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Deep learning Techniques in Image processing

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Abstract

Deep learning and image processing are two areas of great interest to academics and industry professionals alike. The areas of application of these two disciplines range widely, encompassing fields such as medicine, robotics, and security and surveillance. Deep learning a new challenge for all types of well- known applications such as Speech recognition, Image processing and NLP. Deep learning uses neural networks to learn useful representations of features directly from data. It uses a pertained neural network to identify and remove noise from images. The processing of images using deep learning is processed for image pre-processing and image augmentation for various applications with better results.

Keywords — **Deep Learning, Machine Learning, Image Pre-processing, Image augmentation**

I. INTRODUCTION

Deep learning has begun a most recent area of machine learning which built on a collection of algorithms in which high-level concepts of the data exhibited by using deep graph having many processing layers and multiple non-linear and linear transformations. Deep learning abilities to change hand engineered features with feature extraction techniques that are hierarchical, unsupervised or semi-supervised. Deep neural networks have more hidden units between input and output layers. With the coming on big data and high computational properties, the usage of deep learning grow into deep learning algorithms for upturns with the volume of data that is obtainable for training, and they also need of incredible computational power.

Deep Learning is a subfield of machine learning concerned with algorithms inspired by the structure and function of the brain called artificial neural networks. The benefit of deep learning models is their ability to perform automatic feature extraction from raw data, also called feature learning. Deep learning in terms of the algorithms ability to discover and learn good representations using feature learning. Ian Goodfellow and Aaron Courville, they define deep learning in terms of the depth of the architecture of the models. “The hierarchy of concepts allows the computer to learn complicated concepts by building them out of simpler ones. If we draw a graph showing how these concepts are built on top of each other, the graph is deep, with many layers. For this reason, we call this approach to AI deep learning”.

Early approaches published by Hinton and collaborators focus on greedy layer wise training and unsupervised methods like autoencoders, modern state-of-the-art deep learning is focused on training deep (many layered) neural network models using the backpropagation algorithm. The most popular techniques are:

- Multilayer Perceptron Networks.

- Convolutional Neural Networks.
- Long Short-Term Memory Recurrent Neural Networks.

II. Deep Learning

The widely said deep learning founded algorithms are as follows,

A. *Deep Neural Networks (DNN)*

A deep neural network (DNN) is an ANN with multiple hidden layers between the input and output layers. DNN architectures generate compositional models where the object is expressed as a layered composition of primitives. The extra layers enable composition of features from lower layers, potentially modeling complex data with fewer units than a similarly performing shallow network DNNs are typically feed forward networks in which data flows from the input layer to the output layer without looping back.

B. *Convolutional Neural Network (CNN)*

CNN is a variant of the feed-forward network that involves various layers and deeply connected architecture. CNN's trained with a modified form of the back-propagation algorithm. They are capable of recognizing patterns with a lot of variabilities and hence are widely used for this purpose.

C. *Neural Network (RNN)*

RNN is a particular type of Artificial Neural Network (ANN). It has directed cycles between connections. The dynamic temporal behavior exhibits by the internal state of the network. Unlike ANN, arbitrary sequences can process by using the internal state of RNN. There is a time-varying real-valued activation in every unit and modifiable real-valued weight in each connection. The Long short-term memory (LSTM) is an RNN based deep learning system that overcomes the vanishing gradient problem of traditional RNN. The recurrent gates called forget gates augmented in LSTM. It is beneficial for time-series data.

D. *Auto Encoders*

An autoencoder neural network is an unsupervised learning algorithm that applies back propagation, setting the target values to be equal to the inputs. An autoencoder aims to learn a representation (encoding) for a set of data, typically for dimensionality reduction. The concept of autoencoder has become more widely used for determining generative models of data.

E. *Restricted Boltzman Machine*

Restricted Boltzmann machine is an algorithm useful for dimensionality reduction, classification, regression, collaborative filtering, feature learning and topic modeling. RBMs are shallow, two-layer neural nets that constitute the building blocks of deep-belief networks. The first layer of the RBM is called the visible, or input, layer, and the second is the hidden layer.

III. Deep Learning Challenges

Deep Learning has become one of the primary research areas in developing intelligent machines. Most of the well-known applications (such as Speech Recognition, Image Processing and NLP) of AI are driven by Deep Learning. Deep Learning algorithms mimic human brains using artificial neural networks and progressively learn to accurately solve a given problem. But there are significant challenges in Deep Learning systems

- Requires tremendous amount of data for proper training.
- Lack of generic intelligence, most of the deep learning models work for the specific purpose only.
- Requires too many computational resources (like GPUs)
- Running time is very high varying from hours to days.
- Lack of flexibility.

a) Lots and lots of data

Deep learning algorithms are trained to learn progressively using data. Large data sets are needed to make sure that the machine delivers desired results. As human brain needs a lot of experiences to learn and deduce information, the analogous artificial neural network requires copious amount of data. The more powerful abstraction you want, the more parameters need to be tuned and more parameters require more data. For example, a speech recognition program would require data from multiple dialects, demographics and time scales. Researchers feed terabytes of data for the algorithm to learn a single language. This is a time-consuming process and requires tremendous data processing capabilities. To some extent, the scope of solving a problem through Deep Learning is subjected to availability of huge corpus of data it would train on.

