Convolutional Neural Networks

Topics covered in the week:

- What is a Convolution
- Image Processing using Convolution
- Filters for edge detection
- ANN vs CNN
- Convolution process and creation of feature maps
- Pooling layer
- Role of different layers in CNN
- CNN in Keras
- Case Study

What is a Convolution?

Convolution is a mathematical transformation of a given function (analog or digital) into a form that is more useful than the original function given a requirement, for e.g. image classification.

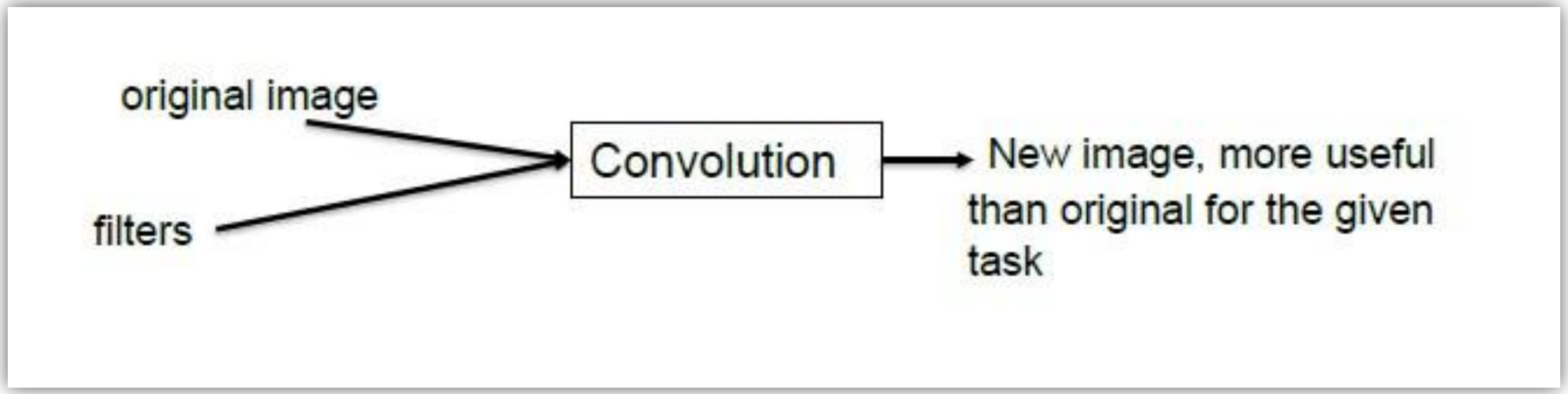
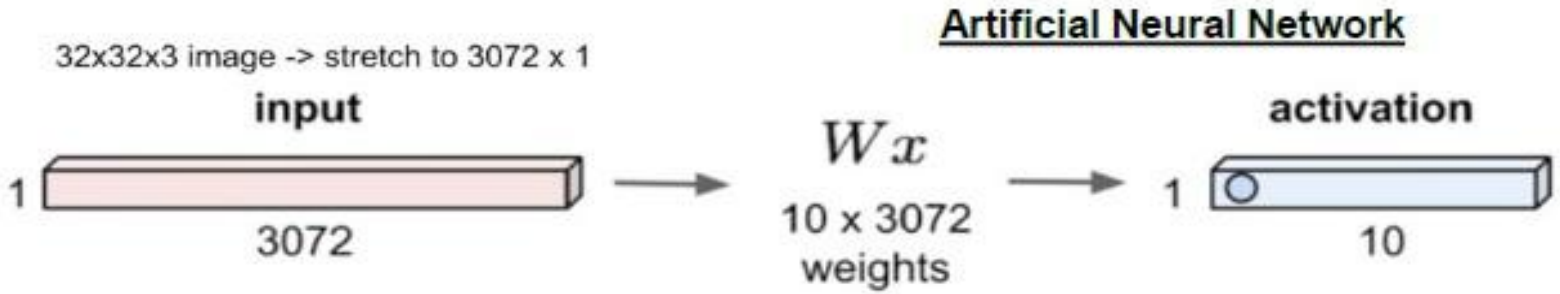


