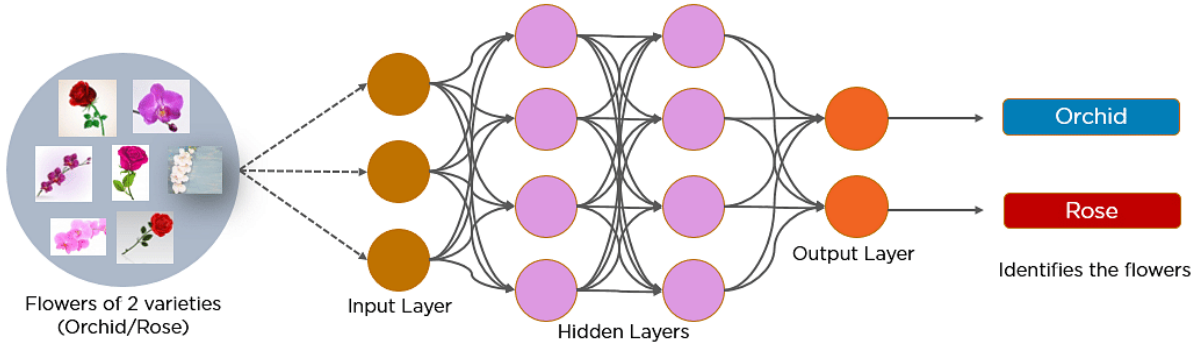
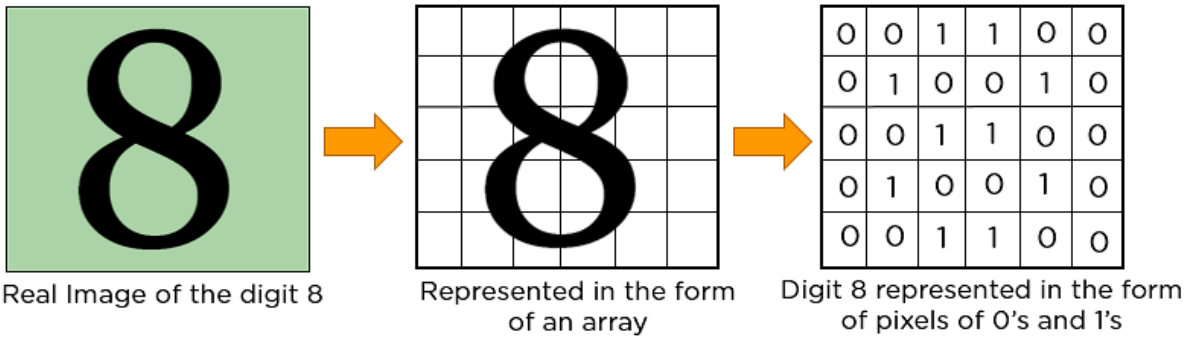
Convolutional Neural Network

What is Convolutional Neural Network?

A convolutional neural network is a feed-forward neural network that is generally used to analyze visual images by processing data with grid-like topology. It's also known as a ConvNet. A convolutional neural network is used to detect and classify objects in an image



n CNN, every image is represented in the form of an array of pixel values.



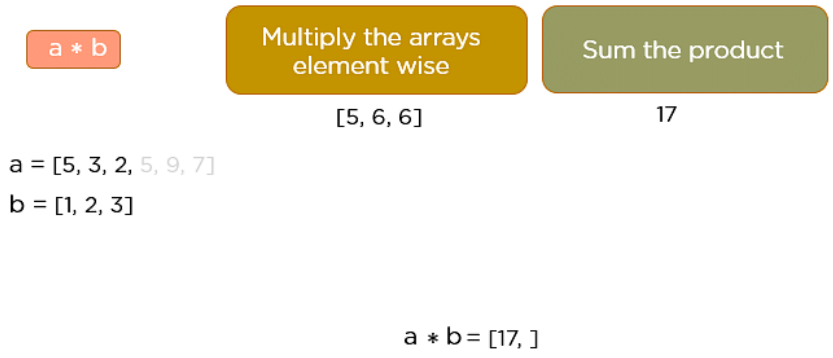
The convolution operation forms the basis of any convolutional neural network. Let's understand the convolution operation using two matrices, a and b, of 1 dimension.

a = [5,3,7,5,9,7]

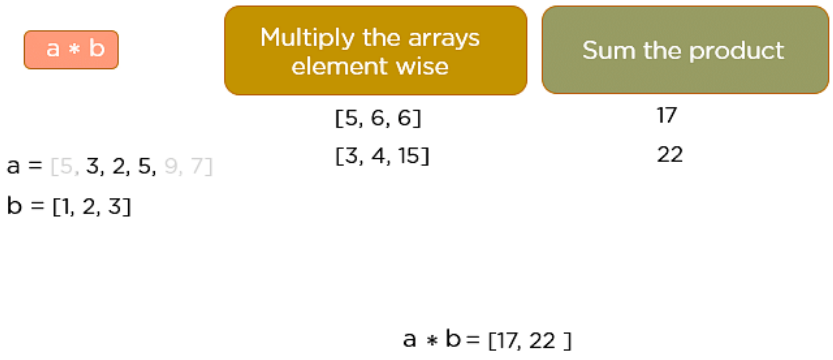
b = [1,2,3]

In convolution operation, the arrays are multiplied element-wise, and the product is summed to create a new array, which represents a*b.

The first three elements of the matrix a are multiplied with the elements of matrix b. The product is summed to get the result.



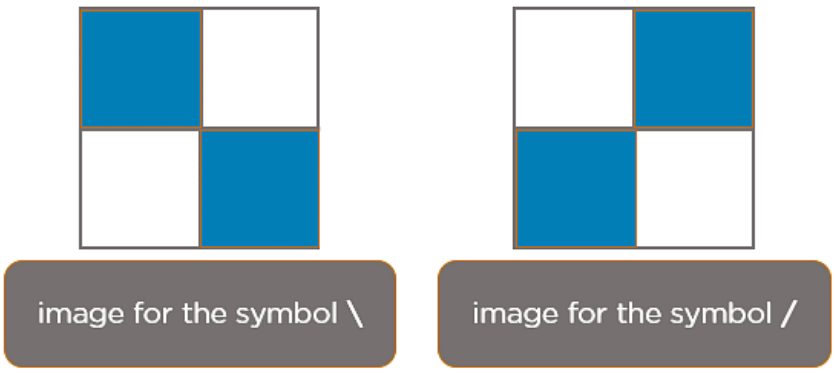
The next three elements from the matrix a are multiplied by the elements in matrix b, and the product is summed up.



This process continues until the convolution operation is complete.

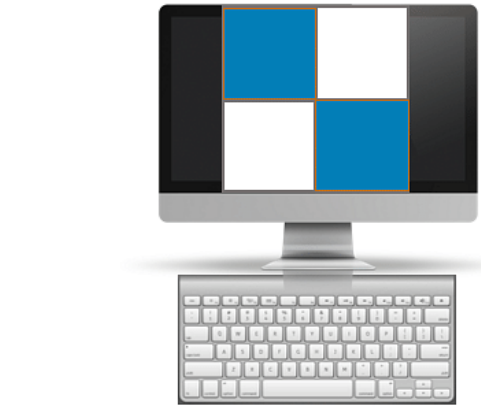
How Does CNN Recognize Images?

Consider the following images:



The boxes that are colored represent a pixel value of 1, and 0 if not colored.

When you press backslash (\), the below image gets processed.

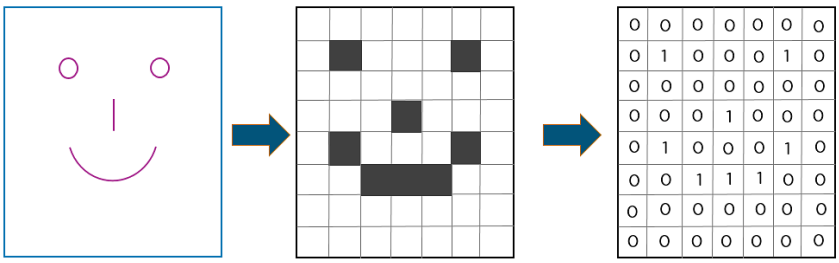


When you press \, the above image is processed

When you press forward-slash (/), the below image is processed:

When you press /, the above image is processed

Here is another example to depict how CNN recognizes an image:



Real Image

Represented in the form of black and white pixels

Image represented in the form of a matrix of numbers

Layers in a Convolutional Neural Network

A convolution neural network has multiple hidden layers that help in extracting information from an image. The four important layers in CNN are:

1. Convolution layer
2. ReLU layer
3. Pooling layer
4. Fully connected layer

Convolution Layer

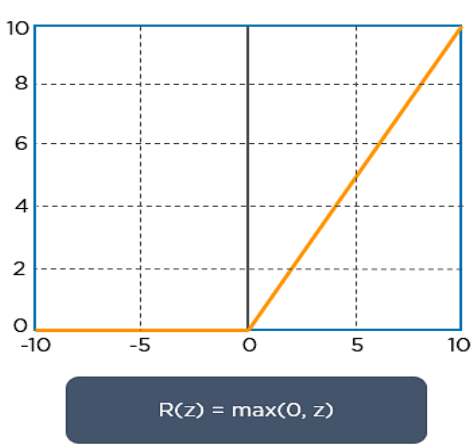
This is the first step in the process of extracting valuable features from an image. A convolution layer has several filters that perform the convolution operation. Every image is considered as a matrix of pixel values.

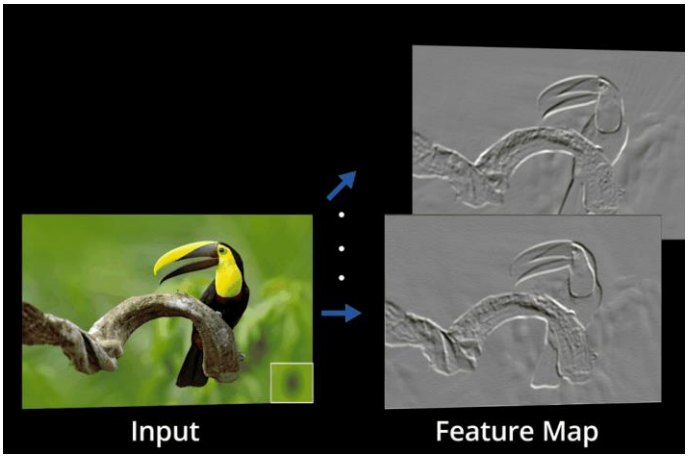
Consider the following 5x5 image whose pixel values are either 0 or 1. There's also a filter matrix with a dimension of 3x3. Slide the filter matrix over the image and compute the dot product to get the convolved feature matrix.

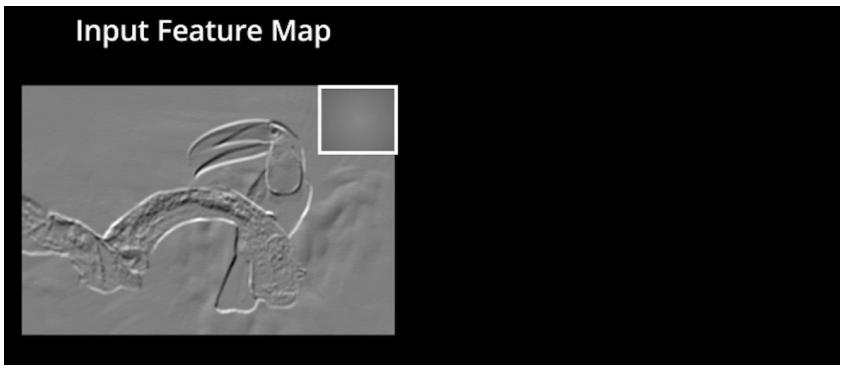
ReLU layer

ReLU stands for the rectified linear unit. Once the feature maps are extracted, the next step is to move them to a ReLU layer.

