02_Normalized_Model

March 24, 2020

0.1 P2. Normalized model

Pascal P.
Mar 2020

- Course: *Introduction to Deep Learning & Neural Networks with Keras*
- Final Project: Build a Regression Model in Keras - Part 2 Normalized Model

Normalize the data (5 marks) Repeat Part A but use a normalized version of the data. Recall that one way to normalize the data is by subtracting the mean from the individual predictors and dividing by the standard deviation.

How does the mean of the mean squared errors compare to that from Step A?

0.1.1 1.1. Download, load and clean the data

[1]:
```
import pandas as pd
import numpy as np
```

[2]:
```
# df_concrete_data = pd.read_csv('https://s3-api.us-geo.objectstorage.softlayer.
↪net/cf-courses-data/CognitiveClass/DL0101EN/labs/data/concrete_data.csv')

df_concrete_data = pd.read_csv("./concrete_data.csv")
df_concrete_data.head(7)
```

[2]:

	Cement	Blast Furnace Slag	Fly Ash	Water	Superplasticizer	Coarse Aggregate	Fine Aggregate	Age	Strength
0	540.0	0.0	0.0	162.0	2.5	1040.0	676.0	28	79.99
1	540.0	0.0	0.0	162.0	2.5	1055.0	676.0	28	61.89
2	332.5	142.5	0.0	228.0	0.0				
3	332.5	142.5	0.0	228.0	0.0				
4	198.6	132.4	0.0	192.0	0.0				
5	266.0	114.0	0.0	228.0	0.0				
6	380.0	95.0	0.0	228.0	0.0				

```
2              932.0           594.0  270     40.27
3              932.0           594.0  365     41.05
4              978.4           825.5  360     44.30
5              932.0           670.0   90     47.03
6              932.0           594.0  365     43.70
```

[3]:
```
# Any null value?
df_concrete_data.isnull().sum()

# ... No, good.
```

[3]:
```
Cement                0
Blast Furnace Slag    0
Fly Ash               0
Water                 0
Superplasticizer      0
Coarse Aggregate      0
Fine Aggregate        0
Age                   0
Strength              0
dtype: int64
```

0.1.2 1.2. Split data into predictors and target

[4]:
```
## Exclude columns 'Age', 'Strength' for predictors
df_predictors = df_concrete_data[df_concrete_data.columns.difference(['Age',␣
↪'Strength'])]

df_target = df_concrete_data['Strength']
```

0.1.3 1.3. Normalizing

[5]:
```
df_predictors_norm = (df_predictors - df_predictors.mean()) / df_predictors.
↪std()
df_predictors_norm.head()
```

[5]:
```
   Blast Furnace Slag    Cement  Coarse Aggregate  Fine Aggregate   Fly Ash  \
0           -0.856472  2.476712          0.862735       -1.217079 -0.846733
1           -0.856472  2.476712          1.055651       -1.217079 -0.846733
2            0.795140  0.491187         -0.526262       -2.239829 -0.846733
3            0.795140  0.491187         -0.526262       -2.239829 -0.846733
4            0.678079 -0.790075          0.070492        0.647569 -0.846733

   Superplasticizer     Water
```

```
0         -0.620147 -0.916319
1         -0.620147 -0.916319
2         -1.038638  2.174405
3         -1.038638  2.174405
4         -1.038638  0.488555
```

[6]:
```
n_cols = df_predictors_norm.shape[1]  # == df_predictors
n_cols # number of predictors
```

[6]:
```
7
```

0.1.4 1.4. Build model with keras

[7]:
```
import keras

from keras.models import Sequential
from keras.layers import Dense
```

```
Using TensorFlow backend.
```

[8]:
```
## Define regression model as a python function (which we can re-use later)

def regression_model(n_cols, nodes_per_hlayer=[10,], opt='adam',␣
 ↪loss='mean_squared_error'):
    ## 1 - Create model
    model = Sequential()
    for ix, num_nodes in enumerate(nodes_per_hlayer):
      if ix == 0: # first layer
        model.add(Dense(num_nodes, activation='relu', input_shape=(n_cols,)))
      else:
        model.add(Dense(num_nodes, activation='relu'))
    model.add(Dense(1)) # output layer

    ## 2 - Compile model
    model.compile(optimizer=opt, loss=loss, metrics=[loss])
    return model
```

[9]:
```
from sklearn.model_selection import train_test_split

## Define train/test split wrapper function

def split_data(df_pred, df_target, test_size=0.3, random_state=6776):
  X_train, X_test, y_train, y_test = train_test_split(df_pred, df_target,
                                                      test_size=test_size,
                                                      random_state=random_state)
  return (X_train, X_test, y_train, y_test) # tuple
```

