# MEDICAL IMAGE ENHANCEMENT THROUGH DEEP LEARNING METHODS

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**Abstract:** In recent years, machine learning algorithms are commonly used in the field of digital image processing for interpreting images based on domain specific knowledge in terms of different aspects like image classification, object/pattern recognition, clinical image diagnosing, traffic control systems, satellite imaging, geomorphological and agriculture sectors etc. to analyse ROI from large amount of captured electronic images via different modalities. Machine Learning (ML) is an outlet of Artificial Intelligence (AI). It has ability to learn by itself without any extra effort like explicit programming. In this paper, we will deliberate the emerged expanse of ML – Deep Learning (DL) which is basically a group of concepts with high level of data abstraction. Its application areas are especially analytical study of medical images such as anatomical structure detection, image registration and enhancement, computer aided disease diagnosis, tissue segmentation, and so on. DL based architecture provides exhilarating results with moral accuracy and enhanced performance for medical image segmentation and classification.

**Keywords:** image classification, image segmentation, machine learning, deep learning

## I. INTRODUCTION

For effective diagnosis and treatment planning, different computer assisted medical imaging modalities are used like CT scan, PET, MR, mammography and so on over the last decades by radiologists and physicians. Recently, machine learning techniques have been improved in computation of medical image analysis by meaningful feature extraction. Still, it is quite difficult for non-experts to exploit few advance techniques for experimental medical imaging study. However, this stage is diluted with the help of learning step rather than feature engineering [1][2].

Due to incredible progression in medical image acquisition tools, the gathered images data are in large extent so, it makes image analysis quite challenging task. To reduce human error and to automate diagnosis process as well as for high performance computing, deep learning techniques will be proven towards the announcement of actionable prediction model to help clinician efficiently. Technically, deep learning methods are the improvement of conventional methods like SVM, NN, K-NN etc. with multiple filtered deep layers to enhance the outcomes when number of samples are large during training stage like CNN, RNN, DBN and many more. The conventional methods have few limitations in processing complex images with a lot time [3][4].

In this research paper, we have discussed few differences between deep and machine learning in medical domain in section II. Deep learning methods are briefed in section III. Various deep learning applications in medical domain are listed in section IV. Section V discusses about future advancement and directions towards deep learning. We end with a summary in subsequent section VI.

## II. DEEP LEARNING OVER MACHINE LEARNING IN MEDICAL IMAGING

For accurate diagnosis and treatment planning, interpretation of medical images paly crucial role. Also, image acquisition hardware devices become advance day by day, so plenty of high resolution images are acquired to study. Though extensive variation in images of patients, traditional learning methods are not reliable. In last few years, the problem is somehow overcome with the help of various machine learning methods. Now, compare to machine learning, deep learning methods are based on concept with sophisticated level of data abstraction by various hidden processing layers between input and output layers [3]. It has the advantage to learn low level features like edges automatically and integrate them to high level features like shapes. It promises to replace manual processing for feature extraction with involvement of unsupervised, supervised or semi-supervised approaches of machine learning. Deep learning methods ensure better outcomes than the shallow traditional machine learning methods in case of vast amount of training data with the need of expensive hardware resources like GPU, memory and all and high running time for implementation [4].

## III. DEEP LEARNING METHODS IN LITERATURE

Generally, ML methods are broadly classified into two approaches – supervised and unsupervised. Supervised approach processes data with labels while unsupervised approach processes data without labels. In unsupervised learning, data are well-trained to recognize patterns. This paradigm led to development of rule-based, expert systems. Then they moved from heuristic based approach to manual feature extraction approach. Below we have discussed some fundamentals of deep learning approaches from the literature survey [5].

### A. Neural Networks

This approach forms the base for most deep learning methods. It comprises of interconnected neurons. They take multiple images as input and perform some computing over them and then forward the current layer outcome to the next subsequent layer for further processing. Such networks majority neighboring units of same layers are fully connected to each other rather than connections among the units in the same layer. You can train a network to accomplish the targeted task by setting the weights of elements. Most applications of neural networks are approximation and classification problems. They are ideal for recognizing diseases using scan. Rather there is no need to define specific algorithm than to select set of examples carefully that are condemnatory of all the variations of the diseases [6].

### B. Convolutional Neural Networks – CNN

It is a supervised learning approach. In CNN, the weights are sharped in a manner that it performs convolutional operations on image data. Here, the number of parameters is not dependent on the image size. It is designed to better utilize spatial and configuration information by taking 2-dimensional and 3-dimensional images. It is well suited to perform tasks like image classification, recognition, detection, localization, segmentation etc. Structurally, pooling layers and convolutional layers are combined. They follow fully connected layers. The role is to perceive various local features at different spots in input feature maps [7][8].

### C. Deep CNN Architectures

In this architecture, more hidden layers are used which allow complex non-linear relationship and beneficial for classification and regression task. Here, the training progression is not inconsequential. The error is circulated back to preceding layers. It gives noticeable results when trained by unsupervised manner followed by supervised manner. It can take more input image data than trained data and generate a likelihood map. Here, no single outcome for an individual pixel. Due to lower memory requirement at the time of inference, they are used in mobile computing. Different types of deep CNN architectures are mentioned in literature for different aspects. Few of them are LeNet, AlexNet, ZFNet, GoogleNet, VGGNet, ResNet, U-Net etc. [9][10][11].

### D. Recurrent Neural Networks – RNN

Generally, RNN is used for learning and analyzing sequences. Due to this capability, it can be applied in applications like character/text prediction, speech recognition, image labeling etc. Here, the output is added to the next subsequent input and is nourished posterior into the layer. This will result in massive relative memory. In medical applications, mainly it is used in segmentation to get accurate and promising results [12][13].

### E. Deep Boltzmann Machines – DBM

DBMs are probabilistic and generative based on Markov Random Field – MRF which require small sized dataset to train. They are bidirectional graphical models comprising of visible and hidden layers. For reconstruction, they use backward pass and estimate original input. The estimated inference process with a preliminary bottom-up pass integrate with top-down feedback allows it to better proliferate uncertainty and hence deal more robustly in case of ambiguous inputs also [14].

### F. Deep Belief Networks – DBN

DBN is unsupervised learning method contrast to backpropagation network. It has one visible and sequences of hidden layers. It is composed of Restricted Boltzmann Machines – RBNs for pre-train phase and then a feed-forward for the fine-tune phase. The aim is to infer the states of unobserved data and adjusting the weights between these data so that the network can generate similar to the observed data. At first, it learns first layer from visible units and then learns features of features in second layer. This learning process will continue till learning for the final hidden layer is achieved. i.e. training can be done by greedy learning approach that trains on RBN at a time and continues until the last one. A good thing about DBN is its scalability means one can adjust parameters and train model accordingly depending on data. So, there are many possibilities to implement it as per application [15].

### G. Deep Auto-Encoders

It is composed of three layers. One is input layer and others are output layers i.e. two symmetrical DBNs, one is encoding DBN and another is decoding DBN. Here, its inputs are reconstructed by training which navies the hidden layer to acquire good representation of inputs. Here, in backpropagation process, the targeted values are equivalent to the inputs. Few variants of auto-encoders are denoising autoencoder, sparse auto-encoder, variational auto-encoder, contractive auto-encoder etc. [16][17].

## IV. DEEP LEARNING APPLICATIONS IN MEDICAL IMAGING

Medical Imaging requires initial diagnosis to identify abnormalities in tissues as well as to study variations in different cells of human anatomy. Automated image analysis tools based on various techniques expand the superiority of diagnosis and treatment planning. Applications of deep learning in the medical domain shelter a varied range of efficient problem-solving mechanism [18-24]. Here, we have highlighted few of them.

**Classification:** Classification separates regions from of medical images based on experimental features into multiple classes results. For deep learning classifiers, transfer learning from pre-train network model is required for large experimental data set.

**Detection:** Detection is based on localization i.e. image feature that can distinguish one structure from another one. It results in Boolean value for medical images i.e. if there is some defect presents then value is true otherwise false. Normally, it is useful to detect organ/tissue. Here, pooling operation is performed after each layer so the features can be compressed in further supervised process.

**Segmentation:** Segmentation of medical images allows quantitative analysis of various parameters for different parts/ anatomical structure of human body through which we can identify set of pixels/voxels of ROI. Especially, plenty of segmentation techniques are used to segment abnormal tissues from brain MR images.

**Registration:** It is used mostly to identify local anatomical characteristic. This technique is generally problem specific so there is no guarantee to apply one approach for the other image type. Current methods use supervised learning to find essential features from targeted image with manual labeled training data. It may be possible to misinterpret data as learning procedure is often restricted to the particular domain. To overcome this limitation, it is necessary to define a general framework that can be compliantly applied to different medical images for accurate feature detection.

### A. Other

**Content Based Image Retrieval** – CBIR : It is an approach of knowledge for identifying similarities based on different criteria from massive medical image dataset. Deep learning models have strength to learn characteristics with remarkable abstraction and from these extracting operative features with pixel level contextual info.

**Image generation and enhancement :** Deep learning architectures are also useful to improve image quality by removing hindering elements from images and to enhance them by normalization. Such techniques find the alterations between the original image and looked-for output image by using loss function and bridge through training the dataset.

### B. Anatomical Application Areas

It is notable that an approach of deep learning can be applied in different aspects without any or few modifications. In some applications, pre-trained models are used while in some applications we have to train images based on problem domain [25-31]. Let us brief about few deep learning applications in various regions of human anatomy.

**Brain:** Deep Learning approaches have been broadly used to classify and segment tumor, cancerous tissues, Alzheimer, WM, GM and CSF from brain MR images as well as studying anatomy of brain.

**Eye:** Now-a-days, deep learning methods are experienced and applied in ophthalmic imaging for detecting retinal abnormalities and diagnosing other eye related diseases. Recently, in Google I/O, Mr. Sundar Pichai has discussed the application of deep learning in which one can measure the age as well as gender from retina scan.

**Chest:** Deep learning has given tremendously hopeful result for cardiac imaging. Various imaging modalities like X-ray, CT scan, MRI are used for calcium quantification, detecting lung diseases etc.

**Breast:** Deep learning algorithms proven a great success in detection and classification of micro calcification, mass lesions, cancer etc. from breast MRI. It is quite difficult as lesser availability of large public dataset compare to mammography technology.

**Skin:** Domains like dermatographia image analysis as well as diagnosing skin cancer, therapy based on deep learning decisions are recognized very fruitful for remarkable cure.

## V. FUTURE ADVANCEMENT IN DEEP LEARNING

There are still several challenges to implement deep learning approaches in medical domain due to many reasons. It is vital to train deep learning-based models due to the inadequate number of training samples compared to the number of varied learnable parameters. So, techniques like initialization and momentum, Rectified Linear Unit (ReLU), drop-connect, batch normalization etc. must require to better train deep models. Apart from this, recent trend of reinforcement and active learning approaches (extension to deep learning) also may offer better solutions in some complex cases like multiclass system. In medical imaging, not all facts are easily found in an image itself. In that case, medical practitioners normally pull few useful information into experimental images for better decision making. Such supplementary information are investigated, combined and nourished into problem under study using advancement of deep learning techniques will make the whole diagnostic process more straight forward and human intervention free.

## VI. SUMMARY

Image processing and machine learning show vibrant part in analyzing, diagnosing and treatment planning in the field of medical domain. Also, during recent few years, deep learning assured improved results compare to traditional approaches in medical imaging sector. We have discussed variety of applications where deep learning approach proved efficient than machine learning approach. Still there are many challenges in deep learning applications especially in healthcare area. There is a requirement of more sophisticated deep learning methods in some clinically complex cases yet limitless openings wait to produce and to improve fully automated diagnostic systems.

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