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Project: Learning of Neural Network by Backpropagation (YouTube Video)

Project Code: Option 2

Course: Artificial Intelligence

PLAYLIST: https://youtube.com/playlist?list=PLOgxymk4fhbstDCWkY1Ae8rAoWNmRv0yH

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Background:

Backpropagation is a technique used for learning of a neural network i.e. enable the neural network to self-organize and adjust its weights. This technique helps minimize the difference in the actual output by the neural network and the desired output by finding the best possible weight vector. So this YouTube video is all about learning related to neural network using the backpropagation method. This method was presented by **David E. Rumelhart***, **Geoffrey E. Hinton** and **Ronal J. Williams.**

Introduction:

This report is related to the making of YouTube video in which detailed explanation of backpropagation is presented along with simplified basic calculus behind it. In "feed forward neural network" information is passed from input layer to the output layer only. For correction of weights according to the cost function value, we have to back propagate the error. It means to find how much each weight is sensitive to the cost function i.e. how we can change the weights to reduce the value of cost function. This video starts with the basic working of single neuron then how their connection builds a neural network. Detail is added so that a person who has some confusion in understanding neuron and artificial neural network may get the starting stuff for understanding backpropagation.

Artificial Neuron

In simple words artificial neuron can be thought of as a function that takes some inputs and produces an output. It is the basic building block of ANN. It has some weights associated with each input and each input gets multiplied by its weights. Every neuron has a bias as well which translates the position of cuts made by neuron. Each neuron's output i.e. summation of each input multiplied by its weight added with bias is passed through an activation function. And if activation function is sigmoid then its value ranges from 0 to 1.

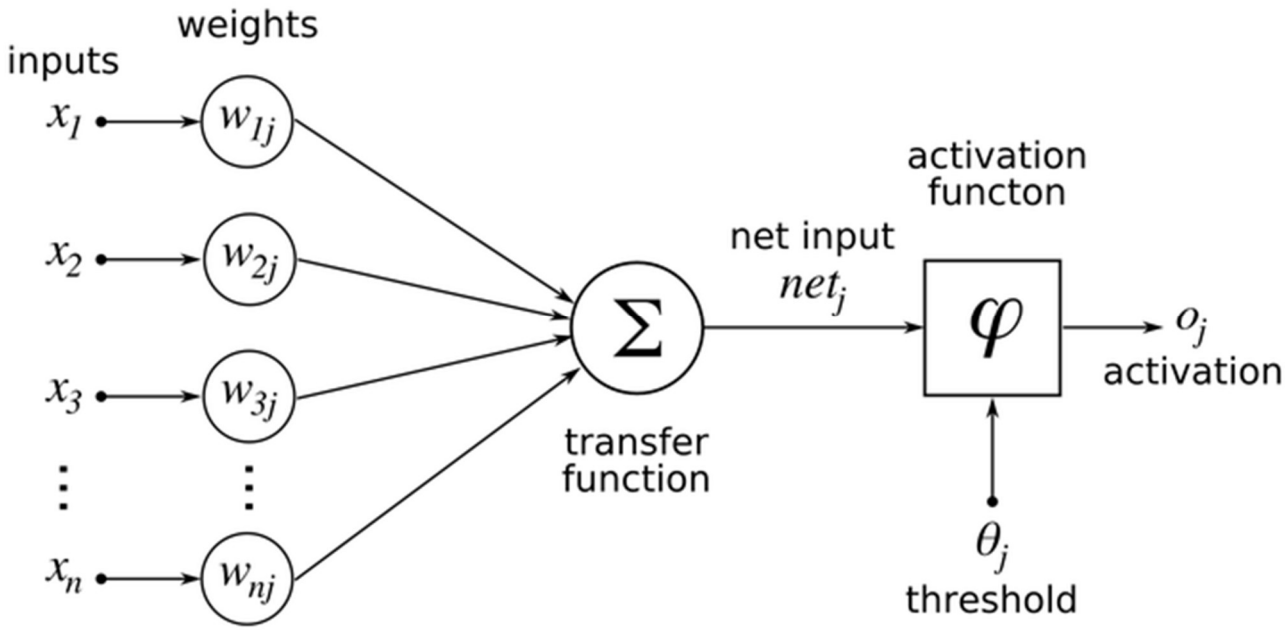

Figure 1 – Artificial Neuron – (What are ANNs) By **Ben Dickson** August 5, 2019

Artificial neuron is also called a perceptron. And perceptron can learn by using perceptron rule.