0.1.5 1.5. Instanciate the model

[10]:
```
## as per spec n_cols input, 10 nodes in only 1 layer (array of length 1)
model = regression_model(n_cols, nodes_per_hlayer=[10])

model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_1 (Dense)              (None, 10)                80
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 11
=================================================================
Total params: 91
Trainable params: 91
Non-trainable params: 0
_________________________________________________________________
```

0.1.6 1.6. Train and evaluate the model

[11]:
```
from sklearn.metrics import mean_squared_error
```

[12]:
```
## Main Train/Eval loop - 50 iterations

N = 50
mse_ary = []

for ix in range(0, N):
  ## Reset model => reset the weigths
  model = regression_model(n_cols, nodes_per_hlayer=[10])

  ## Split the data into train and test set using opur wrapper function
  X_train, X_test, y_train, y_test = split_data(df_predictors_norm, df_target)

  ## Fit the model - No train/validation split
  _history = model.fit(X_train, y_train,
                       epochs=50,
                       verbose=0)

  ## Make Predictions
  pred = model.predict(X_test)

  ## Compare to ground truth
  mse = mean_squared_error(y_test, pred)
```

```
  print("Iteration: {:2d} / MSE: {:1.5f}".format(ix, mse))

  ## Keep it for later
  mse_ary.append(mse)
```

```
WARNING: Logging before flag parsing goes to stderr.
W0322 11:32:16.836442 139797524154176 deprecation_wrapper.py:119] From /home/pas
cal/Projects/ML_DL/anaconda3/envs/tensorflow_keras_gpuenv/lib/python3.7/site-
packages/keras/backend/tensorflow_backend.py:422: The name tf.global_variables
is deprecated. Please use tf.compat.v1.global_variables instead.


Iteration:  0 / MSE: 355.93925
Iteration:  1 / MSE: 512.65372
Iteration:  2 / MSE: 416.27805
Iteration:  3 / MSE: 530.62025
Iteration:  4 / MSE: 369.47872
Iteration:  5 / MSE: 390.52455
Iteration:  6 / MSE: 360.31357
Iteration:  7 / MSE: 302.59599
Iteration:  8 / MSE: 672.30400
Iteration:  9 / MSE: 338.96442
Iteration: 10 / MSE: 599.79051
Iteration: 11 / MSE: 371.22198
Iteration: 12 / MSE: 347.89716
Iteration: 13 / MSE: 284.24522
Iteration: 14 / MSE: 504.95911
Iteration: 15 / MSE: 341.22869
Iteration: 16 / MSE: 404.12333
Iteration: 17 / MSE: 299.67112
Iteration: 18 / MSE: 582.35539
Iteration: 19 / MSE: 381.40654
Iteration: 20 / MSE: 350.48430
Iteration: 21 / MSE: 310.79724
Iteration: 22 / MSE: 315.28477
Iteration: 23 / MSE: 313.97797
Iteration: 24 / MSE: 360.76740
Iteration: 25 / MSE: 359.62957
Iteration: 26 / MSE: 838.86160
Iteration: 27 / MSE: 444.29777
Iteration: 28 / MSE: 424.73098
Iteration: 29 / MSE: 503.28858
Iteration: 30 / MSE: 371.25142
Iteration: 31 / MSE: 346.90339
Iteration: 32 / MSE: 325.30350
Iteration: 33 / MSE: 425.22615
Iteration: 34 / MSE: 657.75759
Iteration: 35 / MSE: 372.94955
```

```
Iteration: 36 / MSE: 515.05474
Iteration: 37 / MSE: 353.32037
Iteration: 38 / MSE: 396.20087
Iteration: 39 / MSE: 469.37401
Iteration: 40 / MSE: 371.33997
Iteration: 41 / MSE: 699.74592
Iteration: 42 / MSE: 287.98738
Iteration: 43 / MSE: 454.66912
Iteration: 44 / MSE: 357.56309
Iteration: 45 / MSE: 400.89007
Iteration: 46 / MSE: 631.04993
Iteration: 47 / MSE: 327.66205
Iteration: 48 / MSE: 368.30210
Iteration: 49 / MSE: 297.18248
```

[13]:
```
## Summary

print("Summary baseline model: ")
np_ary = np.array(mse_ary, dtype=np.float64)

## NOTE: using unbiased std - which means diving by N-1 (where N is the size of␣
 ↪sample here 50)
##       just in case, added biased std.
print("mean(MSE): {:2.5f} / unbiased std(MSE): {:2.5f} / biased std(MSE): {:2.
 ↪5f}"\
      .format(np.mean(np_ary), np.std(np_ary, ddof=1), np.std(np_ary, ddof=0)))
```

```
Summary baseline model:
mean(MSE): 420.36851 / unbiased std(MSE): 121.69352 / biased std(MSE): 120.47044
```

Remarks

- Compare to baseline model, the MSE is *less* (therefore better) for the normalized model.
- Also the spread for the normalized model, as measured by standard deviation, is *less* (less variability) than it is for the baseline model.
- Here normalization does seem to improve the performance in term of:
  - mean (although not by that much in this case) and
  - standard deviation.

