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Date of submission - 26-3-2021

This notebook was written in google colab.
Link to view notebook
https://colab.research.google.com/drive/1EoWhf73D6XL7-j7RwJpYDjtgj0aXgXvQ?usp=sharing

Importing packages

Numpy - Computations
Matplotlib - for plotting a graph

```
import numpy as np
from matplotlib import pyplot as plt
```

Sigmoid function

Function representing the mathematical Sigmoid function
Sig(z) = $\frac{1}{1+e^{-z}}$

```
def sigmoid(z):
  return 1 / (1 + np.exp(-z))
```

Initializing all the neural network parameters

Initializing bias = 0
The names of the parameters are intuitive.

```
def initializeParameters(inputFeatures, neuronsInHiddenLayers, outputFeatures):
    W1 = np.random.randn(neuronsInHiddenLayers, inputFeatures)
    W2 = np.random.randn(outputFeatures, neuronsInHiddenLayers)
    b1 = np.zeros((neuronsInHiddenLayers, 1))
    b2 = np.zeros((outputFeatures, 1))

    parameters = {"W1" : W1, "b1": b1, "W2" : W2, "b2": b2}
    return parameters
```

Forward Propagation

```
def forwardPropagation(X, Y, parameters):
    m = X.shape[1]
    W1 = parameters["W1"]
    W2 = parameters["W2"]
    b1 = parameters["b1"]
    b2 = parameters["b2"]

    Z1 = np.dot(W1, X) + b1
    A1 = sigmoid(Z1)
    Z2 = np.dot(W2, A1) + b2
    A2 = sigmoid(Z2)

    cache = (Z1, A1, W1, b1, Z2, A2, W2, b2)
    logprobs = np.multiply(np.log(A2), Y) + np.multiply(np.log(1 - A2), (1 - Y))
    cost = -np.sum(logprobs) / m
    return cost, cache, A2
```

Backward Propagation

```
def backwardPropagation(X, Y, cache):
    m = X.shape[1]
    (Z1, A1, W1, b1, Z2, A2, W2, b2) = cache

    dZ2 = A2 - Y
    dW2 = np.dot(dZ2, A1.T) / m
    db2 = np.sum(dZ2, axis = 1, keepdims = True)

    dA1 = np.dot(W2.T, dZ2)
    dZ1 = np.multiply(dA1, A1 * (1- A1))
    dW1 = np.dot(dZ1, X.T) / m
    db1 = np.sum(dZ1, axis = 1, keepdims = True) / m

    gradients = {"dZ2": dZ2, "dW2": dW2, "db2": db2, "dZ1": dZ1, "dW1": dW1, "db1": db
    return gradients
```

Updating the weights based on the negative gradient

```
def updateParameters(parameters, gradients, learningRate):
    parameters["W1"] = parameters["W1"] - learningRate * gradients["dW1"]
    parameters["W2"] = parameters["W2"] - learningRate * gradients["dW2"]
    parameters["b1"] = parameters["b1"] - learningRate * gradients["db1"]
    parameters["b2"] = parameters["b2"] - learningRate * gradients["db2"]

    return parameters
```

Training the model to learn the AND truth table

```
X = np.array([[0, 0, 1, 1], [0, 1, 0, 1]]) # AND input
Y = np.array([[0, 0, 0, 1]]) # AND output
```

Defining model parameters

Number of hidden layer neurons = 2

Number of input features = 2

Number of output features = 1

```
neuronsInHiddenLayers = 2
inputFeatures = X.shape[0]
outputFeatures = Y.shape[0]
parameters = initializeParameters(inputFeatures, neuronsInHiddenLayers, outputFeatures
epoch = 100000
learningRate = 0.01
losses = np.zeros((epoch, 1))
for i in range(epoch):
    losses[i, 0], cache, A2 = forwardPropagation(X, Y, parameters)
    gradients = backwardPropagation(X, Y, cache)
    parameters = updateParameters(parameters, gradients, learningRate)
```

Testing the model with different values of x1 and x2

Testing can be done with a different permutation of the AND inputs compared to the inputs the model was trained on.

```
X = np.array([[1, 1, 1, 0], [0, 1, 0, 1]])
cost, _, A2 = forwardPropagation(X, Y, parameters)
prediction = (A2 > 0.5) * 1.0 # Measuring probability >50% and assigning values

# Printing table, P -> Probability that it is 1
print('X0| X1| P      | Y')
print('--|---|--------|--')
for i in range(0,4):
  print('{} | {} | {} | {}'.format(X[0, i], X[1, i], round((float(A2[0, i])), 4), int(

```

```
X0| X1| P      | Y
--|---|--------|--
1 | 0 | 0.0034 | 0
1 | 1 | 0.993 | 1
1 | 0 | 0.0034 | 0
0 | 1 | 0.0034 | 0
```

```
X = np.array([[1, 1, 1, 0], [1, 0, 0, 1]])
cost, _, A2 = forwardPropagation(X, Y, parameters)
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```

```
X0| X1| P      | Y
--|---|--------|--
1 | 1 | 0.993 | 1
1 | 0 | 0.0034 | 0
1 | 0 | 0.0034 | 0
0 | 1 | 0.0034 | 0
```

```
X = np.array([[0, 0, 0, 1], [1, 1, 1, 1]])
cost, _, A2 = forwardPropagation(X, Y, parameters)
prediction = (A2 > 0.5) * 1.0 # Measuring probability >50% and assigning values

# Printing table, P -> Probability that it is 1
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```
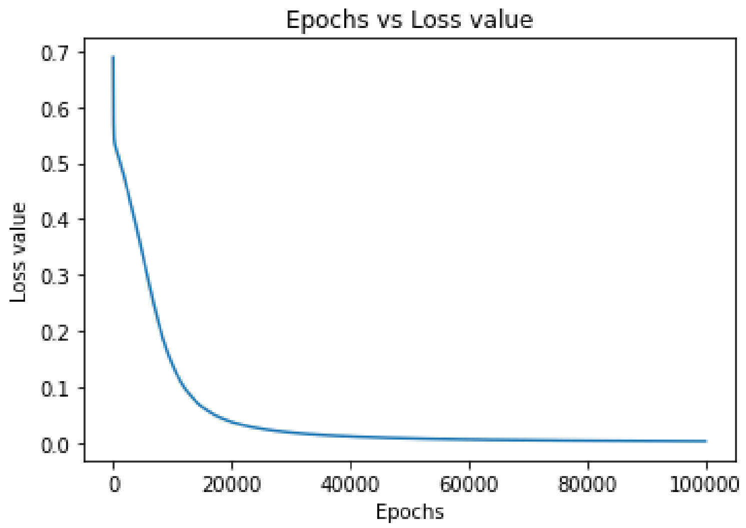

```
X0| X1| P      | Y
--|---|--------|--
0 | 1 | 0.0034 | 0
0 | 1 | 0.0034 | 0
0 | 1 | 0.0034 | 0
1 | 1 | 0.993 | 1
```

```
# Mathplotlb for plotting a graph between the Number of epochs and Loss value.

plt.figure()
plt.plot(losses)
plt.xlabel("Epochs")
plt.ylabel("Loss value")
plt.title('Epochs vs Loss value')
plt.savefig('181CO109 graph.pdf')
plt.show()
```



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