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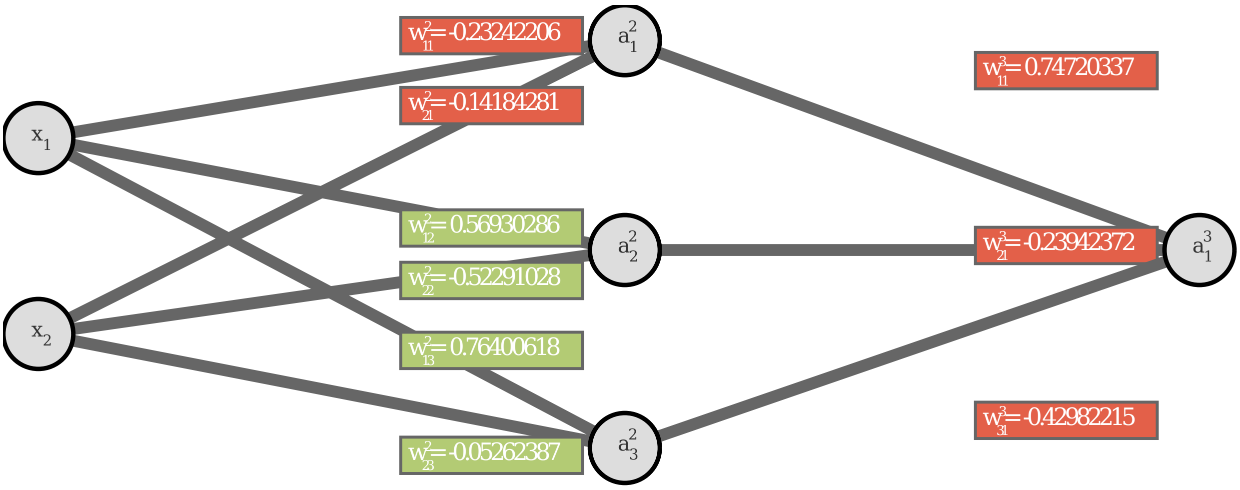
Neural Network Simulator

Neural Network Simulator is a real feedforward neural network running in your browser. The simulator will help you understand how artificial neural network works. The network is trained using backpropagation algorithm, and the goal of the training is to learn the XOR function. One forward and the backward pass of single training example is called iteration, each iteration consists of 10 steps.

Iteration: 0 Step: 10/10

x1	x2	y
1	1	0
0	1	1
1	0	1
0	0	0



Step 0) Initialization

$The\ weights\ are\ randomly\ initialized\ to\ the\ range\ (-1,1).$
Theweightsarerandomlyinitializedtotherange(−1,1).

Forward pass

Step 1) Input layer

x_1 = 1x1=1
x_2 = 1x2=1

Step 2) Hidden layer

$a_1^{(2)} = \sigma\left(w_{11}^{(2)}x_1 + w_{21}^{(2)}x_2\right) = 0.4194143$a1(2)=σ(w11(2)x1+w21(2)x2)=0.4194143
$a_2^{(2)} = \sigma\left(w_{12}^{(2)}x_1 + w_{22}^{(2)}x_2\right) = 0.50883719$a2(2)=σ(w12(2)x1+w22(2)x2)=0.50883719

$a_3^{(2)} = \sigma\left(w_{13}^{(2)}x_1 + w_{23}^{(2)}x_2\right) = 0.66641372$a3(2)=σ(w13(2)x1+w23(2)x2)=0.66641372

Step 3) Output layer

$a_1^{(3)} = \sigma\left(w_{11}^{(3)}a_1^{(2)} + w_{21}^{(3)}a_2^{(2)} + w_{31}^{(3)}a_3^{(2)}\right) = 0.50396263$a1(3)=σ(w11(3)a1(2)+w21(3)a2(2)+w31(3)a3(2)
)=0.50396263

Step 4) Calculate the cost

$E = \frac{1}{2}\left(y - a_1^{(3)}\right)^2 = 0.12698917$E=21(y−a1(3))2=0.12698917

Backpropagation pass

Step 5) Error in the output layer

$\delta_1^{(3)} = \left(y - a_1^{(3)}\right)a_1^{(3)}\left(1 - a_1^{(3)}\right) = -0.12598275$δ1(3)=(y−a1(3))a1(3)(1−a1(3))=−0.12598275

6) Error in the hidden layer

$\delta_1^{(2)} = \left(\delta_1^{(3)}w_{11}^{(3)}\right)a_1^{(2)}\left(1 - a_1^{(2)}\right) = -0.02454334$δ1(2)=(δ1(3)w11(3))a1(2)(1−a1(2))=−0.02454334
$\delta_2^{(2)} = \left(\delta_1^{(3)}w_{21}^{(3)}\right)a_2^{(2)}\left(1 - a_2^{(2)}\right) = 0.00552007$δ2(2)=(δ1(3)w21(3))a2(2)(1−a2(2))=0.00552007
$\delta_3^{(2)} = \left(\delta_1^{(3)}w_{31}^{(3)}\right)a_3^{(2)}\left(1 - a_3^{(2)}\right) = 0.00968658$δ3(2)=(δ1(3)w31(3))a3(2)(1−a3(2))=0.00968658

Step 7) Calculate the error with respect to weights between hidden and output layer

$\frac{\partial E}{\partial w_{11}^{(3)}} = a_1^{(2)}\delta_1^{(3)} = -0.05283897$∂w11(3)∂E=a1(2)δ1(3)=−0.05283897
$\frac{\partial E}{\partial w_{21}^{(3)}} = a_2^{(2)}\delta_1^{(3)} = -0.06410471$∂w21(3)∂E=a2(2)δ1(3)=−0.06410471
$\frac{\partial E}{\partial w_{31}^{(3)}} = a_3^{(2)}\delta_1^{(3)} = -0.08395663$∂w31(3)∂E=a3(2)δ1(3)=−0.08395663

Step 8) Calculate the error with respect to weights between input and hidden layer

$\frac{\partial E}{\partial w_{11}^{(2)}} = x_1\delta_1^{(2)} = -0.02454334$∂w11(2)∂E=x1δ1(2)=−0.02454334
$\frac{\partial E}{\partial w_{12}^{(2)}} = x_1\delta_2^{(2)} = 0.00552007$∂w12(2)∂E=x1δ2(2)=0.00552007
$\frac{\partial E}{\partial w_{13}^{(2)}} = x_1\delta_3^{(2)} = 0.00968658$∂w13(2)∂E=x1δ3(2)=0.00968658
$\frac{\partial E}{\partial w_{21}^{(2)}} = x_2\delta_1^{(2)} = -0.02454334$∂w21(2)∂E=x2δ1(2)=−0.02454334
$\frac{\partial E}{\partial w_{22}^{(2)}} = x_2\delta_2^{(2)} = 0.00552007$∂w22(2)∂E=x2δ2(2)=0.00552007
$\frac{\partial E}{\partial w_{23}^{(2)}} = x_2\delta_3^{(2)} = 0.00968658$∂w23(2)∂E=x2δ3(2)=0.00968658

Step 9) Update the weights between hidden and output layer

$w_{11}^{(3)} := w_{11}^{(3)} + \frac{\partial E}{\partial w_{11}^{(3)}} = 0.74720337$w11(3):=w11(3)+∂w11(3)∂E=0.74720337
$w_{21}^{(3)} := w_{21}^{(3)} + \frac{\partial E}{\partial w_{21}^{(3)}} = -0.23942372$w21(3):=w21(3)+∂w21(3)∂E=−0.23942372
$w_{31}^{(3)} := w_{31}^{(3)} + \frac{\partial E}{\partial w_{31}^{(3)}} = -0.42982215$w31(3):=w31(3)+∂w31(3)∂E=−0.42982215

Step 10) Update the weights between input and hidden layer

$w_{11}^{(2)} := w_{11}^{(2)} + \frac{\partial E}{\partial w_{11}^{(2)}} = -0.23242206$w11(2):=w11(2)+∂w11(2)∂E=−0.23242206

$w_{12}^{(2)} := w_{12}^{(2)} + \frac{\partial E}{\partial w_{12}^{(2)}} = 0.56930286$w12(2):=w12(2)+∂w12(2)∂E=0.56930286

$w_{13}^{(2)} := w_{13}^{(2)} + \frac{\partial E}{\partial w_{13}^{(2)}} = 0.76400618$w13(2):=w13(2)+∂w13(2)∂E=0.76400618

$w_{21}^{(2)} := w_{21}^{(2)} + \frac{\partial E}{\partial w_{21}^{(2)}} = -0.14184281$w21(2):=w21(2)+∂w21(2)∂E=−0.14184281

$w_{22}^{(2)} := w_{22}^{(2)} + \frac{\partial E}{\partial w_{22}^{(2)}} = -0.52291028$w22(2):=w22(2)+∂w22(2)∂E=−0.52291028

$w_{23}^{(2)} := w_{23}^{(2)} + \frac{\partial E}{\partial w_{23}^{(2)}} = -0.05262387$w23(2):=w23(2)+∂w23(2)∂E=−0.05262387

Notation

x_j − *input to neuron j*xj−inputtoneuronj

$w_{ij}^{(l)}$ − *weight from layer l − 1 neuron i to layer l neuron j*wij(l)−weightfromlayerl−1neuronitolayerlneuronj

$a_j^{(l)}$ − *activation of the j neuron in the l layer*aj(l)−activationofthejneuroninthellayer

$\delta_j^{(l)}$ − *error in the j neuron in the l layer*δj(l)−errorinthejneuroninthellayer

$\sigma(x) = \frac{1}{1+e^{-x}}$ − *sigmoid activation function*σ(x)=1+e−x1−sigmoidactivationfunction

y − *target value*y−targetvalue

$E = \frac{1}{2}\left(y - a_1^{(3)}\right)^2$ − *cost function*E=21(y−a1(3))2−costfunction