ReLU performs an element-wise operation and sets all the negative pixels to 0. It introduces non-linearity to the network, and the generated output is a rectified feature map. Below is the graph of a ReLU function:

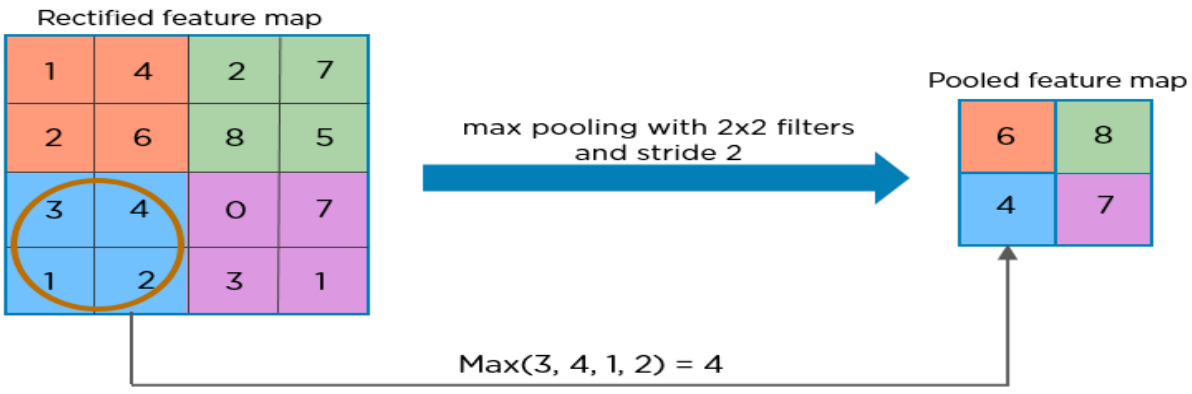




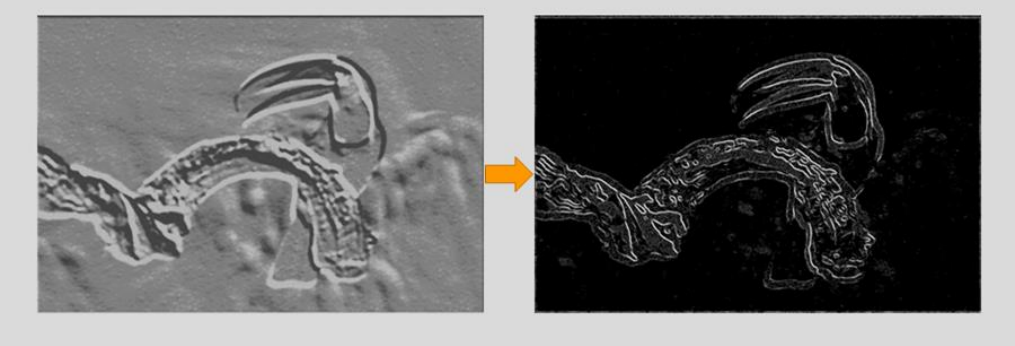


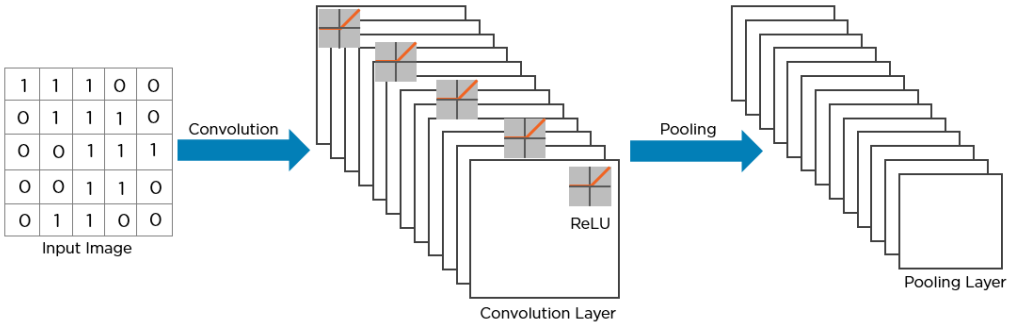
Pooling Layer

Pooling is a down-sampling operation that reduces the dimensionality of the feature map. The rectified feature map now goes through a pooling layer to generate a pooled feature map.

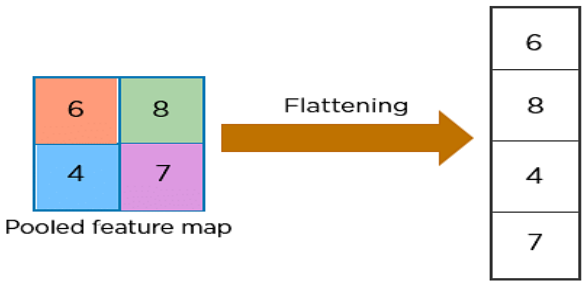


The pooling layer uses various filters to identify different parts of the image like edges, corners, body, feathers, eyes, and beak.

