deep learning much popular. Below mentioned are some of the open source libraries which are widely used while writing software programs specific to deep learning (in alphabetical order). Caffe: A framework developed by Berkeley AI Research (BAIR) which is developed in C++ and with python interfaces [14]
TensorFlow: An open source library developed by the engineers from Google in C++ and python interfaces [15]
Theano: Theano is a Python library developed by MILA in Montreal which optimizes compiler to manipulate and calculate mathematical notations with NumPy-esque syntax [16]
Torch: An open source library in Lua interface which is widely used in many reputed companies [17]

3 DEEP LEANING IN MEDICAL IMAGE CLASSIFICATION

Image classification is one the key areas where deep leaning techniques are used. In medical exam classification, There are one or multiple images (an exam) as input and a single parameter as output (Illness present or not). The Applications of deep learning in healthcare covers a wide range of problems from problem screening to giving personalized treatment suggestions. With the help of different data sources available today, like radiological imaging (X-Ray, CT and MRI scans), pathology imaging

has brought an extremely large amount of data at the physician's disposal.

3.1 Image Classification Process

Image Classification process typically follows below procedure for preparing an image dataset from Image database Image Preprocessing -> Feature Extraction-> Feature Selection-> Classification-> Result To increase the image quality, it is important to preprocess it, so that the phase feature extraction will become easier and the reliable one[10]. There are many classification methods are available in the market like and we choose them as per our requirement. CNN's are one of the most recurrently used deep learning method which learns directly from image data and eliminates manual feature extraction[20]. Hasbi Ash Shiqddieqy, Farkhad Ihsan Hariadi, Trio Adiono experimented two distinct structures of CNN are used, namely with two and five layers and It conclude that the CNN with higher layer performs classification process with much higher accuracy [24] . Rui Wang, Wei Li, Runnan Qin and JinZhong Wu stated that performance of classification accuracy by Simplified-Fast-Alexnet is 96.99 percent for assumed blur dataset and 92.7 percent for natural blur data set, which is almost equals to AlextNet and other well-known models [25]. Ye Tao, Ming Zhang, Mark Parsons proved that deep CNN can achieve higher classification accuracy than a fully connected architecture [26].

3.2 Functional Application Areas

Below is the brief discussion of some application areas of deep learning specific to medical imaging field.

A. Brain

Bayesian networks or belief networks have been widely used for brain image classification. The focus is on Alzheimer's disease and segmentation, detection of lesions including tumors and micro-bleeds. In [22] authors focused on estimating the brain network, Huntington's disease classification and Schizophrenia based on deep belief networks.

B. Eye

Fundus color image classification and analyzation, eye disease diagnosis, detection andsegmentation are the key areas to research in ophthalmology. Blood vessel segmentation wasperformed by authors [28]. They used CNN and Conditional Random Field (CRF) for model to model long range pixel interaction. Still there are many researches going on retinopathy. Giant organizations like Google are focusing more on this field.

C. Heart

Deep learning has been utilizing in many areas of Cardiac Imaginary Analysis. MRI is the most analyzed area, other than this there are researches on calcium scoring, classification and coronary centerline tracking.

3.3 Diabetic Retinopathy

These days, it has diabetes has become one of the common disease where there is a wide range of age of patients suffering from the disease. There had been many causes which may lead to diabetes and knowingly most of them couldn't overcome them to avoid being affected by the disease. As a result, almost half of the population is being or likely to be effected by diabetes. Diabetic patients who couldn't control the levels of blood sugar by any means may have a chance to get their organs of the body slowly affected on a negative note. Up to some extent, they may not be able to recognize this until there is a sign of any problem/ mal-function of the respective organ. One such organ which has a negative effect up on the increased level of blood sugar in diabetic patients is Eye. Eye plays a major role in our day-to-day life. Such a condition, where diabetic patient suffering from Diabetic Retinopathy develops some irregularities in the vision, hemorrhages, exudates, microaneurysm which can be identified in the Retinal Image of the Patient.

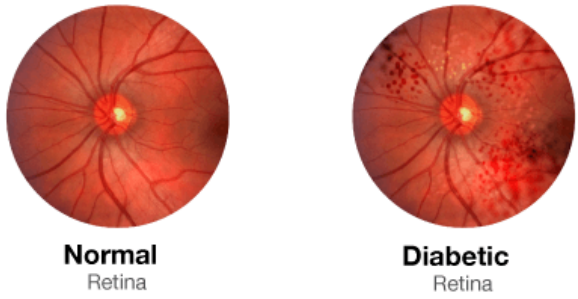

Fig 2: *Normal Vs Diabetic Retinal Image*

Among patients with diabetes, the presence of diabetic retinopathy is approximately 28.5 – 40.0 % among the people in the United States and around 30 % in India. As per the instructions of different health systems, it is advisable to the patient to have an annual screening for those with noDR or mild diabetic retinopathy and repeat the examination in 6 months for moderate diabetic retinopathy, and an ophthalmologist referral for treatment evaluation within a few weeks to months for severe or worse diabetic retinopathy or the presence of referable diabetic macular edema known as "clinically significant macular edema". But these days, clinical testing was not advisable as it may have to make the patient suffer for a while due to the fluids used in their eye pre/post test. So there should be a system to test the patient's eye for DR in an easier and faster manner.

4 CONCLUSION

Diabetic Retinopathy is one of the serious issue for which definitely considerable attention is required to solve the related complications and minimize them at earlier stages. The experimental works which should be done on this area need to concentrate more on accurate results for the mild and earlier stages of DR to give a warning sign to those who may have a chance to reduce the affect with necessary care. This may add advantage to patients not leading to severe stages of DR.

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