**Project Report**

**Title:** Neural Networks

**Results with different combination of parameters:**

|  |  |  |  |
| --- | --- | --- | --- |
| All values are Mean Test Error | | |  |
|  |  |  |  |
| Learning Rate = 0.05 | | | |
| Train to Test split ratio = 3:1 | | | |
|  | **Car** | **Iris** | **Adult(Census)** |
| **Sigmoid** | 0.5347 | 0.1614 | 0.1128 |
| **tanh** | 0.5347 | 0.2894 | 0.3871 |
| **ReLu** | 1.6226 | 0.6842 | 0.1128 |
|  |  |  |  |
| Learning Rate = 0.05 | | | |
| Train to Test split ratio = 9:1 | | | |
|  | **Car** | **Iris** | **Adult(Census)** |
| **Sigmoid** | 0.5333 | 0.1354 | 0.1137 |
| **tanh** | 0.5333 | 0.3 | 0.3862 |
| **ReLu** | 1.7138 | 0.7333 | 0.1137 |
|  |  |  |  |
|  |  |  |  |
| Learning Rate = 0.1 | | | |
| Train to Test split ratio = 4:1 | | | |
|  | **Car** | **Iris** | **Adult(Census)** |
| **Sigmoid** | 0.5347 | 0.1612 | 0.1128 |
| **tanh** | 0.5347 | 0.2894 | 0.8386 |
| **ReLu** | 1.6226 | 0.6812 | 0.1128 |
|  |  |  |  |
|  |  |  |  |
| Learning Rate = 0.1 | | | |
| Train to Test split ratio = 9:1 | | | |
|  | **Car** | **Iris** | **Adult(Census)** |
| **Sigmoid** | 0.5433 | 0.1751 | 0.1137 |
| **tanh** | 0.5433 | 0.3 | 0.3862 |
| **ReLu** | 1.713 | 0.7333 | 0.1137 |

In our testing, we have observed that Sigmoid functions have performed better.   
All the 3 functions gave best results for the Census dataset.

**Changes made in the code:**

* We have simply added “activation” parameter in the arguments of the functions to make the code more dynamic for all the 3 activation function calls.
* Defined a separate function to call the train and predict functions on all the 3 datasets.
* Finally in the predict function we have calculated the Mean Test Error.

**Learning:**

* Importance of preprocessing of data.
* Especially handling the splitting of datasets and standardization.
* Handling of null values.

**Output for reference:**

Please enter the dataset path for Car Evaluation dataset :https://archive.ics.uci.edu/ml/machine-learning-databases/car/car.data

Please enter the dataset path for Iris dataset : https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.data

Please enter the dataset path for Adult Census dataset : https://archive.ics.uci.edu/ml/machine-learning-databases/adult/adult.data

[1] CAR Dataset :

\*\*\*\*\*\*\*\*\*\*\*\* For Sigmoid Activation Function \*\*\*\*\*\*\*\*\*\*\*\*

C:\Users\aashaar\Anaconda3\lib\site-packages\sklearn\utils\validation.py:475: DataConversionWarning: Data with input dtype int64 was converted to float64 by MinMaxScaler.

warnings.warn(msg, DataConversionWarning)

After 1000 iterations, the total error is 696.003972616

The final weight vectors are (starting from input to output layers)

[[ 0.73788438 0.03041064 -0.44313481 -0.72762435]

[ 0.92309752 -0.19265452 -0.18467627 -0.76943562]

[ 0.83426574 -0.19912385 -0.5703747 0.16549353]

[-0.53837722 -0.73626034 0.5670766 0.2829531 ]

[ 0.30298506 -0.47209601 0.08132691 -0.02781951]

[-0.23773996 -0.81982103 0.60081804 -0.36619855]]

[[ 1.34856173 1.57699952]

[ 0.52676907 0.61958204]

[ 0.33700091 1.0454622 ]

[-0.14781998 0.63118307]]

[[ 8.97736284]

[ 5.79669708]]

>>>>> MEAN TEST ERROR : 0.534725455306

\*\*\*\*\*\*\*\*\*\*\*\* For tanh Activation Function \*\*\*\*\*\*\*\*\*\*\*\*

After 1000 iterations, the total error is 697.5

The final weight vectors are (starting from input to output layers)

[[ -9.32608236 -2.31395111 -9.30920102 -7.43624699]

[ -8.45920262 -2.31717345 -8.46427651 -6.95561646]

[ -7.66603508 -2.29861129 -8.11792813 -4.73247912]

[-11.38669829 -1.92215295 -3.8382081 -2.92770261]