The complexity of a neural network can be expressed through the number of parameters. In the case of deep neural networks, this number can be in the range of millions, tens of millions and in some cases even hundreds of millions. *Let's call this number P*. Since you want to be sure of the model's ability to generalize, a good rule of a thumb for the number of data points is at least *P*P*.

b) Overfitting in neural networks

At times, the there is a sharp difference in error occurred in training data set and the error encountered in a new unseen data set. It occurs in complex models, such as having too many parameters relative to the number of observations. The efficacy of a model is judged by its ability to perform well on an unseen data set and not by its performance on the training data fed to it. In general, a model is typically trained by maximizing its performance on a particular training data set. The model thus memorizes the training examples but does not learn to generalize to new situations and data set.

c) Hyperparameter Optimization

Hyperparameters are the parameters whose value is defined prior to the commencement of the learning process. Changing the value of such parameters by a small amount can invoke a large change in the performance of your model. Relying on the default parameters and not performing Hyperparameter Optimization can have a significant impact on the model performance. Also, having too few hyperparameters and hand tuning them rather than optimizing through proven methods is also a performance driving aspect.

d) Requires high-performance hardware

Training a data set for a Deep Learning solution requires a lot of data. To perform a task to solve real world problems, the machine needs to be equipped with adequate processing power. To ensure better efficiency and less time consumption, data scientists switch to multi-core high performing GPUs and similar processing units. These processing units are costly and consume a lot of power. Industry level Deep Learning systems require high-end data centers while smart devices such as drones, robots other mobile devices require small but efficient processing units. Deploying Deep Learning solution to the real world thus becomes a costly and power consuming affair.

e) Neural networks are essentially a Blackbox

We know our model parameters, we feed known data to the neural networks and how they are put together. But we usually do not understand how they arrive at a particular solution. Neural networks are essentially Balckboxes and researchers have a hard time understanding how they deduce conclusions. The lack of ability of neural networks for reason on an abstract level makes it difficult to implement high-level cognitive functions. Also, their operation is largely invisible to humans, rendering them unsuitable for domains in which verification of process is important.

f) Lack of Flexibility and Multitasking

Deep Learning models, once trained, can deliver tremendously efficient and accurate solution to a specific problem. However, in the current landscape, the neural network architectures are highly specialized to specific domains of application. The system using deep learning models are incredibly good at solving one problem. Even solving a very similar problem requires retraining and reassessment. Researchers are working hard in developing Deep Learning models which can multitask without the need of reworking on the whole architecture. Deep Learning may be one the primary research verticals for Artificial Intelligence, but it certainly is not flawless.

IV. Image Processing

The basic mechanics outlined now to focus on actually deconstruct visual images to be processed in machine learning applications. This is an emerging field in machine learning and can be extremely difficult. To tackle these challenges the assessing and analysing image data is processed by image filtering, morphological operations and segmentation. Deep learning requires the ability to learn features automatically from the data, which is generally only possible when lots of training data is available, especially for problems where the input samples are very high-dimensional, like images.

Convolutional neural networks --a pillar algorithm of deep learning-- are by design one of the best models available for most "perceptual" problems (such as image classification), even with very little data to learn from. Training a convnet from scratch on a small image dataset will still yield reasonable results, without the need for any custom feature engineering. Convnets are just plain good.

A. Image Data Pre-Processing for Deep Learning

Deep learning uses neural nets with a lot of hidden layers (dozens in today's state of the art), and requires large amounts of training data. These models have been particularly effective in gaining insight and approaching human level accuracy in perceptual tasks like vision, speech, language processing. The theory and mathematical foundations were laid several decades ago. Primarily two phenomena have contributed to the rise of machine learning a) Availability of huge data-sets/training examples in multiple domains and b) Advances in raw compute power and the rise of efficient parallel hardware.

The most common image data input parameters are the number of images, image height, image width, number of channels, and number of levels per pixel. There are a number of pre-processing steps we might wish to carry out before using this in any Deep Learning are uniform aspect ratio Image scaling, mean standard deviation of input data, normalizing image inputs, and dimensionality reduction.

B. Image Augmentation for Deep Learning

Deep networks need large amount of training data to achieve good performance. To build a powerful image classifier using very little training data, image augmentation is usually required to boost the performance of deep networks. Image augmentation artificially creates training images through different ways of processing or combination of multiple processing, such as random rotation, shifts, shear and flips, etc.

V. CONCLUSIONS

Now, computer industry accepts deep learning a new challenge for all types of well-known applications such as Speech Recognition, Image Processing and NLP. The main problem is how we can use this image processing techniques using deep learning for increasing business and improvement in living standard of people. In this paper we are discussing the issues, challenges, algorithms as well as proposing some actionable insight for Deep learning in image processing. It will motivate researchers for finding knowledge for processing available image data in different forms in different areas.

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