Artificial Neural Network:

We are now comfortable with a single perceptron (neuron). If we connect any number of neurons in some fashion they make a collective network called artificial neural network. Each neuron in ANN is connected to other neuron via an edge and this edge has some weigh which is adjusted during learning process.

Main things which we pointed out in video are that, in ANN there are three layers, i.e. input layer, output layer and hidden layer. Output layer is the top most layer which is visible to us. Input layer don't contain actual neurons but they are just inputs. Hidden layers are interesting ones they help the network to think in many dimensions (in simple words) i.e. we can extract hidden and complex features from our inputs.

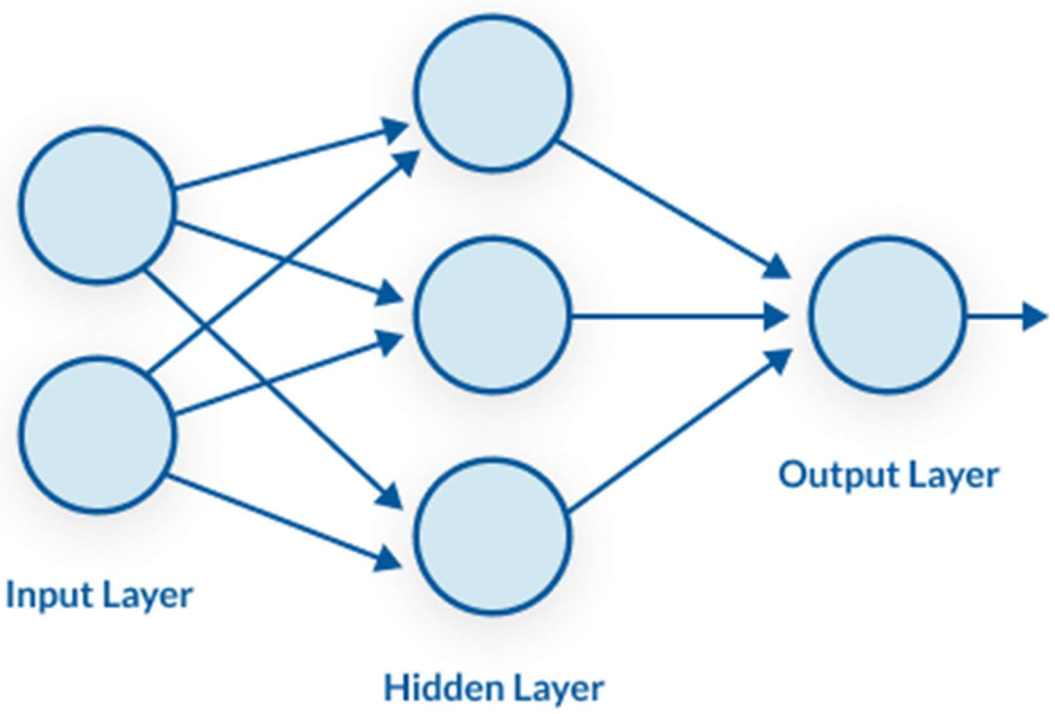

Figure 2 – Artificial Neural Network (Taken From Internet)

Backpropagation:

The aim to build a powerful algorithm that will make neural network self-organize its internal structure according to task domain. At output layer it is easy to compute the error and adjust the weights but it becomes difficult when we introduce hidden layers that are not specific to the task domain. So to adjust those hidden layer weights back propagation is presented by Geoffrey and his colleagues in their classical paper. [1]

Backpropagation is essence of neural network training. In simple words we can say to return specific amount of error to each neuron which they caused and contributed in the total loss by neural network. Loss function is basically computed as difference between actual output by the ANN and desired output then this difference is squared. So back propagation helps in propagating back that error to each node and adjust weights to minimize that loss function.

During forward pass, input is passed to the ANN and then at output layer we get our result but at start we have set weights randomly and our ANN behaves very strangely on given inputs. So at output, loss function is computed and then backpropagation starts and weights are adjusted accordingly from back to front or from top to bottom i.e. towards input layer.

1. Compute Cost Function

Cost Function is basically square of difference between actual output of ANN and the desired one. There can be any number of outputs by the ANN so we can compute cost for each output then sum all the costs of each output neuron.

Cost E = ∑ (actual Outputj – Desiredj) ^2

Here j represents total number of output neurons.

2. Find New Weight Vector

In this report we are avoiding adding too much detail related to mathematical computation. After finding cost function our next goal is now to somehow find new updated set of weights which will reduce the cost function.

And new weight is computed as,

W = W + ∂W **eq - 1**

∂W = -η∂E / ∂W **eq – 2**

In simple words computes - **∂E / ∂W** and then steps in its direction as it will lead you towards optimum minima. As gradient indicates the direction in which function is increasing so negative of it indicates the direction in which function can decrease. Here we want to minimize the cost function. In video we have presented many good examples that will help understand backend mathematics.

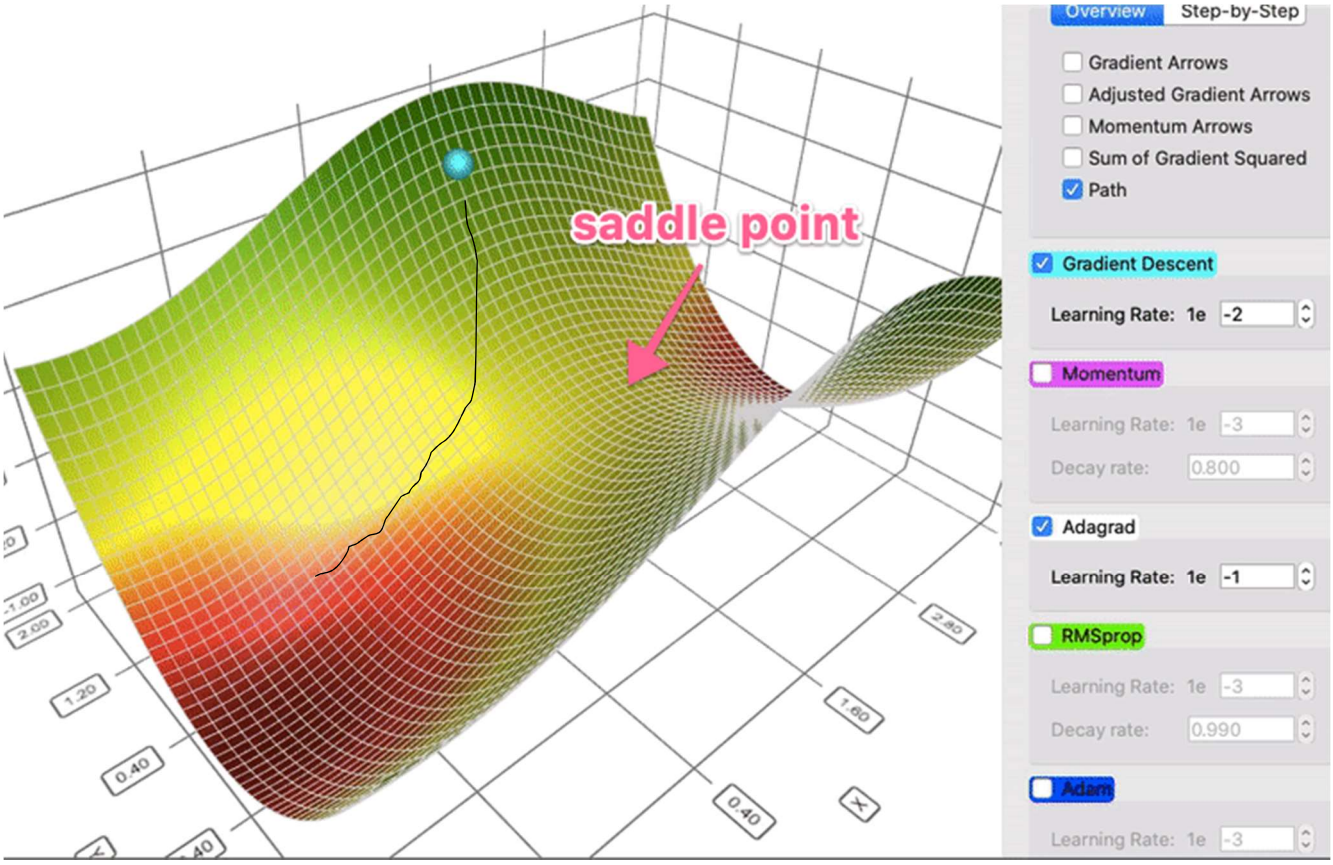

Figure: Representing Gradient Descent (converging towards minima)

Important Notes:

Input to a neuron is basically output of previous neuron multiplied by weight of that connection and added with a bias. In complex neural network neuron is connected with many other neurons from previous layer. So for example if we represent a neuron with "J" then its input is as explained by **Geoffrey** and his colleagues in his paper **(Learning Representation by back propagation.)** [1]

Xj = ∑ (Ai0 * Wji0 + Ai1 * Wji1+ …… + bias)

And output of a neuron in an ANN is basically the input to the neuron passed from the sigmoid function i.e. activation function.

Output: An or Yn = Sigmoid (Xn)

Making Of YouTube Video:

1. Tools used:

Filmora Video Editor.

Google Slides for introductory slide.

2. Lecture Recorded On:

Redmi Note 9s Rear Camera (Mobile Phone).

3. Resources or References

[1] Learning Representations by back propagating errors. David E. Rumelhart, Geoffrey and Ronald.

[2]Animated Explanation of Feed Forward Neural Network Architecture. By MLK – OCT-19. https://machinelearningknowledge.ai/animated-explanation-of-feed-forward-neural-network-architecture/

Two animation images are taken from internet and its reference is mentioned above [2].

[3] Video Lectures by "**The Coding Train**" on Gradient descent, neural network and Backpropagation.

[4] Wikipedia contributors. "Artificial neural network." *Wikipedia, the Free Encyclopedia*. Wikipedia, the Free Encyclopedia, 17 Dec. 2020. Web. 27 Dec. 2020.

[5] CS50's Intro to AI, Lecture 4 and Lecture 5

[6] YouTube video class on ANN (Last Lecture on ANNs – AI Class)

[7] http://neuralnetworksanddeeplearning.com/chap1.html (Detailed Chapter on Neural Networks)

YouTube Video Links:

This video series is divided in three parts.

1. Introductory Video

This Part contains introduction, contents to be covered and a brief go through over neurons and artificial neural network.

Link: https://youtu.be/6B7HfjgIIeU

2. Neural Network and Back propagation Part 1

This part contains a detailed working of a neuron and explanation of what is back propagation and how it makes our neural network a self-organizing neural network.

Link: https://youtu.be/c-zs7jjLTQQ

3. Neural Network and Back propagation Final Part

This part contains a detailed go through over mathematical explanation behind back propagation. That was the main demand of our project.

Link: https://youtu.be/AsF_RYEo6cc

Playlist is created on YouTube with the title as "**AI PROJECT 2**" containing all the three video parts. Here is the playlist **Link**:

https://youtube.com/playlist?list=PLOgxymk4fhbstDCWkY1Ae8rAoWNmRv0yH