Artificial Intelligence Masterclass

Convolutional Neural Network (CNN)

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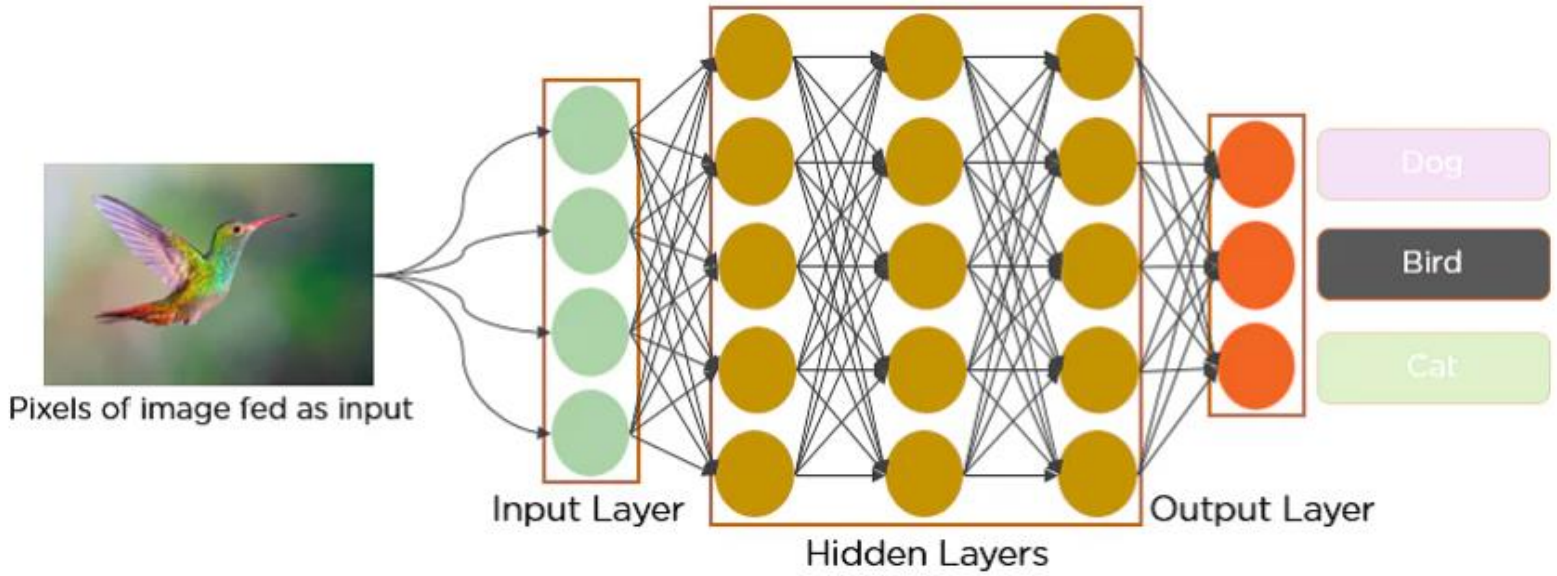
Introduction to CNN

- Convolutional neural networks were invented by Yann LeCun, who also serves as director of Facebook's AI Research Group.
- In 1988, he created the first convolutional neural network, known as LeNet.
- For character recognition tasks like reading zip codes and numbers, LeNet was employed.
- Have you ever wondered how object detection helps to construct self-driving cars, how facial recognition works on social media, or how disease identification is done using visual imaging in healthcare?
- All of this is made possible by convolutional neural networks (CNN).

Introduction to CNN

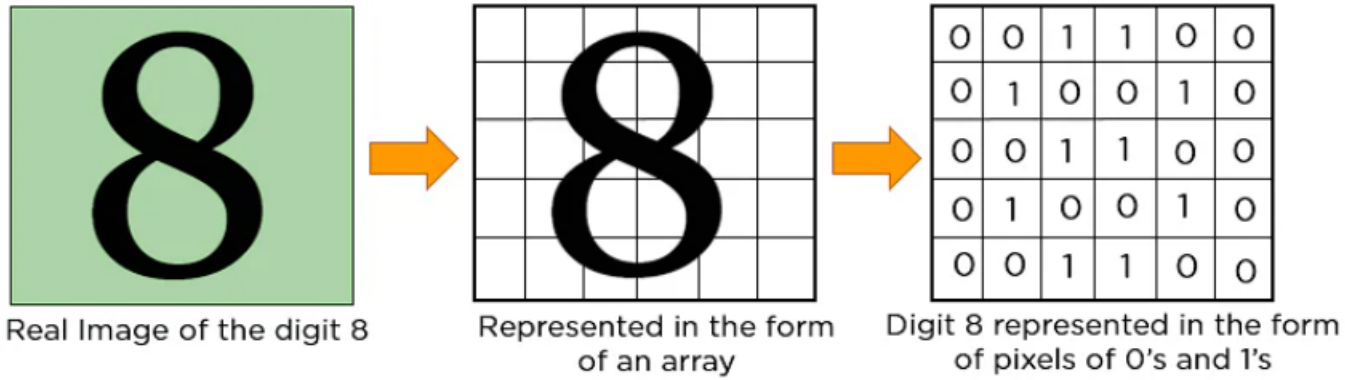
- Think there's an image of a bird, and you want to identify whether it's really a bird or some other object.
- The first thing you do is feed the pixels of the image in the form of arrays to the input layer of the neural network (multi-layer networks used to classify things).
- The hidden layers carry out feature extraction by performing different calculations and manipulations.
- There are multiple hidden layers like the convolution layer, the ReLU layer, and pooling layer, that perform feature extraction from the image.
- At the end, there's a fully connected layer that identifies the object in the image.

Introduction to CNN



Introduction to CNN

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



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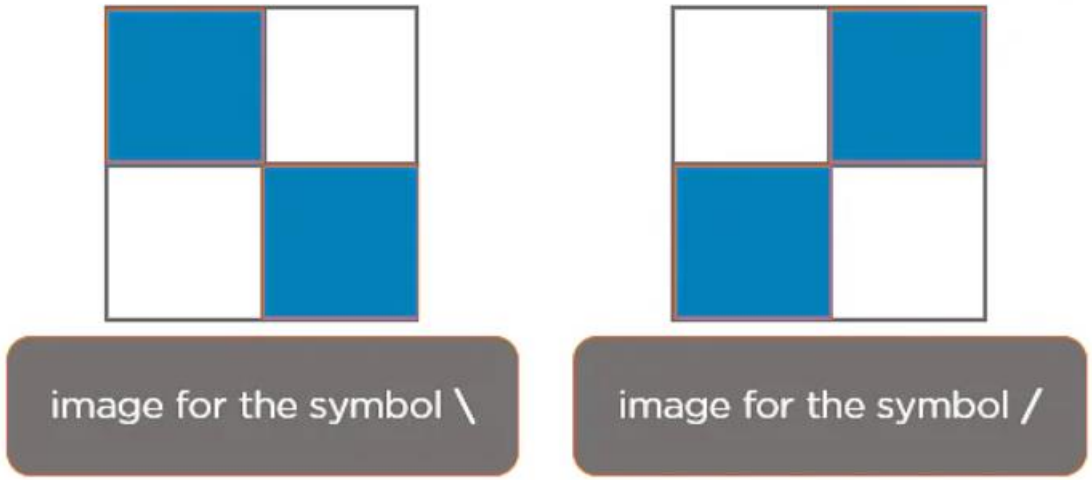

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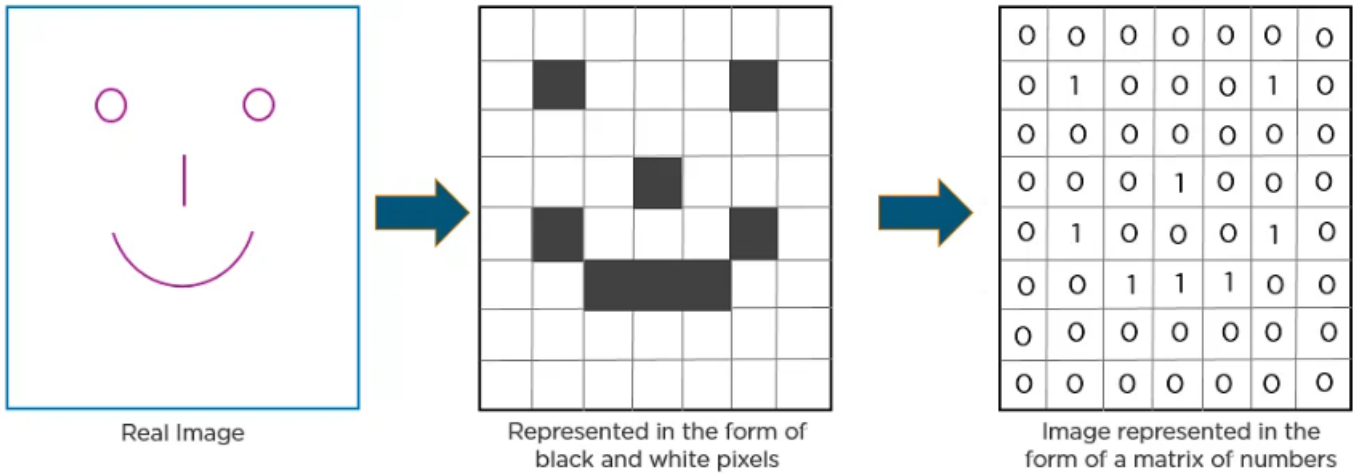
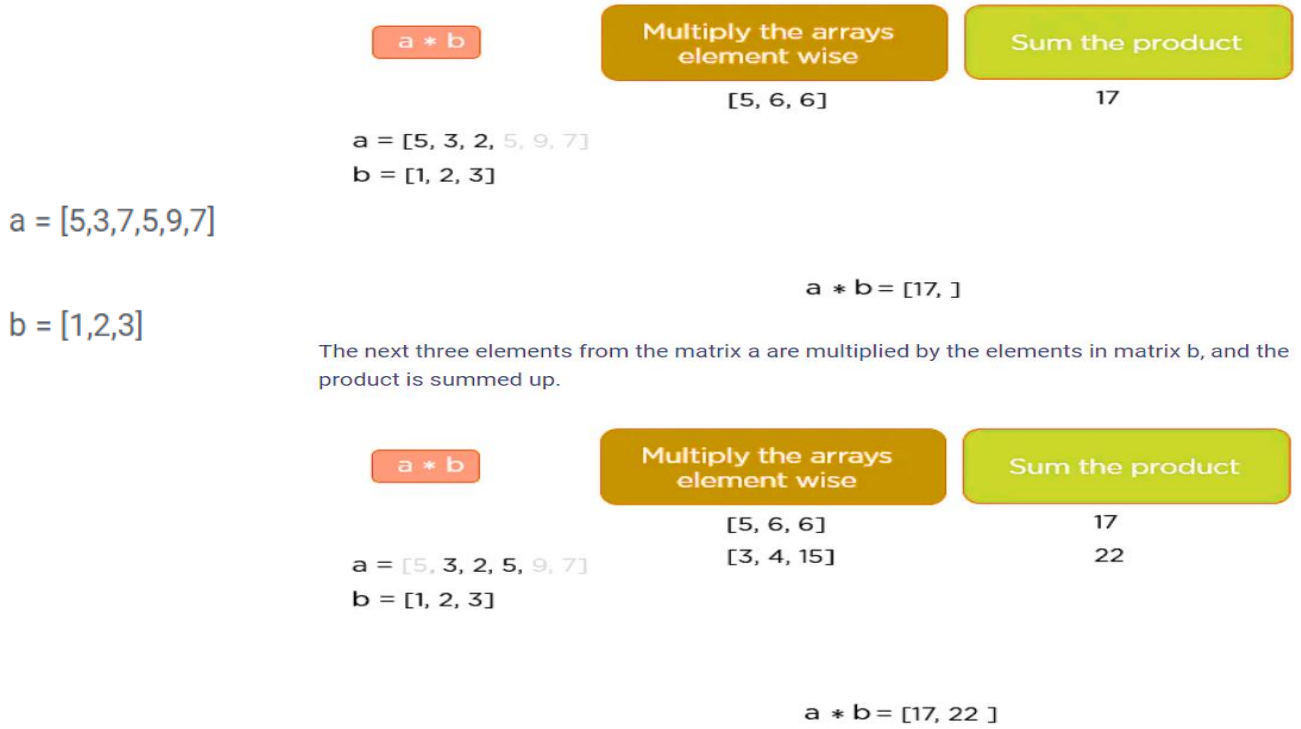


Convolutional Operations

- Any convolutional neural network's foundation is the convolution process.
- Let's examine the convolution operation using two 1-dimensional matrices, a and b.



- This process continues until the convolution operation is complete.

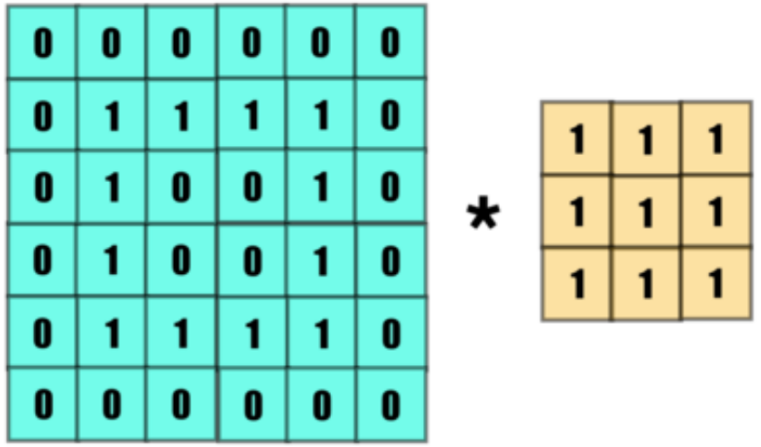
Layers of CNN

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

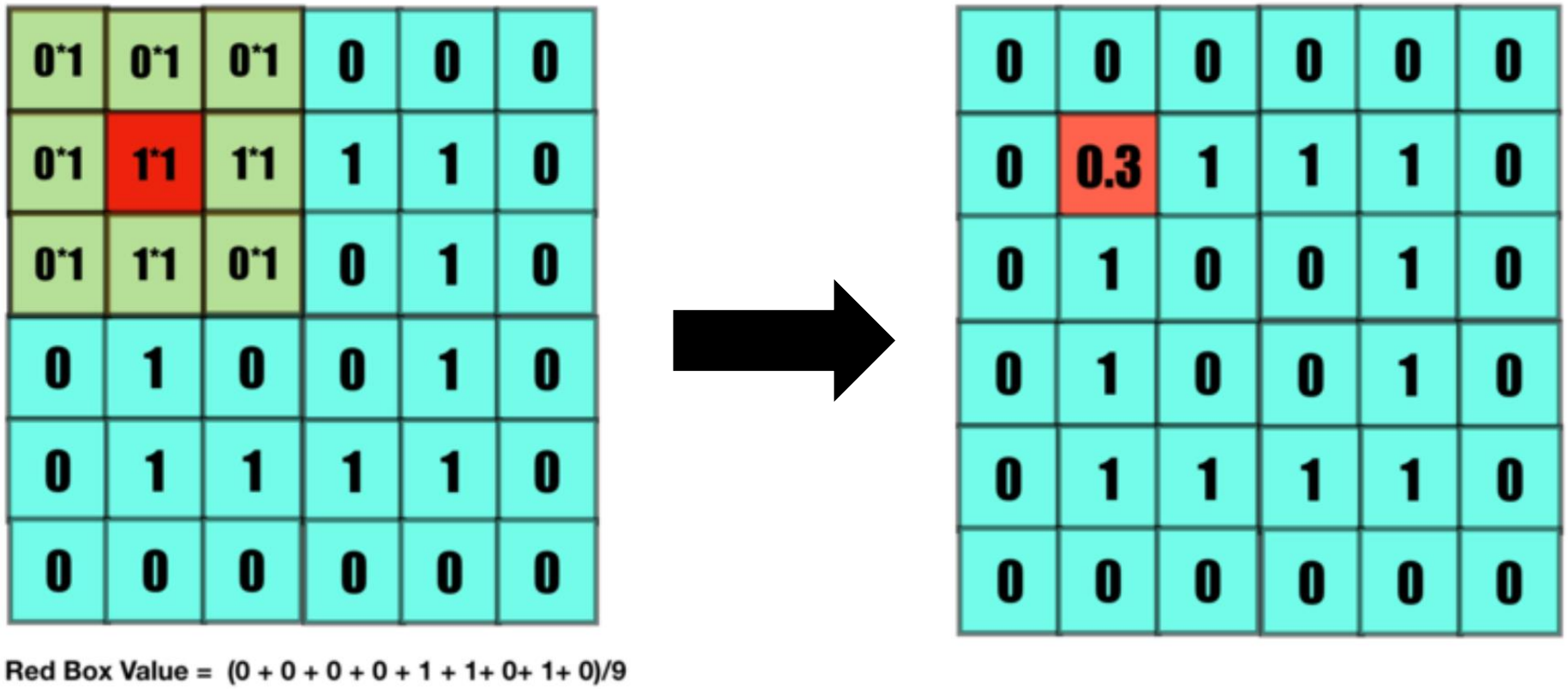
  - Convolution layer
  - ReLU (Rectified Linear Unit) layer
  - Pooling layer
  - Fully connected layer

Convolution Layer

- The process of removing useful elements from an image begins with this.
- Multiple filters work together to perform the convolution action in a convolution layer.
- Each image can be thought of as a matrix of pixel values.

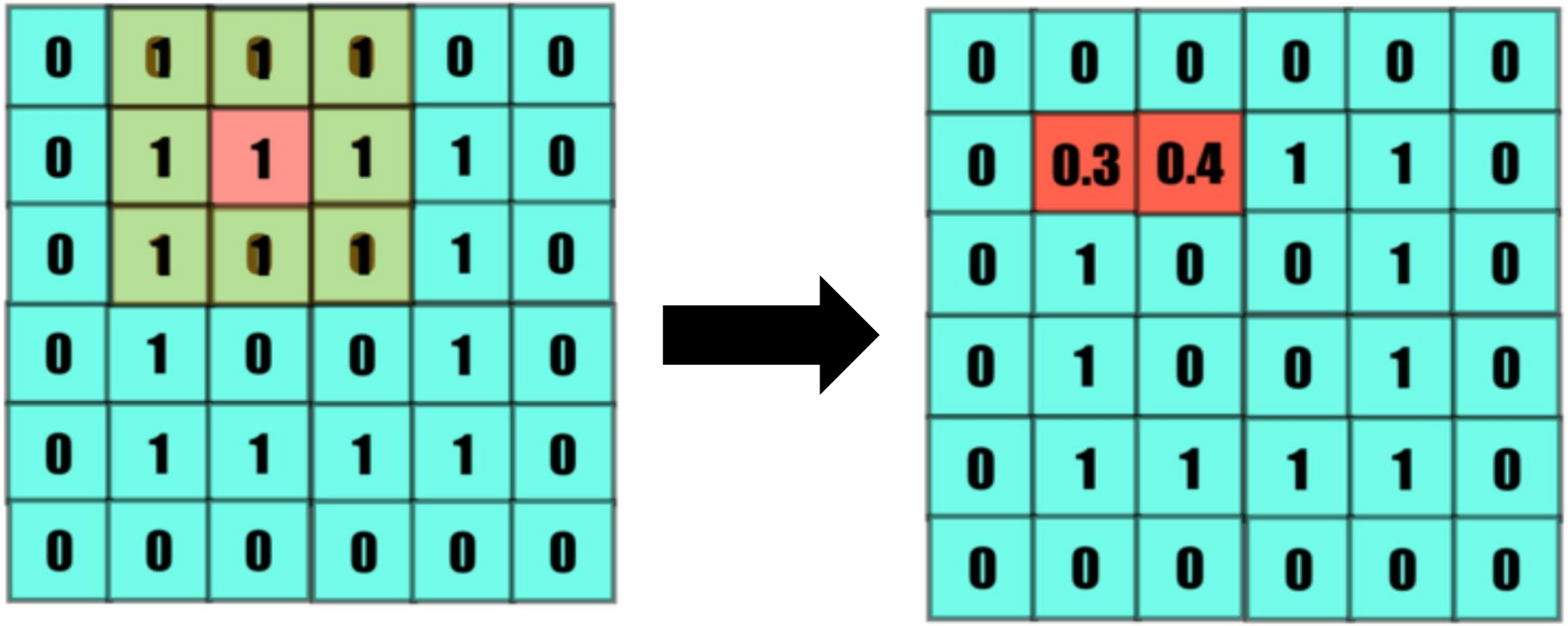


Convolution Layer



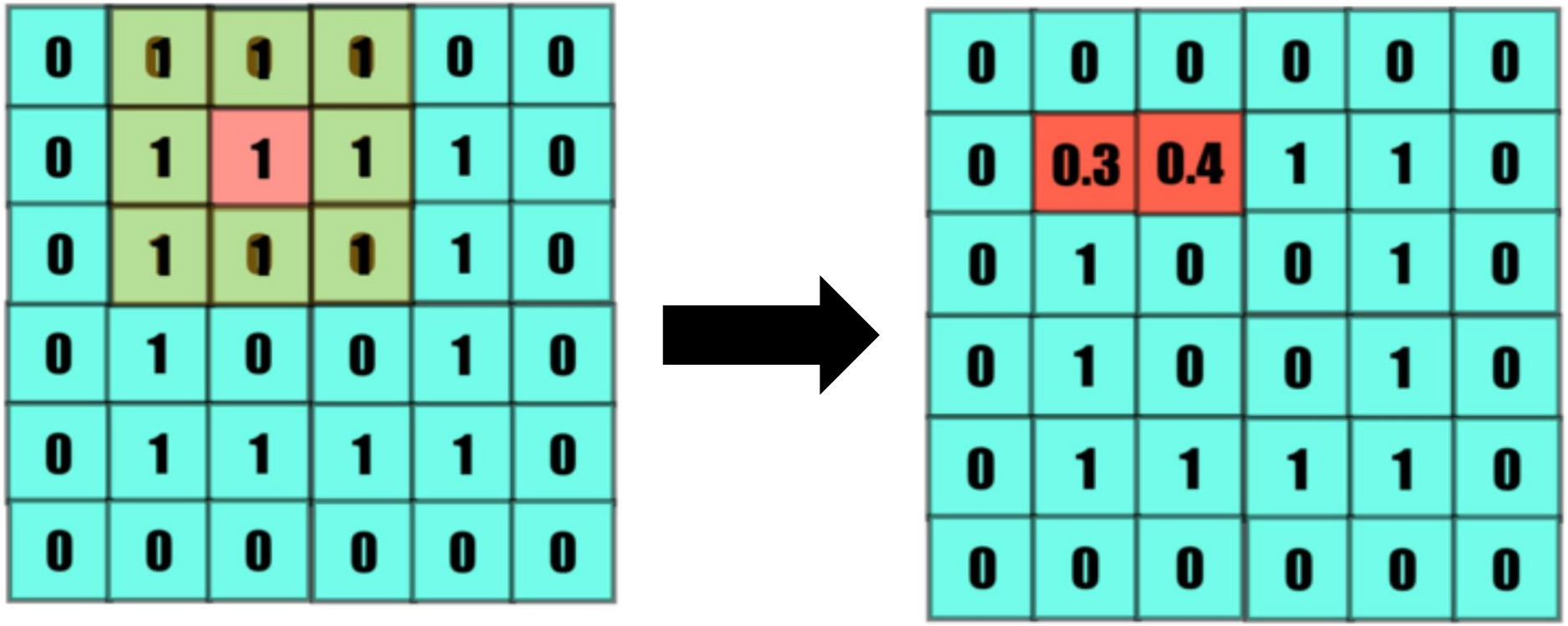
Red Box Value = (0 + 0 + 0 + 0 + 1 + 1+ 0+ 1+ 0)/9

Convolution Layer



Red Box Value = (0 + 0 + 0 + 1 + 1 + 1+ 1+ 0+ 0)/9

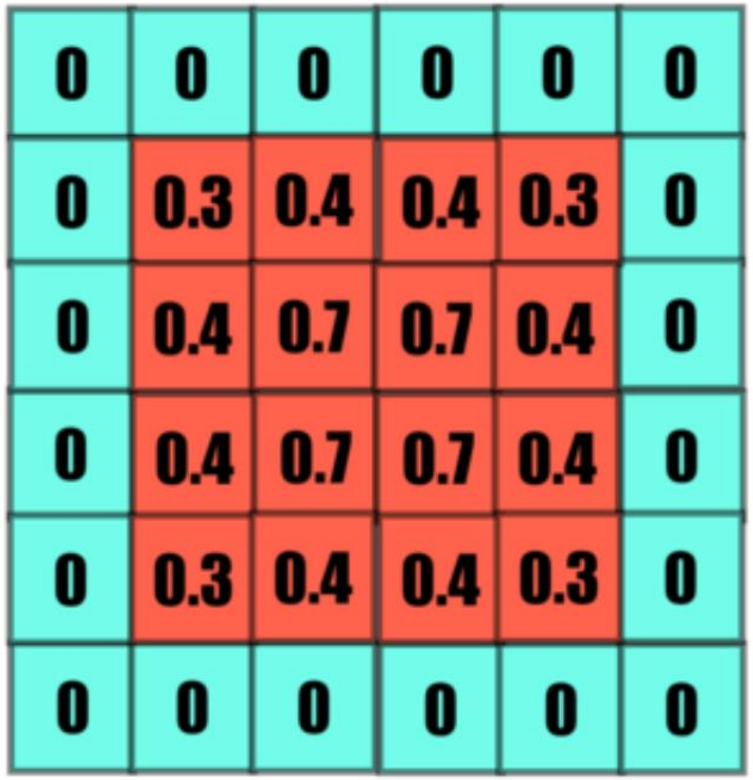
Convolution Layer



Red Box Value = (0 + 0 + 0 + 1 + 1 + 1+ 1+ 0+ 0)/9

Convolution Layer

- Get up to

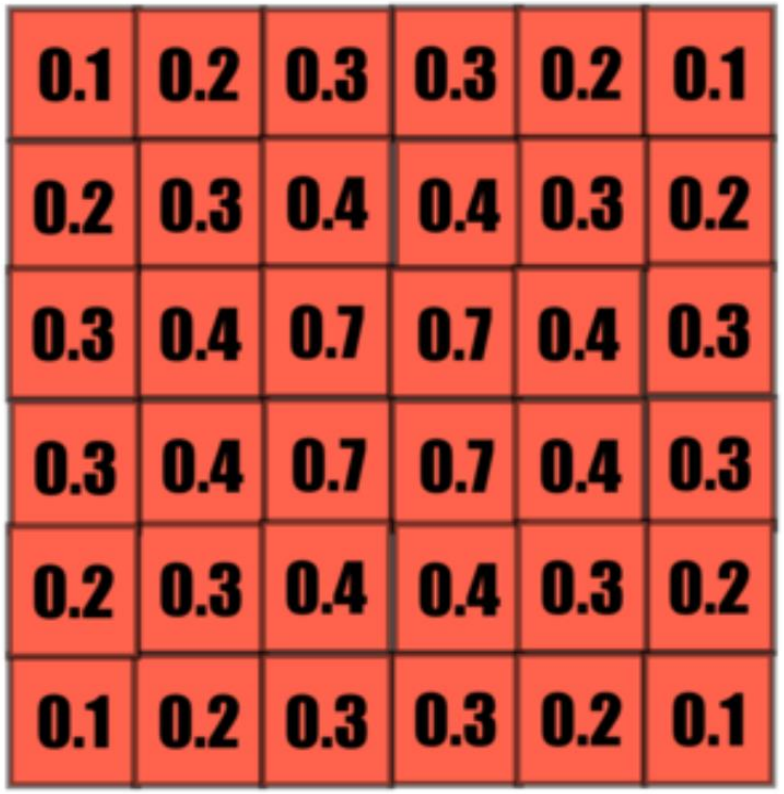


Convolution Layer

- **Padding** virtually extends the matrix to cater to border values as described in the image below. The pink layer isn't a part of the feature matrix, but helps in convolution.
- In below example padding is taken as 0.

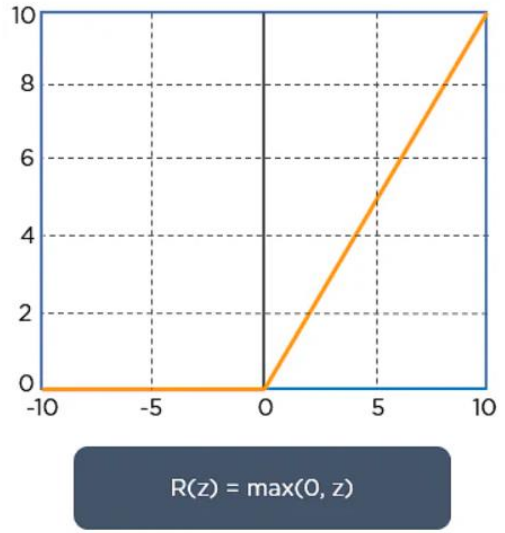
Convolution Layer

- Get up to

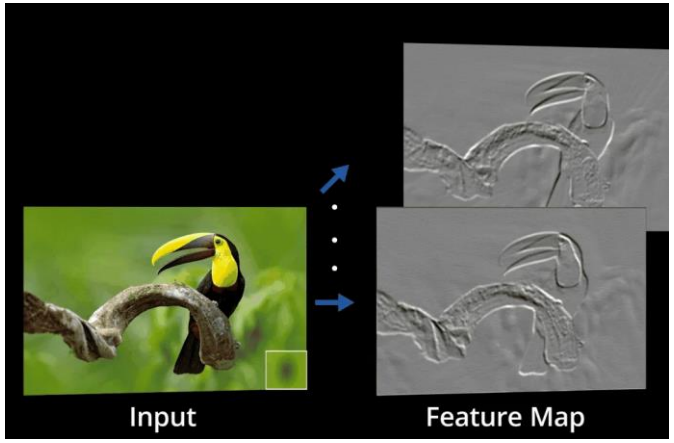


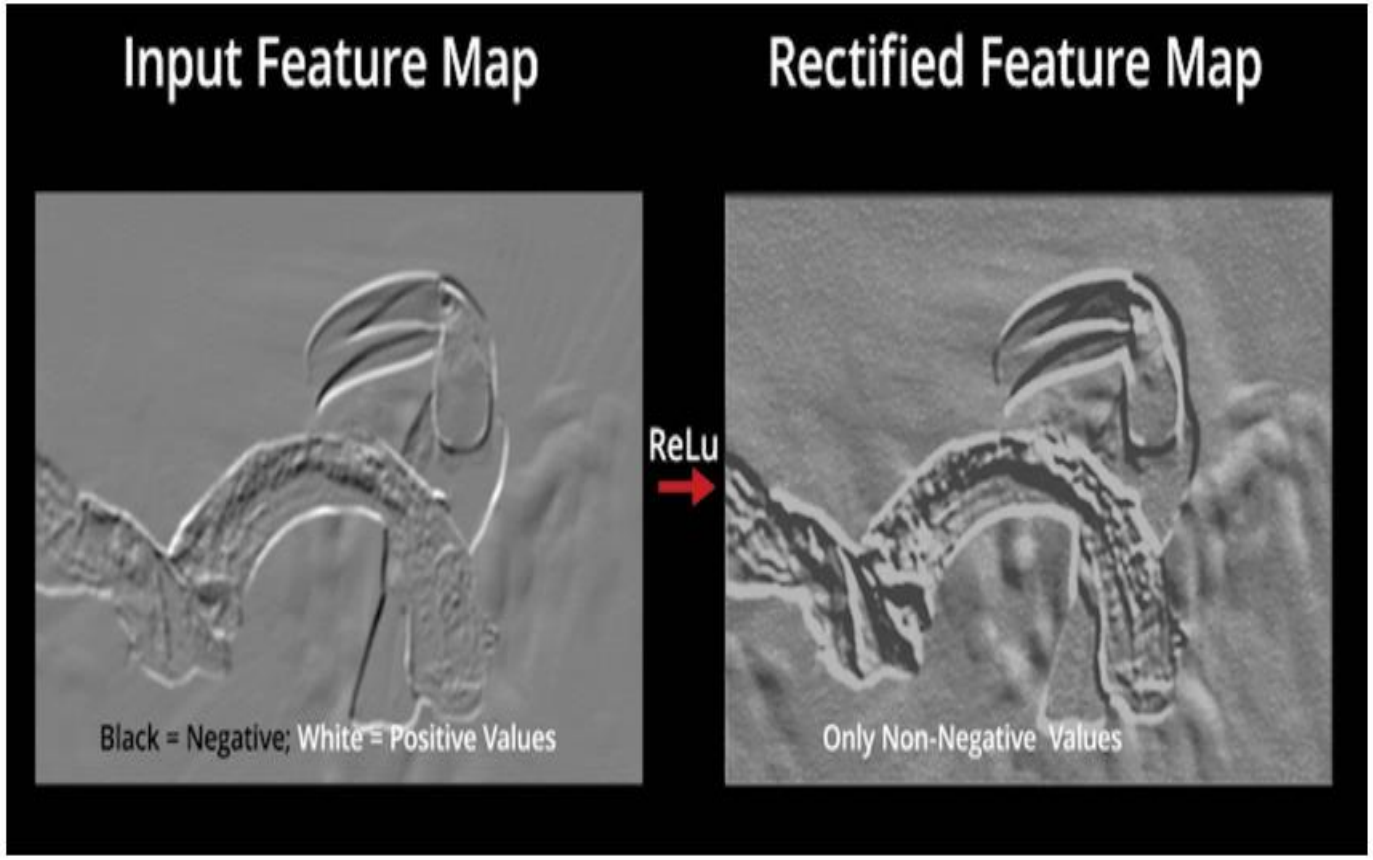
ReLU layer

- 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.



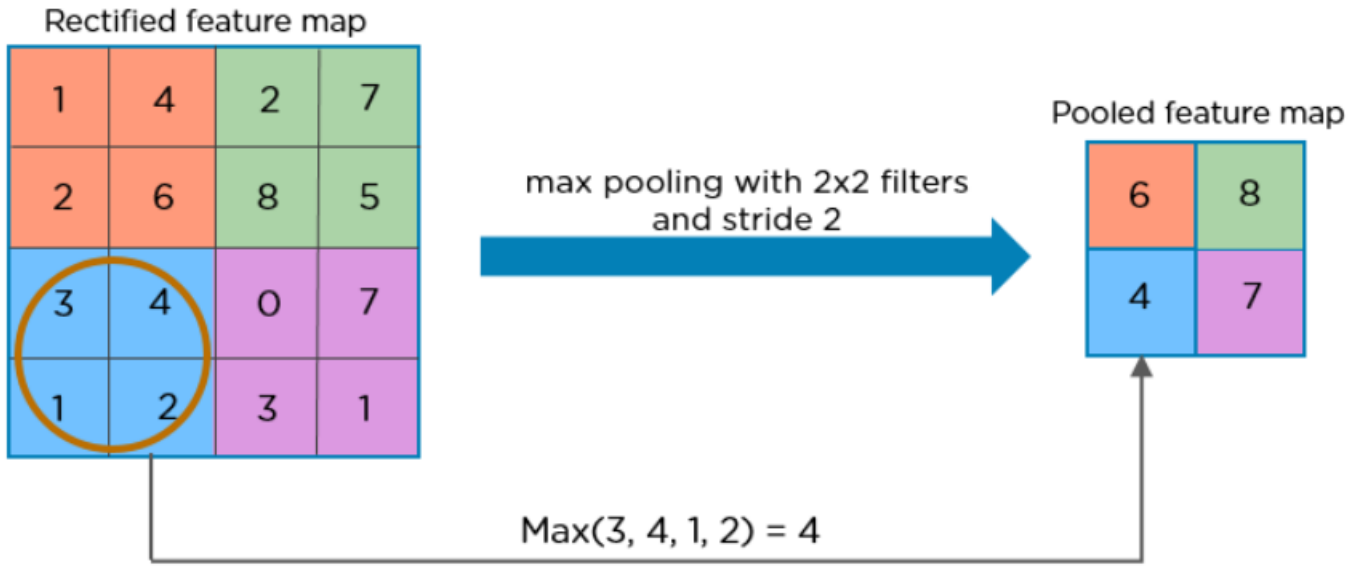
ReLU layer


Input
Feature Map


Input Feature Map
Rectified Feature Map
ReLu
Black = Negative; White = Positive Values
Only Non-Negative Values

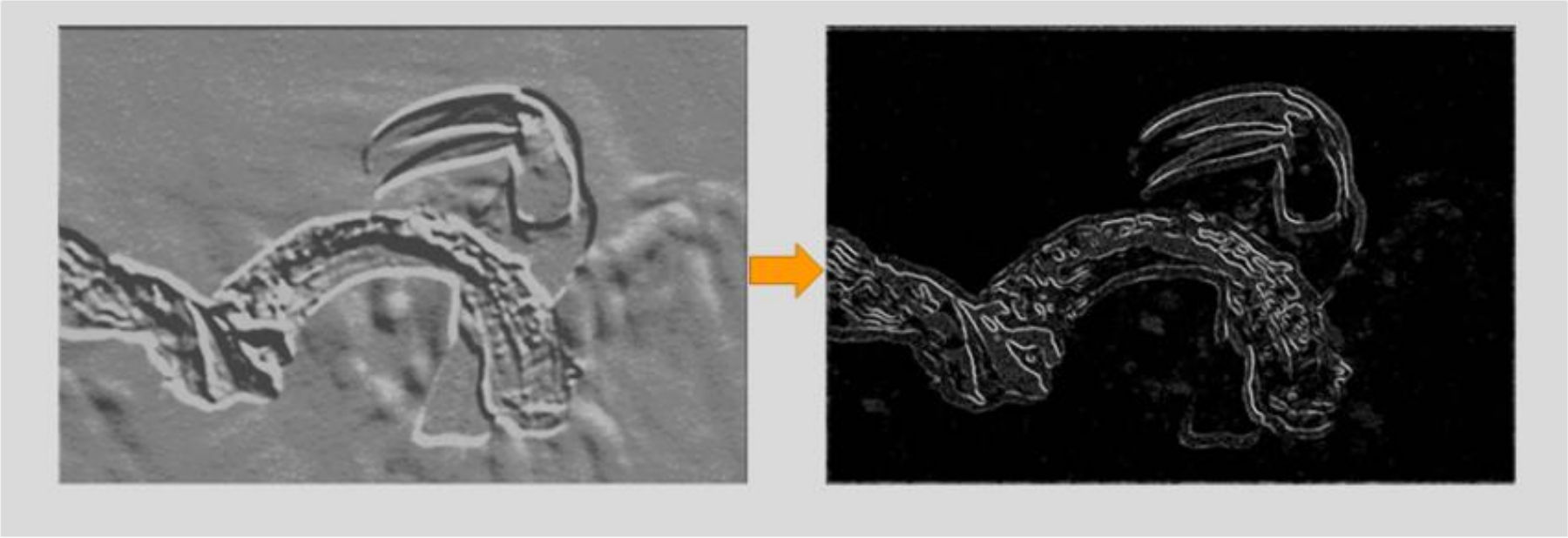
Pooling Layer

- 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.



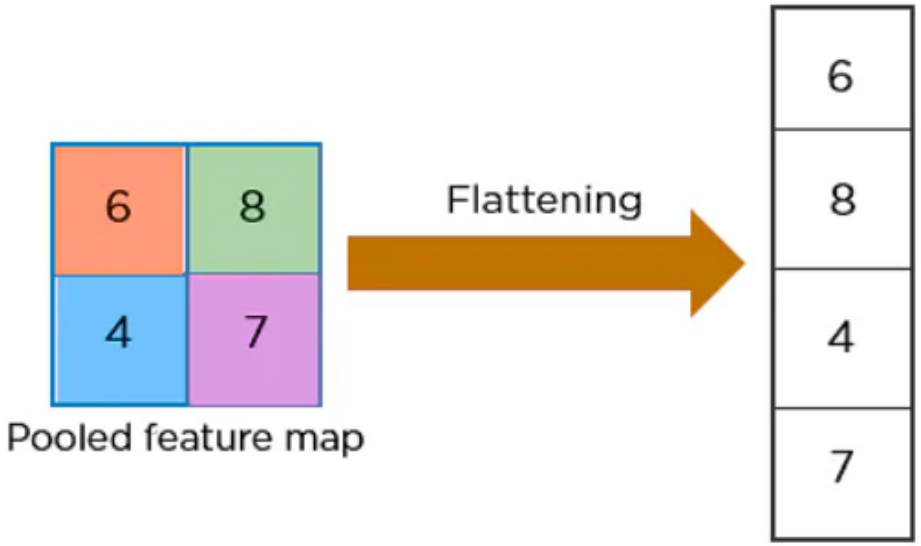
Pooling Layer

- To distinguish distinct portions of the image, such as edges, corners, bodies, feathers, eyes, and beak, the pooling layer employs a variety of filters.



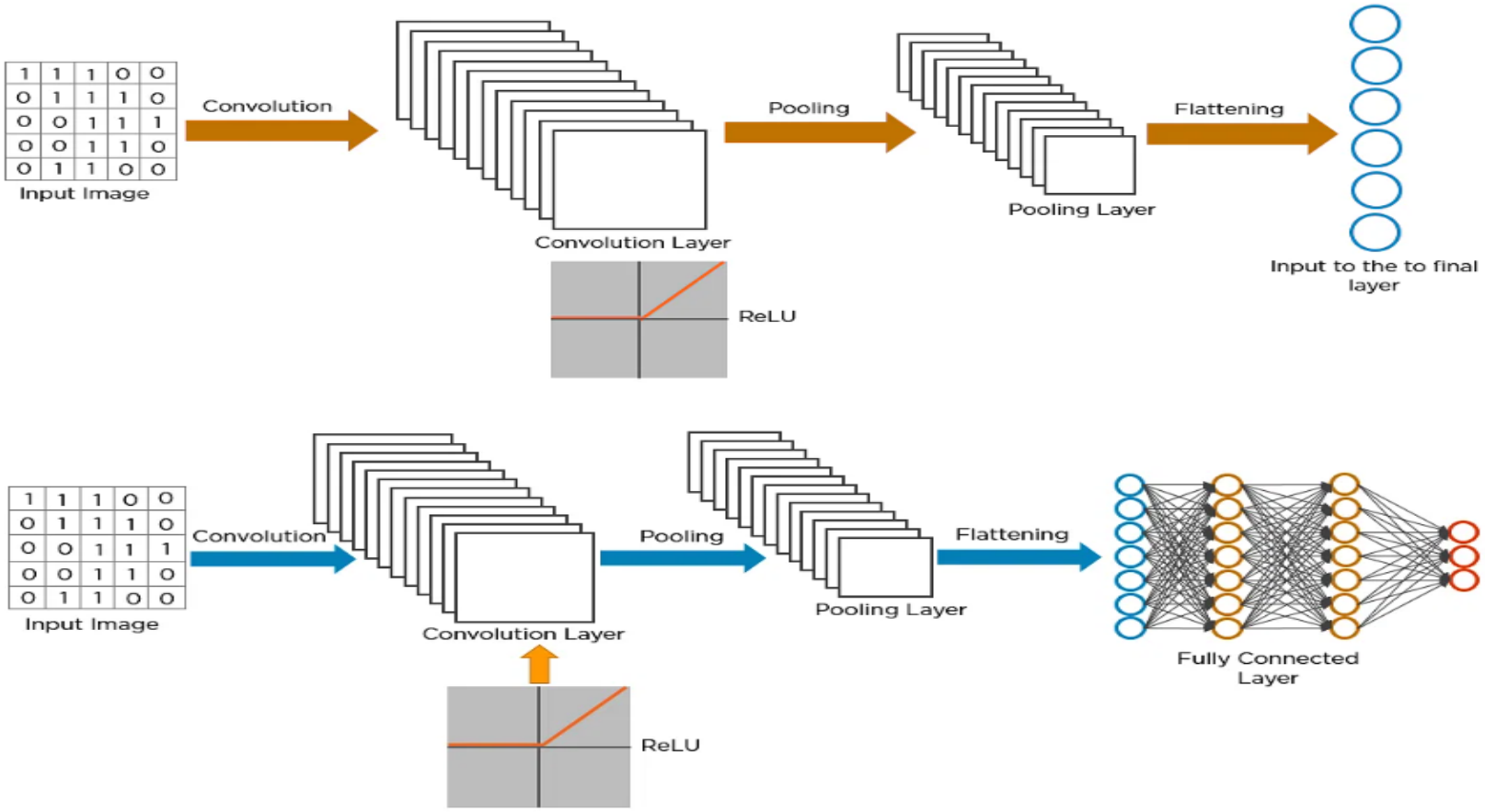
Flattening

- 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.



Fully Connected Layer

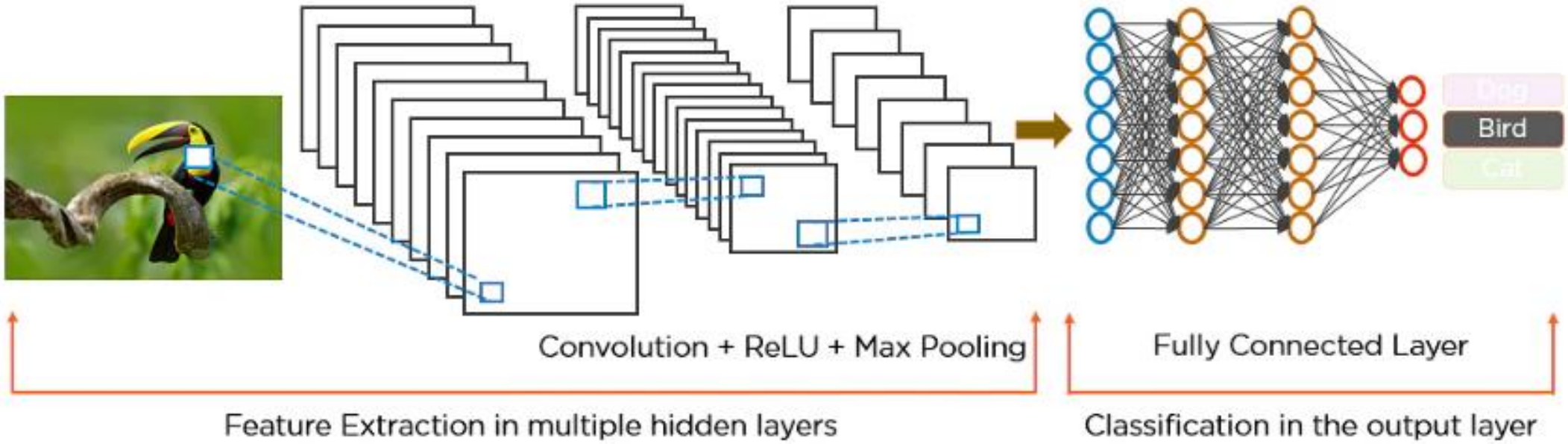
- The flattened matrix is fed as input to the fully connected layer to classify the image.



Summary

- 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

Summary


Bird
Convolution + ReLU + Max Pooling
Fully Connected Layer
Feature Extraction in multiple hidden layers
Classification in the output layer