Optional

[14]:
```
ix_max = np_ary.argmax()
ix_min = np_ary.argmin()

print("max: {:2.5f} at epoch: {:2d} / min: {:2.5f} at epoch: {:2d}"\
      .format(np_ary[ix_max], ix_max, np_ary[ix_min], ix_min))
```

```
max: 838.86160 at epoch: 26 / min: 284.24522 at epoch: 13
```

[15]:
```
df_ = pd.read_csv("./01_baseline_model.csv")

df_['mse_02_norm'] = np_ary
df_.to_csv('02_norm_model.csv', sep=',', encoding='utf-8', index=False)
```

[16]:
```
df_.head()
```

[16]:

	mse_01_bl	mse_02_norm
0	208.949511	355.939247
1	210.507436	512.653717
2	190.812754	416.278048
3	206.248697	530.620247
4	189.519537	369.478724

[17]:
```
df_.describe()
```

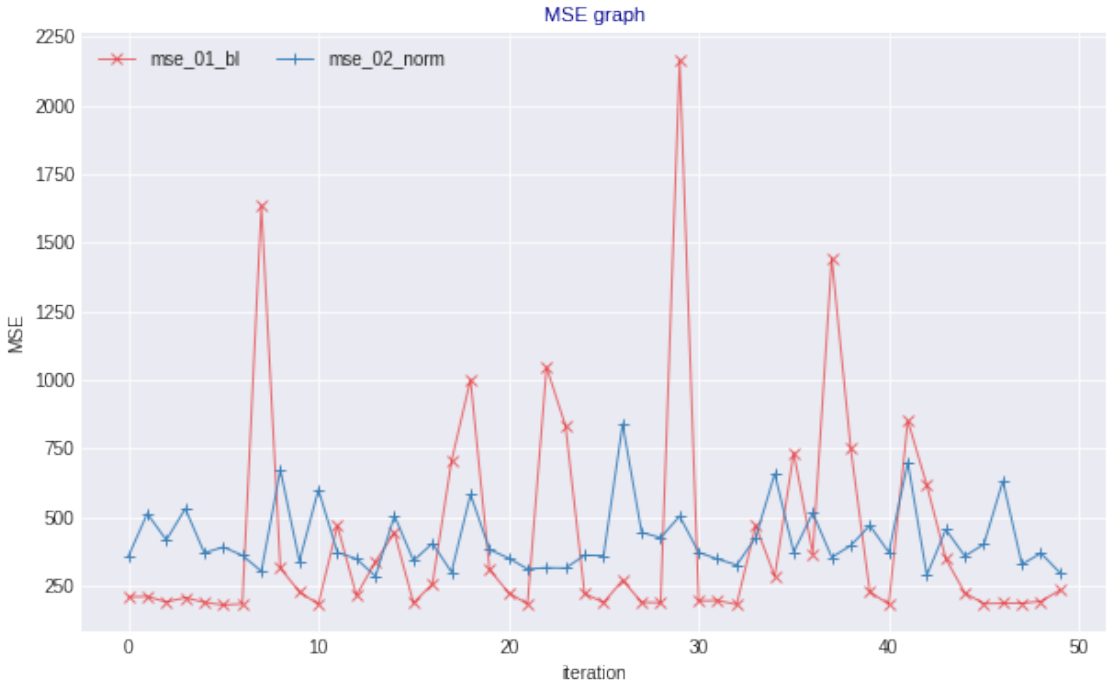
[17]:

	mse_01_bl	mse_02_norm
count	50.000000	50.000000
mean	424.129761	420.368508
std	415.684991	121.693519
min	179.674799	284.245219
25%	189.380645	347.151831
50%	225.632202	371.295692
75%	462.052733	465.697787
max	2164.597530	838.861597

[18]:
```
import matplotlib.pyplot as plt
%matplotlib inline

fig = plt.figure(figsize=(10, 6))

# style
plt.style.use('seaborn-darkgrid')

# create a color palette
palette = plt.get_cmap('Set1')

# multiple line plot
ixes = list(range(0, df_.shape[0]))

alpha =0.6
mark='x'
for ix, col in enumerate(df_):
  plt.plot(ixes, df_[col], marker=mark, color=palette(ix), linewidth=1,␣
 ↪alpha=alpha,
```

```
                label=df_.columns[ix])
  alpha=0.9
  mark='+'

# Add legend
plt.legend(loc=2, ncol=2)

# Add titles
plt.title("MSE graph", loc='center', fontsize=11, fontweight=0,␣
 ↪color='darkblue')
plt.xlabel("iteration")
plt.ylabel("MSE")
```

[18]: Text(0, 0.5, 'MSE')



[ ]: