G H RAISONI COLLEGE OF ENGINEERING &
MANAGEMENT, WAGHOLI, PUNE

An Autonomous Institute, Affiliated to Savitribai Phule Pune University

Handwritten Digits Recognizer

An Application of Convolution Neural Networks

Our Team

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MOTIVATION

- Despite the abundance of technical writing tools, many people still choose to take their notes traditionally: with pen and paper. However, there are drawbacks to handwriting text. It’s difficult to store and efficiently access physical documents, search through them efficiently, and share them with others.
- Thus, a lot of important knowledge gets lost or does not get reviewed because documents never get transferred to digital format
- The purpose of this project is to take handwritten Digit as input and recognize it.

A Short Introduction to Neural Networks

NEURAL NETWORKS CAN DO ANYTHING!!

A Neural Network is a method in AI that is inspired by the human brain
It is a type of machine learning process, called deep learning, that uses interconnected nodes or neurons in a layered structure that resembles the human brain.
It creates an adaptive system that computers use to learn from their mistakes and improve continuously.

The human brain is the inspiration behind neural network architecture. Human brain cells, called neurons, form a complex, highly interconnected network and send electrical signals to each other to help humans process information. Similarly, an artificial neural network is made of artificial neurons that work together to solve a problem. Artificial neurons are software modules, called nodes, and artificial neural networks are software programs or algorithms that, at their core, use computing systems to solve mathematical calculations.

THE 3 LAYERS OF NEURAL NETWORKS

Input Layer

Information from the outside world enters the artificial neural network from the input layer. Input nodes process the data, analyze or categorize it, and pass it on to the next layer.

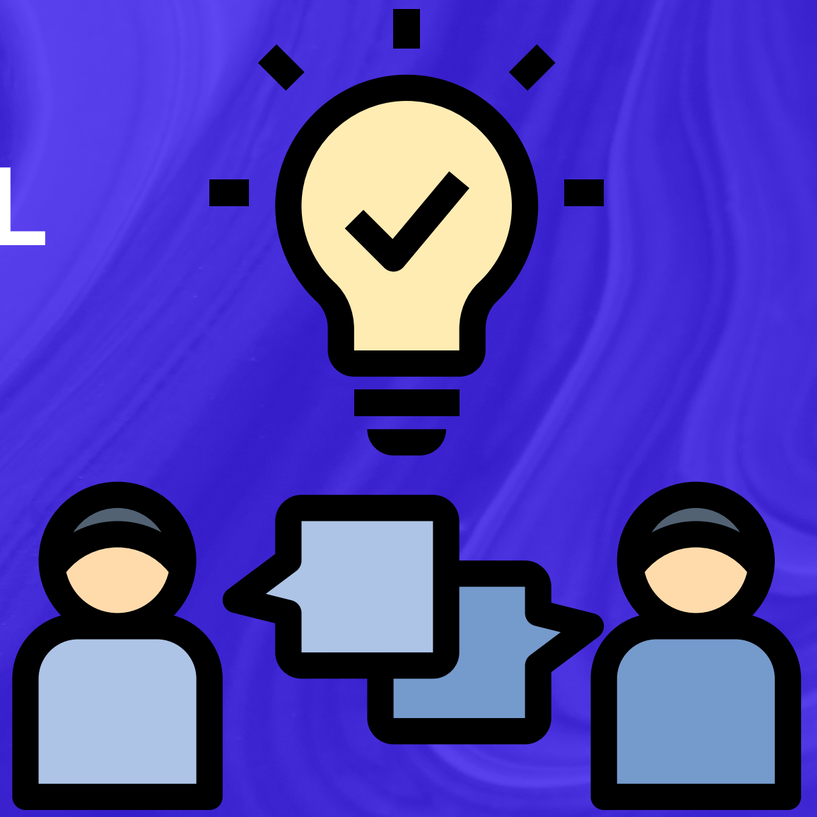
Hidden Layer

Hidden layers take their input from the input layer or other hidden layers. Artificial neural networks can have a large number of hidden layers. Each hidden layer analyzes the output from the previous layer, processes it further, and passes it on to the next layer.

Output Layer

The output layer gives the final result of all the data processing by the artificial neural network. It can have single or multiple nodes. For instance, if we have a binary (yes/no) classification problem, the output layer will have one output node, which will give the result as 1 or 0. However, if we have a multi-class classification problem, the output layer might consist of more than one output node.

SO, NOW AS YOU HAVE UNDERSTOOD THAT NEURAL NETWORKS ARE MADE UP OF VARIOUS LAYERS, LET'S SEE LAYERS IN OUR CONVOLUTIONAL NEURAL NETWORK



LAYERS IN OUR NEURAL NETWORK

no.1

The Convolution layer,
The main building block of CNN, contains a set of filters (or kernels), parameters which are to be learned throughout the training.

no.2

The ReLU Layer,
Being one of the input layers, ReLU or the Rectified Linear Unit is the most common activation Function, used to get a Rectified Linear Map.

no.3

The Pooling layer.
the pooling layers carry out down sampling operation to reduce the dimensions of Rectified Feature Map to summarise the features.

no.4

The Fully Connected Layer
A fully Connected Layer is simply, feed-forward neural networks. Fully Connected Layers form the last few layers in the network.

INPUT LAYER

CONVOLUTION LAYER(CONV2D)

RELU LAYER

HIDDEN LAYER

POOLING LAYER
(MAX-POOLING 2D)

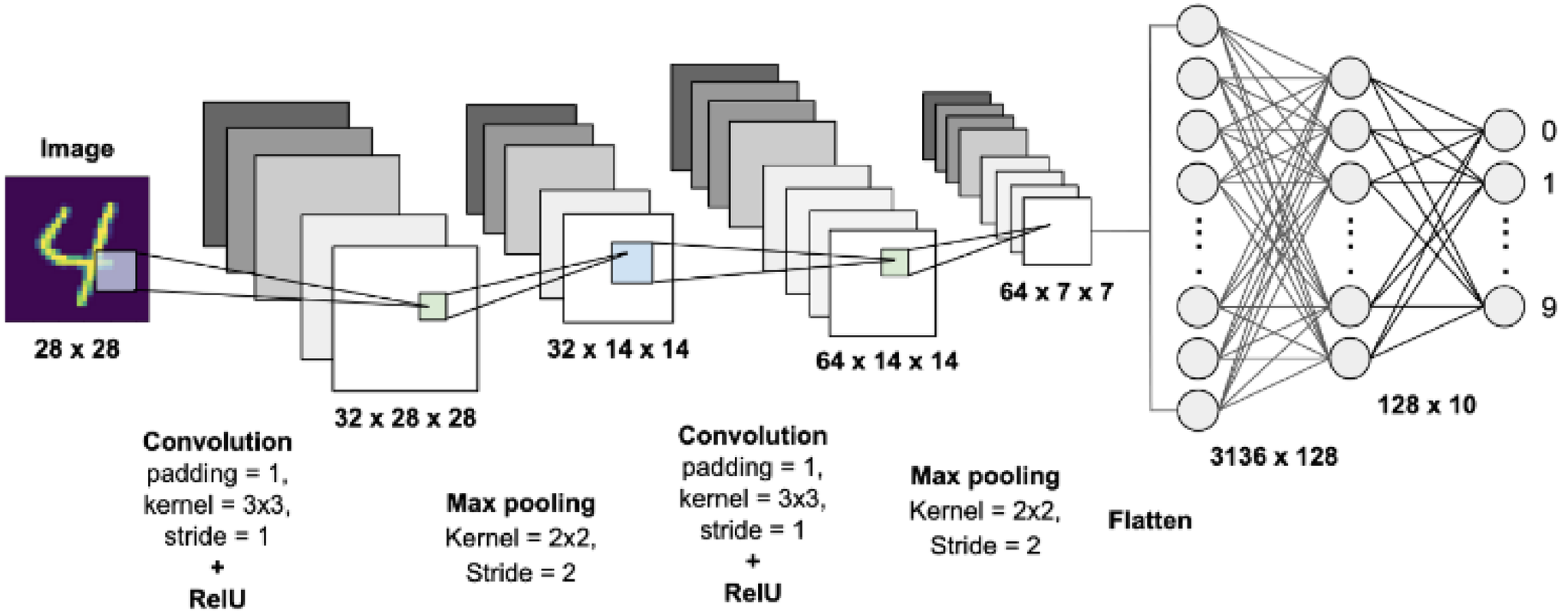
OUTPUT LAYER

FLATTEN LAYER

DROPOUT LAYER

DENSE LAYER

PICTORIAL REPRESENTATION



CONVOLUTION LAYER

A convolutional layer is the main building block of a CNN. It contains a set of filters (or kernels), The size of the filters is usually smaller than the actual image. Each filter convolves with the image and creates an activation map. For convolution the filter slid across the height and width of the image and the dot product between every element of the filter and the input is calculated at every spatial position.

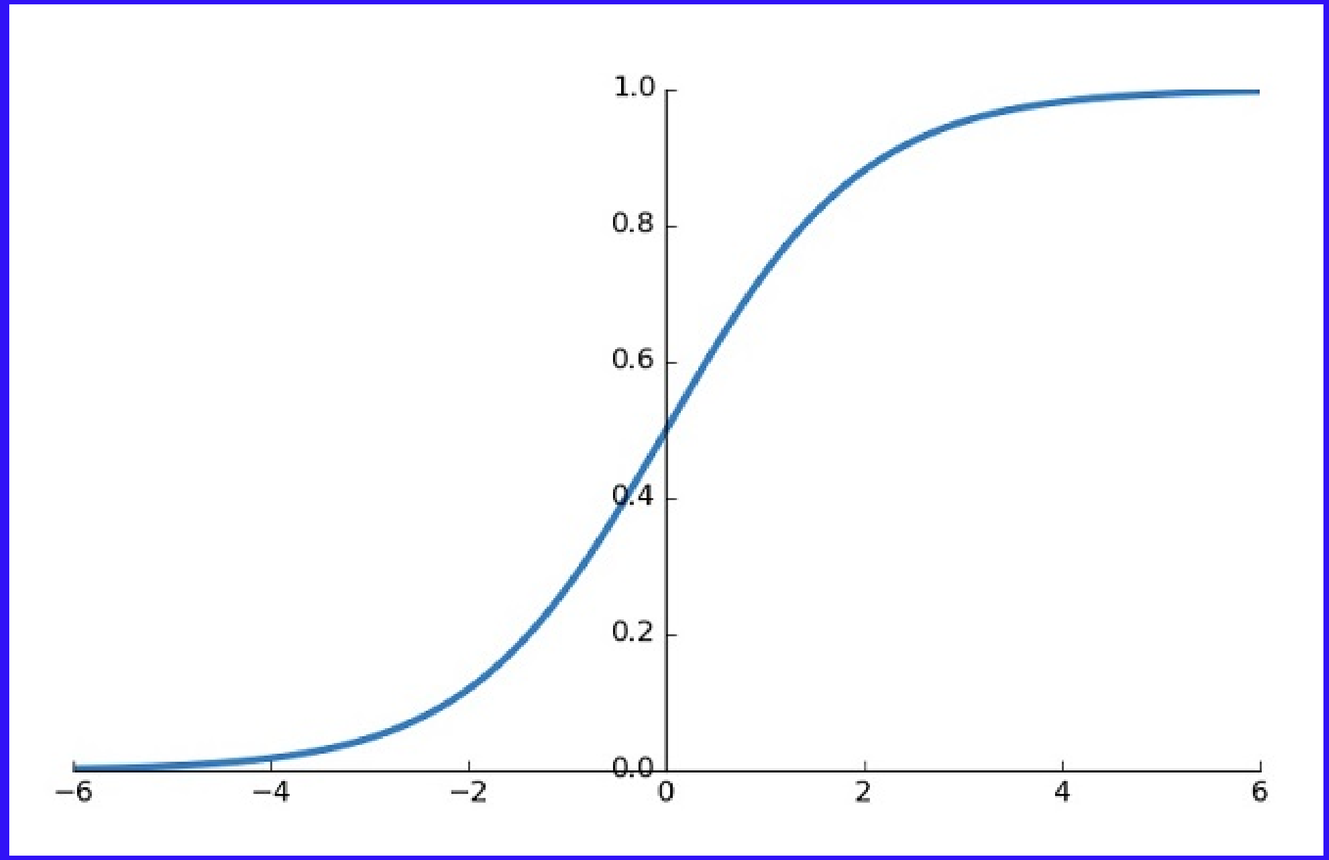
The output volume of the convolutional layer is generated by stacking the activation maps of every filter along the depth dimension. Every component of the activation map can be thought to be the output of a neuron. Therefore each neuron is connected to a small local region in the input image, and the size of the area equals the size of the filter.

THE ReLU LAYER [f(x)=(0,x)]

- The most commonly used activation function in Neural Networks is ReLU or the Rectified Linear Unit.
- It helps the model account for the interaction effect.
- It performs element-wise operations in other words, the set of all negative values is converted to 0; this introduces non-linearity to the network.
- In simple terms, The ReLU helps in controlling the activation by not activating all the neurons at the same time.

About Softmax Activation Function

The Softmax Activation is also used in the model.
the softmax is a combination of multiple sigmoid functions, it is mostly used in non-linear activation. basically, a sigmoid is an 's-shaped' curve
and softmax uses the sigmoid for the probability distribution of multiple values of 0's & 1's which are probabilities of data points of a particular class.



THE POOLING LAYER

The Pooling layer reduces the rectified feature map. Pooling is a downsampling operation that reduces the dimensionality of the feature map. For example 16X16 matrix into 4X4 matrix

The pooling layers also use multiple filters (kernels) to extract features like lines, edges, corners, and curves.

There are 2 common types of pooling

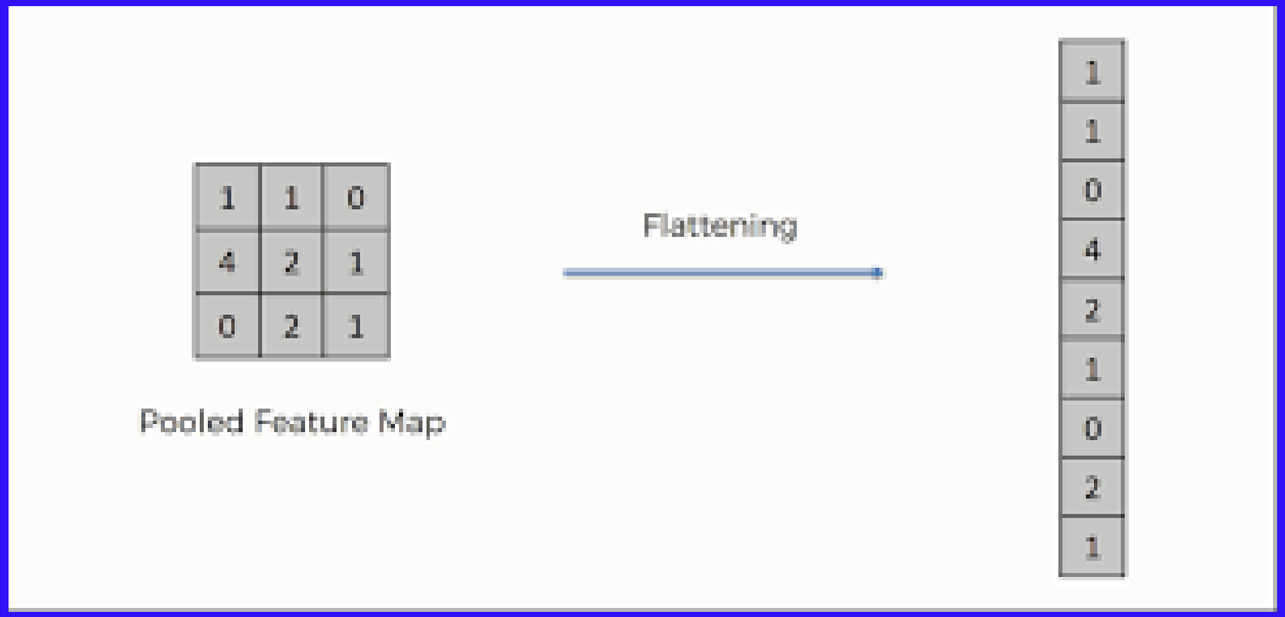
- Average pooling
- Max Pooling

here we have used Max Pooling which needs less computation power and it is simple because, it selects the max value from the matrix

