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A Review of Deep Learning Techniques

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Abstract: *In today's world, Deep learning techniques are playing a vital role in all areas. It has already made a massive impact in almost every field, such as self-driving cars, cancer diagnosis, predictive forecasting, precision medicine and speech recognition. The limitations of traditional learning techniques are overcome by deep learning techniques. In this paper deep learning and its techniques are discussed.*

Keywords*—Deep Neural Network, Recurrent Neural Network, Convolutional Neural Network, Restricted Boltzmann Machine.*

1. Introduction: With a massive influx of multimodality data, the role of machine learning has grown rapidly in the last few years. In last decade various machine learning techniques like decision tree, naive Bayesian, support vector machine and K-Nearest Neighbour have been utilized for developing models to solve real life problems such as predictive forecasting, speech recognition, diseases diagnosis and NLP. These techniques have provided successful results but fails when amount of data increases abruptly. And one of the other reasons for traditional machine learning failure is its features extraction capability. These classification techniques do not give good result if we forget to give some parameter. These problems are overcome as the concept of neural network was introduced in AI. After that machine learning is revolutionized completely. Deep learning techniques are based on the concept of neural network; provide amazing results in all fields. In this paper we discussed deep learning, various techniques of deep learning. In the first section of paper introduction is given. In second section of the paper deep learning and its working is described. In next section various deep learning techniques such as CNN, RNN, LSTM and Autoencoder and Restricted Boltzman Machine are described. In fourth section of the paper conclusion is given and last section contains references.

2. Deep Learning: Deep learning is a subarea of machine learning that is emerged from the concept of neural network. Neural network is inspired by and resembles the human nervous system and the structure of the brain [1][2]. It is an application of Artificial Neural Network in which number of hidden layer is one but as number of hidden number of hidden layer increases network goes deeper and it refers to deep neural network. Deep learning can be applied in almost every machine learning problem. The layers in DNN are divided into three categories broadly input layer, multiple hidden layer and output layers. Input layer is used

to give input to the network, hidden layer process the input provided and output layer generates output to the system. Input in hidden layers processed a distributed representation and the main driving variables of the input data. Deep learning working model is divided into two phases, training and testing. In training phase of model, model parameters with random numbers are introduced and the pre-train some models are done. After first iteration completes then next step is to read and processes the training data and training errors are calculated by comparing the obtained output with expected output. Then parameters are upgraded according to training error through error backpropagation. Then testing phase is performed to find whether conditions of the iterative training are met for termination or continue the iterative process of training [3]. For designing a complex deep neural network requires complex and high level resources for computation along with large amount of training data. Deep learning models have automatic feature extraction capability that make it different from traditional machine learning algorithms, means user need not to specify the feature to the model, neural network architecture itself find out important feature required for desired results. Deep learning network provides high level of abstraction; even developer does not know how neurons in the network are connected and how data is processed within the network. For solving problems deep learning uses end to end process. Suppose we have a task of multiple object detection, when we solve this problem with earlier machine learning model then whole task is divided into two phases in first phase we apply bounding box detection algorithm to find all the objects on a image and then we apply a recognizer algorithm like support vector machine to detect a particular object on the image. Whereas deep learning performs whole task in one go. We apply euro net deep learning algorithm in which we pass image to the model it gives the location along with the name of the object. As deep neural network is very complex, it requires Graphics processing units for processing large matrix multiplication and other complex operations. Deep learning requires large amount of data to train the machine so that it can generate accurate results so training time of DNN is more than traditional machine learning models. Where is best to apply deep learning:

Deep learning is ideal to use where we have to predict results from large amount of data.

Deep learning is applied to solve those complex problems that are very expensive to solve with human decision making.

3. Techniques of deep learning [1]:

CNN: is a feedforward neural network that is generally used to analyse the static or image data and is also known as ConvNet. In CNN, whole architecture is divided into three layered structure. In image identification, CNN take the input image, process it, and classify it in a certain category e.g. cat, dog, tiger. In computer image is stored as an array of pixels. Like the traditional machine learning architecture, CNN also have to train for data to solve a particular problem. For this first architecture of Neural network is decided like how many layers are used in network, how we arrange the layers, which layer to use, and how many neuron to be used in a layer. Various CNN architectures are AlexNet, GoogleNet, Inception ResNet, and VGG. Once network architecture is decided after that various biases and parameters for the network are selected bases on the problem. At first these are selected randomly but further they are changed through back propagation. Objective of this phase is to find the best possible values of network parameters and data

features so that further identification of data can be accurately done. For e.g. when we try to build a classifier for cat and dog then we are looking to find the parameters that gives the probability of dog 1 or higher than cat and for all the images of dog or 0 or less than dog for cat image. Whole CNN process is divided into two parts feature learning and classification. In feature learning there are three steps performed many times for different feature detection. These are convolutional operation, ReLu and Pooling. In classification image is classification is performed. In this phase three operation is performed flattened, fully connected and softmax operations [4][5].

