

Trevor Bright

Assignment 1

1/28/2020

$$1) \tanh(v) = 2\text{sigmoid}(2v) - 1$$

$$\boxed{\tanh(x)} = \frac{e^x - e^{-x}}{e^x + e^{-x}} = \frac{e^x + e^{-x} - 2e^{-x}}{e^x + e^{-x}} = 1 + \frac{-2e^{-x}}{e^x + e^{-x}}$$

$$= 1 + \frac{-2}{e^{2x} + 1} = 1 - \frac{2}{e^{2x} + 1} = 1 - 2\text{sigmoid}(2x) =$$

$$= -1(1 - 2\text{sigmoid}(2x)) = \boxed{2\text{sigmoid}(2x) - 1}$$

$$2) a) \text{Sigmoid}(-v) = \frac{e^{-v}}{e^{-v} + 1} \quad \phi(-v) = 1 - \phi(v)$$

$$\text{sigmoid}(v) = \frac{e^v}{e^v + 1} \Rightarrow \frac{e^v}{e^v + 1} \Rightarrow \frac{1+e^v}{1+e^v} - \frac{e^v}{1+e^v} = \frac{1}{1+e^v} \left(\frac{e^v}{e^v} \right)$$

$$= \frac{e^{-v}}{e^{-v} + 1} = \text{sigmoid}$$

$$b) \text{Tanh activation: } \phi(-v) = -\phi(v)$$

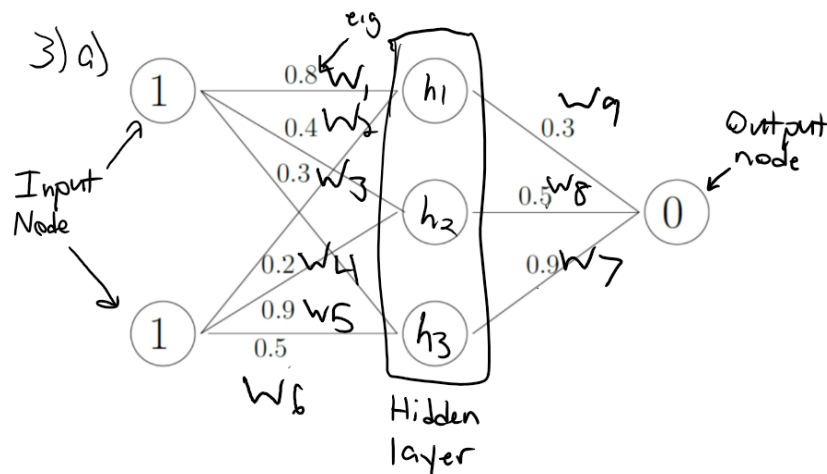
$$\text{Tanh activ.} = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

$$\phi(-x) = \frac{e^{-x} - e^x}{e^{-x} + e^x} \cdot (-1) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

$$c) \text{Hard tanh activation: } \phi(-v) = -\phi(v)$$

$$\text{hardtanh}(v) = \begin{cases} -1 & v < -1 \\ v & -1 \leq v \leq 1 \\ 1 & v > 1 \end{cases} \quad \text{hardtanh}(-v) = \begin{cases} -1 & -v < -1 \quad (-) \\ -v & -1 \leq -v \leq 1 \quad (-) \\ 1 & -v > 1 \quad (+) \end{cases}$$

$$\boxed{(-) \text{hardtanh}(v) = \begin{cases} 1 & v > 1 \\ v & -1 \leq v \leq -1 \\ -1 & v < -1 \end{cases}}$$



Input node: This is the point where input data is received.

Weights: These determine how important each of the nodes are. This is the only thing we can change in our neural network.

Hidden layer: Does the computation. It adds the weights to the input from all or a select range of activation function outputs

Output node: The point of output after processing data in hidden layer.

b) Sigmoid = $\frac{1}{1+e^{-x}}$

$$x_1 = (.8)(1) + (.2)(1) = 1 \quad x_2 = .4(1) + .9(1) = 1.3$$

$$h_1 = \frac{1}{1+e^{-1}} = .731058 \quad h_2 = .785834983$$

$$x_3 = .3(1) + (.5)(1) = .8$$

$$h_3 = \frac{1}{1+e^{-.8}} = .689974$$

$$x_o = .731058(.3) + .7858349(.5)$$

$$+ .689974(.9) = 1.233212098$$

$$h_o = \frac{1}{1+e^{-1.233}} = .774380$$

$$E = (0 - .774380)^2 = .596648$$

c)

.5 seems to be a common learning rate

$$E_{w_9} = \frac{\partial E_{\text{total}}}{\partial w_9} * \frac{\partial \text{out}_0}{\partial 0} + \frac{\partial 0}{\partial w_9}$$

$$\frac{\partial E_{\text{total}}}{\partial w_9} = 2(0 - \text{out}_{h1}) * (-1 + 0) \\ = 2(0 - .731058) = 1.54876$$

$$\frac{\partial \text{out}_0}{\partial 0} = \text{out}_0(1 - \text{out}_0) = .774(1 - .774) = .174715$$

$$\frac{\partial h1}{\partial w_9} = 1 * \text{out}_{h1} * w_9^0 + 0 + 0 \\ = \text{out}_{h1} = .774380$$

$$E_{w_9} = 1.54876 * .174715 * .774380 \\ = .2095413587$$

$$w_9 = .3 - (.5)(1.198) = .201$$

$$E_{w_8} = \frac{\partial E_T}{\partial w_8} * \frac{\partial \text{out}_0}{\partial 0} + \frac{\partial 0}{\partial w_8}$$

$$\frac{\partial E_T}{\partial w_8} = 2(0 - .785834) * (-1 + 0) = 1.571668$$

$$\frac{\partial \text{out}_0}{\partial 0} = .174715$$

$$\frac{\partial 0}{\partial w_8} = .786$$

$$E_{w_8} = (1.572)(.175)(.786) = .213$$

$$w_8 = .5 - (.5)(1.213) = .3935$$

$$E_{w_7} = \frac{\partial E_T}{\partial w_7} * \frac{\partial \text{out}_0}{\partial 0} + \frac{\partial 0}{\partial w_7} = (-2(-.774))(1.774(1 - .774))(.60) \\ = .187$$

$$w_7 = .9 - (.5)(1.187) = .807$$

$$E_{w_1} = \frac{\partial E_T}{\partial w_1} = \frac{\partial E_T}{\partial \text{out}_{h_1}} \left(\frac{\partial \text{out}_{h_1}}{\partial 1} \right) \left(\frac{\partial h_1}{\partial w_1} \right)$$

$$\frac{\partial E_T}{\partial \text{out}_{h_1}} = \frac{\partial E_T}{\partial 0} \left(\frac{\partial 0}{\partial \text{out}_{h_1}} \right) = .271(0.3) = 0.081$$

$$\frac{\partial E_T}{\partial 0} = \frac{\partial E_T}{\partial \text{out}_0} \left(\frac{\partial \text{out}_0}{\partial 0} \right) = 1.548(1.78) = .271$$

$$\frac{\partial E_T}{\partial 0} = \frac{\partial E_T}{\partial \text{out}_0} \left(\frac{\partial \text{out}_0}{\partial 0} \right) = 1.548(1.75) = .271$$

$$\frac{\partial E_T}{\partial \text{out}_{h_2}} = \frac{\partial E_T}{\partial 0} \left(\frac{\partial 0}{\partial \text{out}_{h_2}} \right) = .271(0.5) = .136$$

$$\frac{\partial E_T}{\partial 0} = \frac{\partial E_T}{\partial \text{out}_0} \left(\frac{\partial \text{out}_0}{\partial 0} \right) = 1.548(1.75) = .271$$

$$\frac{\partial E_T}{\partial 0} = \frac{\partial E_T}{\partial 0} \left(\frac{\partial 0}{\partial \text{out}_{h_3}} \right) = .271(0.9) = .244$$

$$\frac{\partial E_T}{\partial \text{out}_{h_1}} = \frac{\partial E_T}{\partial \text{out}_{h_1}} + \frac{\partial E_T}{\partial \text{out}_{h_2}} + \frac{\partial E_T}{\partial \text{out}_{h_3}} = .461$$

$$\frac{\partial \text{out}_{h_1}}{\partial h_1} = \text{out}_{h_1}(1 - \text{out}_{h_1}) = .73(1 - .73) = .197$$

$$\frac{\partial h_1}{\partial w_1} = x_1 = 1$$

$$E_1 = \frac{\partial E_T}{\partial \text{out}_{h_1}} \left(\frac{\partial \text{out}_{h_1}}{\partial h_1} \right) \left(\frac{\partial h_1}{\partial w_1} \right) = .461(.197)(1) = .091 = E_4$$

$$w_1 = .8 - (.5)(.091) = .755$$

$$E_2 = \frac{\partial E_T}{\partial \text{out}_{h_2}} \left(\frac{\partial \text{out}_{h_2}}{\partial h_2} \right) \left(\frac{\partial h_2}{\partial w_2} \right) = .461(.786(1 - .786))(1) = .078 = E_5$$

$$w_2 = .4 - (.5)(.078) = .361$$

$$E_3 = \frac{\partial E_T}{\partial \text{out}_{h_3}} \left(\frac{\partial \text{out}_{h_3}}{\partial h_3} \right) \left(\frac{\partial h_3}{\partial w_3} \right) = .461(.669(1 - .669))(1) = .099 = E_6$$

$$w_3 = .3 - (.5)(.099) = .251$$

$$w_4 = .2 - (.5)(.091) = .155$$

$$w_5 = .9 - (.5)(.078) = .861$$

$$w_6 = .5 - (.5)(.099) = .451$$

$$x_1 = (1)(.755) + (1)(.155) = .91$$

$$h_1 = \frac{1}{1 + e^{-.91}} = .713$$

$$x_2 = (1)(.361) + (1)(.861) = 1.22$$

$$h_2 = \frac{1}{1 + e^{-1.22}} = .772$$

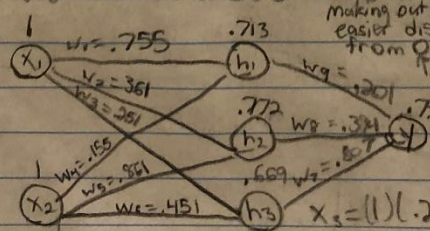
$$x_3 = (1)(.251) + (1)(.451) = .702$$

$$h_3 = \frac{1}{1 + e^{-.702}} = .669$$

$$x_y = (.713)(.22) + (.772)(.394) + (.669)(.669) = .927$$

$$y = \frac{1}{1 + e^{-.927}} = .728$$

$$E = (0 - .728)^2 = .530$$



Pass 2

$$\frac{\partial T}{\partial out_4} = -2(0 - .728) = 1.456$$

$$\frac{\partial out_4}{\partial y} = .728(1 - .728) = .198$$

$$E_7 = 1.456(.198)(.669) = .193$$

$$w_7 = .807 - (.5)(.193) = .711$$

$$E_8 = 1.456(.198)(.772) = .223$$

$$w_8 = .394 - (.5)(.223) = .283$$

$$E_9 = 1.456(.198)(.713) = .206$$

$$w_9 = .201 - (.5)(.206) = .098$$

$$\frac{\partial T}{\partial out_{h1}} = \frac{\partial E_1}{\partial out_{h1}} + \frac{\partial E_2}{\partial out_{h1}} + \frac{\partial E_3}{\partial out_{h1}} = 0.098 + 0.113 + 0.232 = 0.403$$

$$\frac{\partial E_1}{\partial y} = 1.456(.198) = .288 \quad \frac{\partial E_1}{\partial out_{h1}} = .288(.201) = .058$$

$$\frac{\partial E_2}{\partial y} = 1.456(.198) = .288 \quad \frac{\partial E_2}{\partial out_{h2}} = .288(.394) = .113$$

$$\frac{\partial E_3}{\partial y} = 1.456(.198) = .288 \quad \frac{\partial E_3}{\partial out_{h3}} = .288(.807) = .232$$

$$E_1 = (.461)(.713(1 - .713))(1) = .094 = E_4$$

$$w_1 = .755 - (.5)(.094) = .708$$

$$E_2 = (.461)(.772(1 - .772))(1) = .081 = E_5$$

$$w_2 = .361 - .5(.081) = .321$$

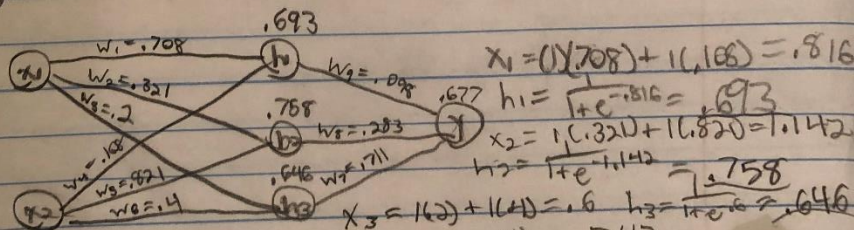
$$E_3 = .461(.669(1 - .669))(1) = .102 = E_6$$

$$w_3 = .251 - .5(.102) = .2$$

$$w_4 = .155 - (.5)(.094) = .108$$

$$w_5 = .861 - .5(.081) = .821$$

$$w_6 = .451 - .5(.102) = .4$$



$$x_4 = (.693)(.098) + (.758)(.283) + (.646)(.711) = .742$$

$$y = \frac{1}{1 + e^{-.742}} = .677$$

$$E = (0 - .677)^2 = .458 \text{ or } 45.8\%$$

4. a)

```
(tf_gpu) PS C:\Users\Trevor\OneDrive\Spring 2020\Deep Learning\HW1> python .\HW1-4a.py
2020-01-28 18:02:47.745986: I tensorflow/stream_executor/platform/default/dso_loader.cc:44] Successfully opened dynamic
library cudart64_100.dll
WARNING:tensorflow:From C:\Users\Trevor\Anaconda3\envs\tf_gpu\lib\site-packages\tensorflow_core\python\keras\initializer
s.py:143: calling RandomNormal.__init__ (from tensorflow.python.ops.init_ops) with dtype is deprecated and will be remov
ed in a future version.
Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to the constructor
WARNING:tensorflow:From C:\Users\Trevor\Anaconda3\envs\tf_gpu\lib\site-packages\tensorflow_core\python\ops\resource_vari
able_ops.py:1630: calling BaseResourceVariable.__init__ (from tensorflow.python.ops.resource_variable_ops) with constrai
nt is deprecated and will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
WARNING:tensorflow:From C:\Users\Trevor\Anaconda3\envs\tf_gpu\lib\site-packages\tensorflow_core\python\ops\nn_impl.py:18
3: where (from tensorflow.python.ops.array_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
2020-01-28 18:03:03.978817: W tensorflow/stream_executor/platform/default/dso_loader.cc:55] Could not load dynamic libra
ry 'nvcuda.dll'; dLError: nvcuda.dll not found
2020-01-28 18:03:04.006484: E tensorflow/stream_executor/cuda/cuda_driver.cc:318] failed call to cuInit: UNKNOWN ERROR (
303)
2020-01-28 18:03:04.035995: I tensorflow/stream_executor/cuda/cuda_diagnostics.cc:169] retrieving CUDA diagnostic inform
ation for host: DESKTOP-DK5D7US
2020-01-28 18:03:04.057408: I tensorflow/stream_executor/cuda/cuda_diagnostics.cc:176] hostname: DESKTOP-DK5D7US
2020-01-28 18:03:04.082302: I tensorflow/core/platform/cpu_feature_guard.cc:142] Your CPU supports instructions that thi
s TensorFlow binary was not compiled to use: AVX AVX2
Standardized: 97.50% (4.03%)
(tf_gpu) PS C:\Users\Trevor\OneDrive\Spring 2020\Deep Learning\HW1>
```

b)

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(tf_gpu) PS C:\Users\Trevor\OneDrive\Spring 2020\Deep Learning\HW1> python .\HW1-4b.py
2020-01-28 18:06:11.822870: I tensorflow/stream_executor/platform/default/dso_loader.cc:44] Successfully opened dynamic
library cudart64_100.dll
WARNING:tensorflow:From C:\Users\Trevor\Anaconda3\envs\tf_gpu\lib\site-packages\tensorflow_core\python\keras\initializer
s.py:143: calling RandomNormal.__init__ (from tensorflow.python.ops.init_ops) with dtype is deprecated and will be remov
ed in a future version.
Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to the constructor
WARNING:tensorflow:From C:\Users\Trevor\Anaconda3\envs\tf_gpu\lib\site-packages\tensorflow_core\python\ops\resource_vari
able_ops.py:1630: calling BaseResourceVariable.__init__ (from tensorflow.python.ops.resource_variable_ops) with constrai
nt is deprecated and will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
WARNING:tensorflow:From C:\Users\Trevor\Anaconda3\envs\tf_gpu\lib\site-packages\tensorflow_core\python\ops\nn_impl.py:18
3: where (from tensorflow.python.ops.array_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
2020-01-28 18:06:17.308231: W tensorflow/stream_executor/platform/default/dso_loader.cc:55] Could not load dynamic libra
ry 'nvcuda.dll'; dLError: nvcuda.dll not found
2020-01-28 18:06:17.321935: E tensorflow/stream_executor/cuda/cuda_driver.cc:318] failed call to cuInit: UNKNOWN ERROR (
303)
2020-01-28 18:06:17.345021: I tensorflow/stream_executor/cuda/cuda_diagnostics.cc:169] retrieving CUDA diagnostic inform
ation for host: DESKTOP-DK5D7US
2020-01-28 18:06:17.358441: I tensorflow/stream_executor/cuda/cuda_diagnostics.cc:176] hostname: DESKTOP-DK5D7US
2020-01-28 18:06:17.367711: I tensorflow/core/platform/cpu_feature_guard.cc:142] Your CPU supports instructions that thi
s TensorFlow binary was not compiled to use: AVX AVX2
Standardized: 99.00% (2.00%)
(tf_gpu) PS C:\Users\Trevor\OneDrive\Spring 2020\Deep Learning\HW1>
```