FLATTENING LAYER

The flattening layer converts the resultant 2d array from pooled feature map into a single long and continuous linear vector
it converts spatial dimensions into channel dimensions

It is also considered a first fully connected layer

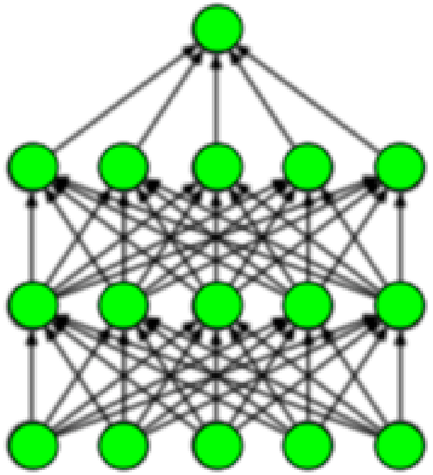


THE DROPOUT LAYER

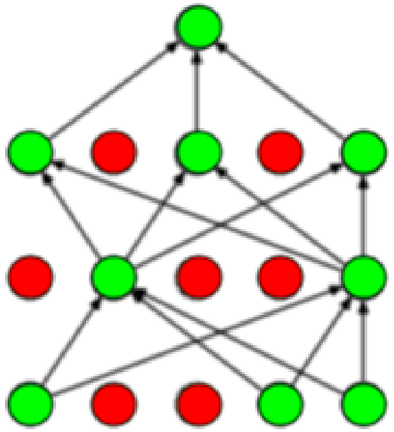
The Dropout is in the Fully Connected layer which randomly drops out some of the neurons to reduce the overfitting and coadaptation.

- **Overfitting:** When we train our data without cleaning or there is a lot of noise in our data and our model starts to learn from that noise is called overfitting
- **Coadaptation:** When there are multiple neurons, with the exact same feature and weight; such condition refers to coadaptation. this can happen when the connection weight of two different neurons is identical.

The Dropout randomly shuts down a fraction of the layer's neurons at each training step by zeroing out the weight of a neuron. The Dropout rate is given by r_d.
In our model, the Dropout rate is 0.25.



