CONVOLUTIONAL NEURAL NETWORK

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Abstract:

Over the few years deep learning is one of the emerging technologies. There are many innovations occurred in the deep learning industry. Among different types of neural networks Convolutional Neural Network (CNN) is one among the most used tool for solving various computer vision problems like object detection, face recognition, and for various monitoring related purposes. CNN has various reasons why it takes the lead among others. In this paper we will go through the various aspects of Convolutional Neural Networks.

Introduction:

The convolutional neural network (CNN) gives a great impact over the past few years in various domains. It is mostly used because it has more benefits over the other type of neural networks like Artificial Neural Network (ANN) as it has reduced number of training parameters. In mathematics and image processing the term convolution means generating a function based on the operation of two different functions. Unlike image processing there is no need of pixel to pixel calculations in CNN as it has the aspect of extracting contextual information from the input data. There is no need of paying attention where the features are located in the data which is the advantage of Deep Learning. It makes it so popular to handle huge amount of data to process without any hardships.

In simpler words we give an input image and we humans know what will be the output so we adjust the values in the network so that we obtain our output. This principle is called Learning a problem which is the backbone of Machine Learning. Here the system learns the values of convolutional filters and the vectors associated with the calculation in the neural network.

Convolutional Neural Network Components:

The commonly used architecture of convolutional neural network consists of four important components

- Convolutional Layer
- Pooling layer

- Activation function
- Fully Connected layer

Convolutional Layer:

Convolution layer by default has the potential of image sampling and dimensionality reduction of the given input image. This makes the algorithm much more efficient. This layer is for extracting the features maps from the input image. Generally, convolution layer creates various feature maps of an image by applying filters on it.

In simple expression we can say that,

$$Z = X * f$$

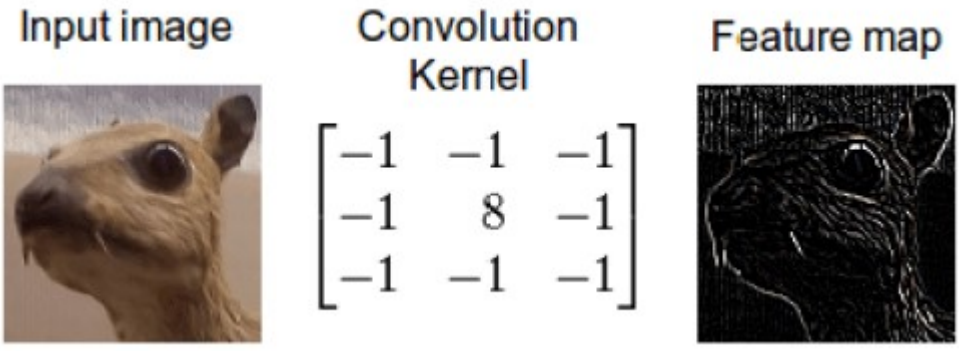
Where

X is the input image

f is the filter

Always * refers to the convolution operation.

The feature maps are created by summing up the product values of each element of input and the filter value on the basis of element-wise. In this way arbitrary number of feature maps are created for an image. There will be N number of distinct features created from a single layer of neural network and that will be passed on to the next layer of network. If the dimensionality of a image is (n,n) and filter is (f,f) then the dimension of the output vector will be ((n-f+1),(n-f+1)). It is made to pass through the number of convolution layers for distinct feature maps extraction.



An illustration of feature map generation is

Pooling layer:

The pooling layer down samples the image which will result in lesser complexity of processing in the upcoming layers. Moreover, it creates a window in which the feature is found which depends on the application. In the pooling layer, a window of input vector is passed through a pooling function. The pooling layer generates the output vector. There are few pooling techniques are there. Some of the most commonly used pooling technique is max pooling. Max pooling creates various sub divisions of the image according to the pooling function specified and returns the maximum value of each subregion and forms a output vector. The advantage of pooling technique is it will reduce the number of trainable parameters which will increase the efficiency of the algorithm.

Fully Connected Layer:

The features extracted from the convolution and the pooling layer is made to fed into the fully connected layer. The fully connected layer will only work on the one-dimensional data. So, in order to feed the features maps created into this layer, the multi-dimensional features maps will be converted into the data of one-dimensional format which is called as flattening. Then the linear and non-linear transformation of the data will be done in the layer using the formula,

$$a_{ij=}\sigma((W*X)_{ij}+b)$$

where

X is the input vector

W is the weight vector

b is the bias(constant)

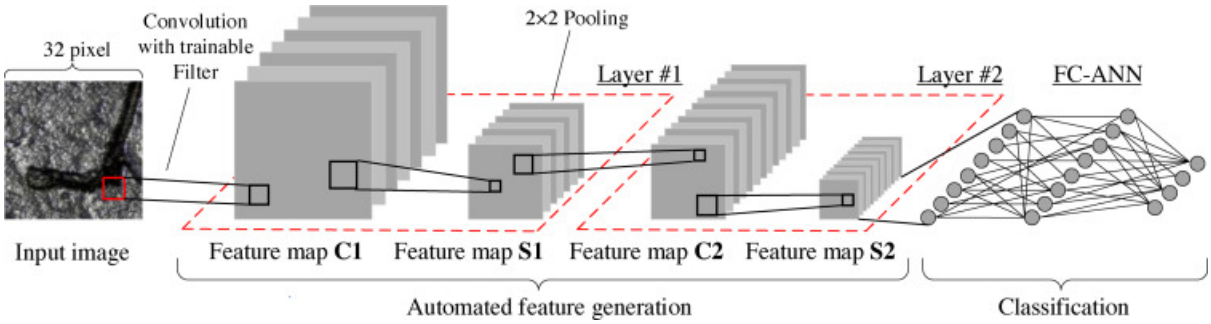
σ is the non-linearity function

The weight matrix will be automatically created by CNN using random initialization.

Activation Function:

If we design our neural network without any non-linear function, it will give the linear data. Then it will not learn any complex pattern from the data. So we have to make some non-linear transformation of the outcome from each layer and also to normalize the values. In order to apply non-linearity to the data, we are applying some non-linear functions called activation function. It is added to each layer of the fully connected layers and the convolutional layers of the neural network. There are many activation functions like sigmoid, ReLU,

tanh, softmax, etc., Sigmoid is mostly used for binary classification which returns the output in the range of 0 to 1. But ReLU is better than the sigmoid activation function. The activation function will be chosen based on the type of the problem.



Challenges:

Although we have lot of details about CNN , it is still a black box. We cannot able to identify what the feature maps are extracting in each layer. CNN models will result in overfitting for small amount of dataset. We cannot expect to have large amount of dataset in all kind of domains which will be expensive in cost.

Conclusion:

Convolutional Neural Network has reached the greater heights in the field of computer visions by solving many real-time problems over the other kinds of neural network. Almost it is evolving in all domains like healthcare, finance, networking etc., In future days, it will overcome the challenges and will be better efficient as lots of different architectures are published often in the open-source community.

Reference:

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