[-10.04189721 -2.2085573 -6.47136102 -4.65194824]

[-11.77834837 -2.28850165 -5.72025069 -5.38959125]]

[[-21.37188695 22.73991677]

[ 30.03602122 -29.80201961]

[-14.26287693 11.48874994]

[ -2.50321245 -1.71108931]]

[[ 4.53690512]

[-43.439414 ]]

>>>>> MEAN TEST ERROR : 0.534722222222

\*\*\*\*\*\*\*\*\*\*\*\* For ReLu Activation Function \*\*\*\*\*\*\*\*\*\*\*\*

After 1000 iterations, the total error is 2046.0

The final weight vectors are (starting from input to output layers)

[[ 0.654272 -0.00834721 -0.27302263 -0.44879379]

[ 0.84948163 -0.22602153 -0.01423825 -0.4911238 ]

[ 0.76993304 -0.23347309 -0.40485057 0.43518992]

[-0.61826011 -0.76361474 0.67399556 0.48827184]

[ 0.1810411 -0.51421685 0.24649429 0.27671064]

[-0.34486111 -0.86502131 0.7610772 -0.08008654]]

[[ 0.52774544 -0.49222276]

[ 0.18277436 -0.14240968]

[-0.23579871 -0.74657323]

[-0.51146667 -0.84131683]]

[[-0.39428339]

[ 0.4834096 ]]

>>>>> MEAN TEST ERROR : 1.62268518519

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[2] IRIS Dataset :

\*\*\*\*\*\*\*\*\*\*\*\* For Sigmoid Activation Function \*\*\*\*\*\*\*\*\*\*\*\*

After 1000 iterations, the total error is 25.2003944746

The final weight vectors are (starting from input to output layers)

[[-0.86262439 -0.95082044 1.53264343 -0.40886373]

[ 2.82269367 0.18037156 -4.34758698 3.17851512]

[-1.80187537 -1.14769603 2.74366158 -1.37462602]

[-1.5670067 0.08101173 1.82864675 -3.02690391]]

[[-3.69320956 -4.20914169]

[-2.33553789 -1.59725668]

[ 2.35437709 4.30817037]

[-3.19626197 -5.87360343]]

[[ 1.4444747]

[ 6.8382935]]

>>>>> MEAN TEST ERROR : 0.161485269278

\*\*\*\*\*\*\*\*\*\*\*\* For tanh Activation Function \*\*\*\*\*\*\*\*\*\*\*\*

After 1000 iterations, the total error is 39.0000000187

The final weight vectors are (starting from input to output layers)

[[ 1.69302198 -6.02422502 6.05550717 -0.58338352]

[ 1.46054316 -3.63619633 2.82271885 -0.16456536]

[ 2.24214159 -7.18690515 6.71776271 -0.50410973]

[ 2.5897585 -6.17468475 5.67992104 -2.02827692]]

[[ -3.08599148 -18.35155101]

[ 1.49072665 9.30536694]

[ -0.0913726 5.4302029 ]

[ 0.12687542 20.83001502]]

[[-5.89419745]

[-4.02130472]]

>>>>> MEAN TEST ERROR : 0.289473683693

\*\*\*\*\*\*\*\*\*\*\*\* For ReLu Activation Function \*\*\*\*\*\*\*\*\*\*\*\*

After 1000 iterations, the total error is 99.0

The final weight vectors are (starting from input to output layers)

[[ 0.24672023 -0.96835751 0.85887447 0.38179384]

[ 0.9946457 -0.65531898 -0.7257285 0.86519093]

[ 0.39363632 -0.86799965 0.51092611 0.50775238]

[ 0.84604907 0.42304952 -0.75145808 -0.96023973]]

[[-0.94757803 -0.94338702]

[-0.50757786 0.7200559 ]

[ 0.07766213 0.10564396]

[ 0.68406178 -0.75165337]]

[[-0.44163264]

[ 0.17151854]]

>>>>> MEAN TEST ERROR : 0.684210526316

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[3] ADULT Dataset

\*\*\*\*\*\*\*\*\*\*\*\* For Sigmoid Activation Function \*\*\*\*\*\*\*\*\*\*\*\*

After 1000 iterations, the total error is 3001.5

The final weight vectors are (starting from input to output layers)

[[ 0.47036135 -0.62649246 0.39948246 -0.36778964]

[ 0.33505427 0.78221152 0.65812603 0.82622733]

[ 0.3506404 0.96881962 0.51110136 0.10682109]

[-0.95498664 1.06294922 0.27384976 0.76699436]

[-1.11718106 0.19350882 0.70198664 0.32201301]

[-0.76929276 0.03543726 -0.0151106 0.18217134]

[ 0.08485471 -0.27016687 -0.19545516 0.57521508]

[-1.11395237 0.92939043 -0.86505415 0.64396209]

[-0.24897863 1.54493412 -0.33973276 0.98428126]

[ 0.53924195 -0.03863853 0.47461841 0.74957418]

[-0.10542201 -0.06743937 -0.65273025 0.147441 ]

[-0.78449889 -0.82257442 0.39362432 -0.76036445]

[-0.8375708 0.05277715 0.74246597 0.3043481 ]

[-1.31451303 0.91832346 0.43344167 -0.4619422 ]]

[[ 5.20922159 -7.84841968]

[ 2.52524044 -4.70735833]

[ 9.30362543 -13.59864157]

[ 9.77963456 -14.0575452 ]]

[[-69.01945914]

[-60.04628777]]

>>>>> MEAN TEST ERROR : 0.112885394915

\*\*\*\*\*\*\*\*\*\*\*\* For tanh Activation Function \*\*\*\*\*\*\*\*\*\*\*\*

After 1000 iterations, the total error is 9208.5

The final weight vectors are (starting from input to output layers)

[[ 1.70602773 -2.15750929 0.65037692 -0.37073832]

[ 1.70567608 -1.25060975 0.97878119 0.78954888]

[ 0.70425766 0.37524938 0.6156229 0.10406491]

[ 1.28687162 -2.49921426 0.89786562 0.7241824 ]

[ 1.23510927 -3.05665984 1.26298546 0.2835301 ]

[-0.20498649 -1.27351094 0.26259242 0.16737941]

[ 1.19358414 -1.46001731 0.02034707 0.52903128]

[ 0.05565758 -2.98754511 -0.07050961 0.71356826]

[ 2.51873305 -2.90727283 0.4663522 0.94548822]

[ 2.237549 -0.83105955 0.54220335 0.64719553]

[ 0.12277456 -0.28048315 -0.60353109 0.1465694 ]

[-0.5485148 -0.92916588 0.40795849 -0.76651232]

[ 0.56322891 -1.82082623 1.05238698 0.27909663]

[ 1.25482417 -3.25972116 1.15608224 -0.48895689]]

[[ -3.34963918 0.90339219]

[ 10.06338021 -14.63394887]

[-11.20685436 19.21056725]

[-11.28770146 20.05902518]]

[[-294.85102927]

[ 510.77741108]]

>>>>> MEAN TEST ERROR : 0.387114605085

\*\*\*\*\*\*\*\*\*\*\*\* For ReLu Activation Function \*\*\*\*\*\*\*\*\*\*\*\*

After 1000 iterations, the total error is 3001.5

The final weight vectors are (starting from input to output layers)

[[ -1.13462895e+14 6.57646673e+08 -3.59101239e+14 -6.18497763e+00]

[ -1.86046387e+14 1.59624828e+09 -5.88822348e+14 -6.76981441e+00]

[ -4.51093843e+13 8.22670245e+08 -1.42767693e+14 -1.61023458e+00]

[ -2.64043141e+14 3.16882202e+09 -8.35676007e+14 -9.41248094e+00]

[ -2.32257813e+14 2.12132022e+09 -7.35077915e+14 -9.73895633e+00]

[ -1.62561776e+14 4.56350949e+08 -5.14495378e+14 -4.42138489e+00]

[ -1.84060775e+14 2.58046529e+08 -5.82538041e+14 -7.21156894e+00]

[ -9.81978816e+13 3.05119410e+09 -3.10788659e+14 5.79186349e-01]

[ -3.50567837e+14 3.79367329e+09 -1.10951994e+15 -1.25651398e+01]

[ -2.74726965e+14 -6.09515889e-01 -8.69489481e+14 -1.32438606e+01]

[ -4.44394038e+12 1.47168614e+06 -1.40647257e+13 -2.34822628e-01]

[ -8.10794334e+12 -8.25661381e-01 -2.56610101e+13 -1.17408751e+00]

[ -1.54284278e+14 1.22904020e+09 -4.88297742e+14 -6.07848095e+00]

[ -3.40924584e+14 3.07201788e+09 -1.07899979e+15 -1.30564315e+01]]

[[ -7.86120181e+01 -4.64582484e+14]

[ -5.09159458e-02 -6.38732664e+08]

[ -2.49161488e+02 -7.66244261e+13]

[ -2.18621228e+02 2.94699873e+02]]

[[ 4.97674492e+02]

[ -1.98691572e+14]]

>>>>> MEAN TEST ERROR : 0.112885394915

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