Before Applying the Dropout



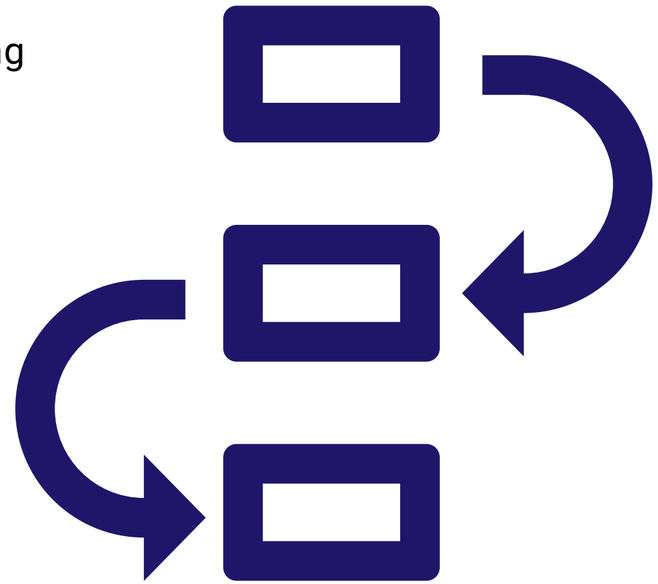
After Applying the Dropout

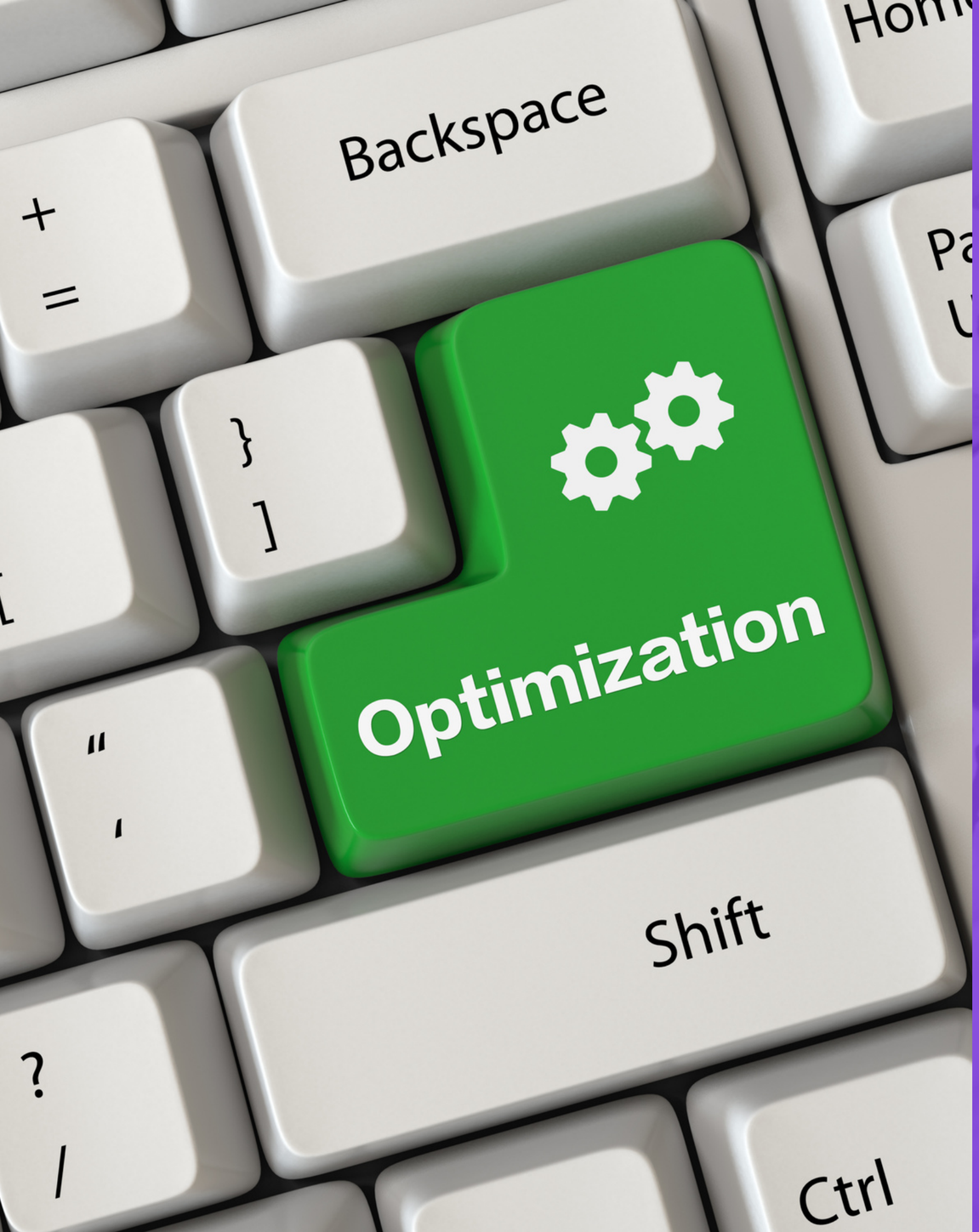
THE DENSE LAYER

The Main fully Connected Layer or the Dense Layer is a layer that is deeply connected with its preceding layer which means the neurons of the layer are connected to every neuron of its preceding layer.
In the background, the dense layer performs a matrix-vector multiplication. The values used in the matrix are actually parameters that can be trained and updated with the help of backpropagation.

Backpropagation uses the gradient descent method to calculate the error in the accuracy of input and the weights of neurons.

The output generated by the dense layer is an ‘m’ dimensional vector. Thus, the dense layer is basically used for changing the dimensions of the vector.





About the Optimizer

- The Optimizer is a mathematical function used to modify weights of the given network.
- There is one optimizer like SGP, AdaGrad, etc. But we choose AdaM or the Adaptive Moment Estimation
- AdaM is simplest to use and do not require tuning like AdaGrad
- It gives Functioinality of both Momentum and RMSP

We Hope You Liked it!!
Thanks for lending your ears!!