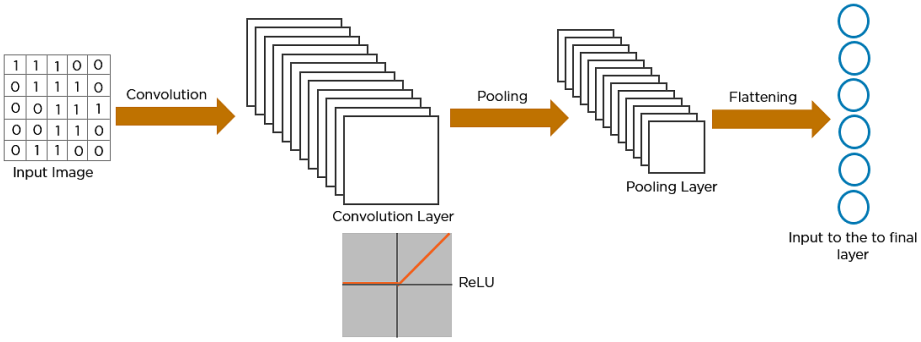


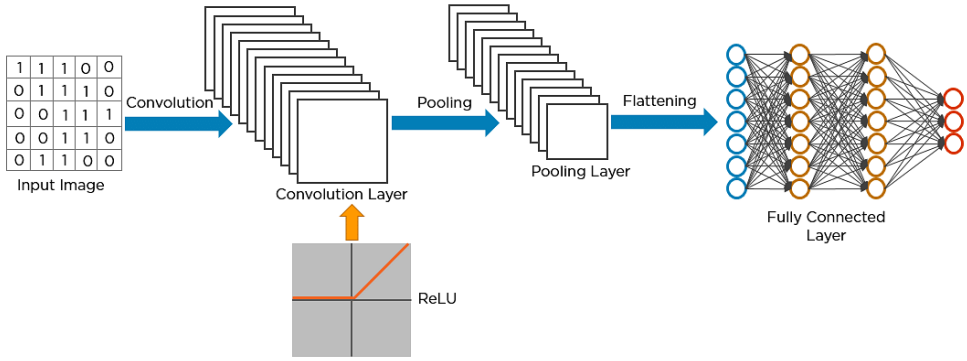


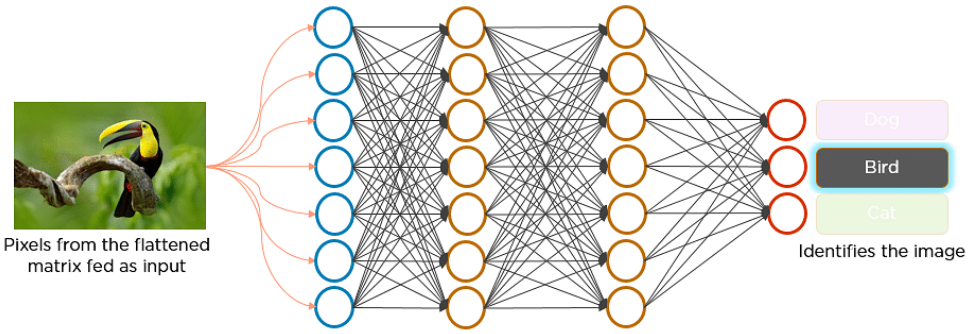
The next step in the process is called flattening. Flattening is used to convert all the resultant 2-Dimensional arrays from pooled feature maps into a single long continuous linear vector.



The flattened matrix is fed as input to the fully connected layer to classify the image.







Here's how exactly CNN recognizes a bird:

- The pixels from the image are fed to the convolutional layer that performs the convolution operation
- It results in a convolved map
- The convolved map is applied to a ReLU function to generate a rectified feature map
- The image is processed with multiple convolutions and ReLU layers for locating the features
- Different pooling layers with various filters are used to identify specific parts of the image
- The pooled feature map is flattened and fed to a fully connected layer to get the final output