Image Processing using Convolutions

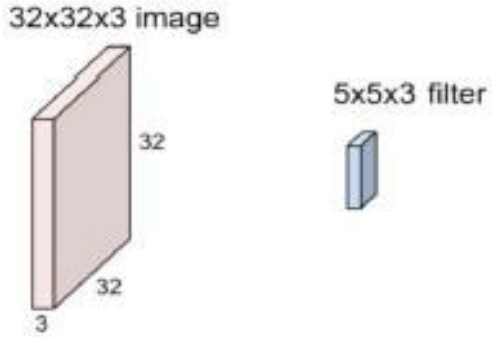
- Through the use of a filter function on the image function (convolution) , we try to detect edges.
- Convolution for Edge Detection / Horizontal edge detection.
- Convolution for Vertical Edge detection.
- Image gradient using Sobel operator / filter.

ANN vs CNN

Artificial neural network takes a vector as input. Spatial structure is ignored



Unlike ANN which work on vectors, CNN works on volumes maintaining spatial structures



Convolutional Neural Network

Filter will slide over the image (convolve) computing dot product
A single filter will apply on all 3 color channels

Convolution: Kernels and Filters

- Convolution uses a small array of numbers called a filter/kernel on the input image.
- The resulting output value in the corresponding pixel position of the output image is called a feature map.

Filters and Activation Map Size:

Size of the new image in row and column is given by:

$$Rnew = ((image\_rows - filter\_rows) / stride) + 1.$$

Similarly,

$$Cnew = ((image\_cols - filter\_cols)/stride) + 1$$

Padding

- Filter convolution reduces output image size.
- In the convolution process, it is not possible to center the filter over the outermost pixels of the input image.
- A technique called **padding** is used to prevent image size reduction.

Pooling Layers

- For object recognition we need high level features. Many of the low level features are redundant.
- Pooling layers provide an approach to down sampling feature maps by summarizing the presence of features in patches of the feature map.
- Two common pooling methods are **average pooling** and **max pooling** that summarize the average presence of a feature and the most activated presence of a feature respectively.
- A pooling layer is added after the convolutional layer.

Max Pooling Layer

- Max pooling operation breaks the convolutional layer output into smaller patches, often 2x2 pixel areas (pooling layer filter size) with a stride of 2.
- For each 2x2 patch, a max pooling layer looks at each value in a patch and selects only the maximum gradient value.
- Max pooling helps feature selection by avoiding weak features and thus helps in dimensionality reduction.

Fully Connected Layer

- At this layer, the high level features extracted by the previous conv layers are used for classification.
- This layer looks at the output of the previous layer i.e. the activation maps with high level features and determines which features most correlate to a particular class.

Convolutional Neural Network

The different layers in the CNN model are:

- Input layer (the image)
- Convolutional Layer
- Nonlinearity (activation function)
- Pooling Layer
- Dense layer

Case Study: Brain Tumor Classification

Context:

- Brain tumor is known to be one of the most aggressive diseases that affect both children and adults. Of all primary Central Nervous System (CNS) tumors, brain tumors account for 85 to 90 percent of cases.
- Around 11,700 individuals are diagnosed with a brain tumor every year. For individuals with a cancerous brain or CNS tumor, the 5-year survival rate is around 34 percent for men and 36 percent for women.
- Brain tumors are classified into Benign Tumors, Pituitary Tumors, Malignant Tumors etc. In order to increase the life expectancy of patients, adequate care, preparation and reliable diagnostics are required in the treatment process.
- **Problem Statement:** To build a classification model that can take images of MRI scans as input and can classify them into one of the following classes: **glioma tumor**, **meningioma tumor**, **pituitary tumor** and **no tumor**.

Steps

- Import the necessary libraries.
- Get the data.
- Explore the data
- Convert labels to one hot vectors
- Understand the layers used in the model
- Fit the model
- Model score and Summary

Great Learning
POWER AHEAD

Questions?

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Happy Learning!