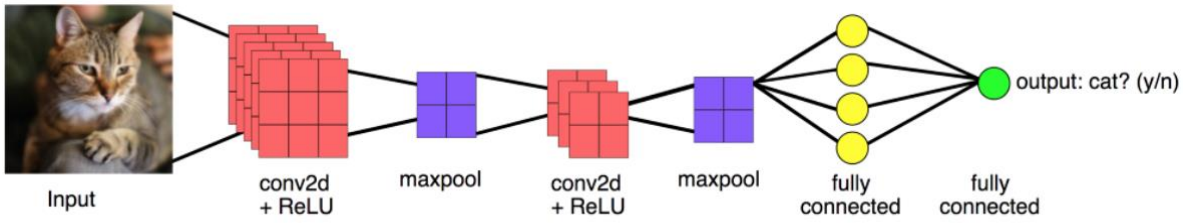

Figure 1. CNN Architecture[5][6]

Convolutional layer: in this layer filter works on every part of the image. And search same feature everywhere in the image. This layer involves shift, multiply and sum operations. The purpose of this layer is to identify the basic pattern of which the object in the image is made up of. Output of this layer is a new modified filtered image. In this layer features are identified. In training phase this layer identified the most accurate feature for image classification.

ReLU layer: is rectified linear unit. Once features are extracted then next step is to move them to ReLU layer. This layer mainly performs element wise operations, sets all the negative values to zero and introduces non linearity to the network. At this layer sigmoid function are applied. This function removes all the black elements from the images.

Pooling layer: provides the down sampling to the output that reduces the dimensionality of the feature map. Pooling layer reduces size of each feature map by 2. Two types of pooling can be applied in CNN, Average pooling and max pooling. In average pooling feature map is patched with average value and in max pooling feature map is patched by maximum value of the matrix.

These three steps are applied multiple times to find best features of the data.

***Flattening layer*:** this layer transforms the matrix into a vector form so that it can be fed into a fully connected NN classifier.

Fully connected layer: at this layer data is in one dimensional structure. This layer helps in classifying the input pattern with high-level features extracted by previous layer. This layer gives a probability that a certain feature belongs to a label. For example, if the image is of a cat, features representing things like whiskers or fur provide high probabilities for the label "cat". Surtax activation function is used to provide probability to each label.

RNN: is Recurrent Neural Network that is applied to problems where data changes according to time. A single time step of input is provided to the network in RNN. In first step current state is calculated by using current input and output from the previous state. In next step current state become the previous state. Once all time steps are completed then output state is calculated from the current state. Output obtained is then compared with expected output and error is calculated. This error is back propagated in the network to upgrade the parameters and weights. In this way RNN network is trained. The process of calculating error rate and upgrading weights and parameters is called vanishing gradient. In RNN vanishing gradient can only remember one step output but sometime problem requires outputs from long distant states for this LSTM is used. LSTM have a chain like structure. In LSTM first architecture identify unnecessary information that is throwing away from the cell state. This is done by sigmoid layer called forget layer. Then model identify the information that is necessary for further processing. This is done through tanh activation function. After this output from previous stages is combined to update new cell state [7][8].

Autoencoders: is an unsupervised algorithm which uses back propagation algorithm for setting the desired output equal to the input. Autoencoders are based on the concept of principal component analysis (PCA). It uses layer by layer fin-tuning with backpropagation and unsupervised pretraining [9] It is lossy compression. Autoencoder can easily works on non linear data. Autoencoder have multiple representations of data. Autoencoder uses convolutional layer for learning feature from data so it does not require learning from dense layer. It is widely used in image reconstruction, image colorization, and dimensionality reduction. . Hinton et al. achieved a perfect reconstruction of 784- pixel images using autoencoders which was better than principal component analysis technique [10]. Autoencoder are used only for which they are trained only we cannot apply autoencoder for another applications.

Restricted Boltzmann Machine (RBM): Restricted Boltzmann Machine is a deep learning technique applied on unlabeled data to build non-linear generative models [11]. RBM contains two layers called visible layer and hidden layer. Each node of visible layer is connected to all nodes in the hidden layer and no nodes are connected to other nodes in the same layer.RBM increases at the probability of vectors in the visible layers so that it can probabilistically reconstruct the unlabeled data. The energy (E) function of the configuration is used for this [12]

4. Conclusion:

The unmatched learning capability of deep learning made it an attractive and indispensable technique for analyzing data and images. It is successfully used in bioinformatics, medical diagnosing, precision medicine and speech recognition. Deep learning techniques are contributing to the high level of services in every field. In this paper we discussed various deep learning techniques CNN, RNN, Autoencoders and RBM. CNN technique is successfully used on image data whereas RNN and LSTM provide amazing results in textual data. RBM is usually used to build non-linear generative models. Feature extraction capabilities of deep learning techniques make it indispensably useful in every field.

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