prabhudayala@gmail.com_Anonymous Ratings Data from the Jester Online Joke Recommender System

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0.1 Anonymous Ratings Data from the Jester Online Joke Recommender System

0.2 Data source:

Description: Jester dataset is provided by berkeley university, freely available for research. The data contains 4.1 Million continuous ratings (-10.00 to +10.00) of 100 jokes from 73,421 users: collected between April 1999 - May 2003.

web link: https://goldberg.berkeley.edu/jester-data/
Total users : 73421
Total jokes : 100

0.3 Business problem:

User will be recommended jokes from all available jokes in system.

There is no network latency as the jokes can be recommended to users over batch job.
The error metric is decided as NAME by the provider of data.

0.4 Error metric:

As per the requirement of the problem barkley university has choosen NMAE(Normalized Mean Absolute Error)

NMAE:

$$\mathbf{1} \quad \frac{\frac{1}{n}\sum_{i}^{n}|(\widehat{y}-y)|}{max(y)-min(y)}$$

[1]:
```
#import all required libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import surprise
import os
import itertools
import matplotlib as plt
```

```
import seaborn as sns

from sklearn.model_selection import train_test_split
from sklearn.metrics.pairwise import cosine_similarity

from surprise import Reader, Dataset, BaselineOnly, KNNBaseline, SVDpp
from surprise.model_selection import cross_validate
from surprise.model_selection.search import GridSearchCV, RandomizedSearchCV

import random
from datetime import datetime
import pickle

from scipy import sparse
from scipy.sparse import csr_matrix

import xgboost as xgb
from xgboost import XGBRegressor
```

1.0.1 1.1 Data collection

[2]:
```
#combine all 3 input files
raw_data = pd.DataFrame()
for i in os.listdir('./'):
    if(i.endswith('.xls')):
        tmp_data = pd.read_excel(i, header=None)
        print('length of records in %s is %s' %(len(tmp_data),i))
        raw_data = pd.concat([raw_data,tmp_data],axis=0)
print('Total lenth of records is '+str(len(raw_data)))
```

```
length of records in 24983 is jester-data-1.xls
length of records in 23500 is jester-data-2.xls
length of records in 24938 is jester-data-3.xls
Total lenth of records is 73421
```

[3]:
```
raw_data_copy = raw_data.copy()
#raw_data = raw_data_copy.copy()
```

[4]:
```
pickle.dump(raw_data_copy, open("dataframe.pickle","wb"))
raw_data.head()
```

[4]:

	0	1	2	3	4	5	6	7	8	9	...	91	\
0	74	-7.82	8.79	-9.66	-8.16	-7.52	-8.50	-9.85	4.17	-8.98	...	2.82	
1	100	4.08	-0.29	6.36	4.37	-2.38	-9.66	-0.73	-5.34	8.88	...	2.82	
2	49	99.00	99.00	99.00	99.00	9.03	9.27	9.03	9.27	99.00	...	99.00	
3	48	99.00	8.35	99.00	99.00	1.80	8.16	-2.82	6.21	99.00	...	99.00	
4	91	8.50	4.61	-4.17	-5.39	1.36	1.60	7.04	4.61	-0.44	...	5.19	

```
     92     93     94     95     96     97     98     99     100
0  99.00  99.00  99.00  99.00  99.00  -5.63  99.00  99.00  99.00
1  -4.95  -0.29   7.86  -0.19  -2.14   3.06   0.34  -4.32   1.07
2  99.00  99.00   9.08  99.00  99.00  99.00  99.00  99.00  99.00
3  99.00  99.00   0.53  99.00  99.00  99.00  99.00  99.00  99.00
4   5.58   4.27   5.19   5.73   1.55   3.11   6.55   1.80   1.60

[5 rows x 101 columns]
```

[5]:
```
print('Total number of users who rated all jokes are:␣
 ↪',len(raw_data[raw_data[0]==100]))
```

```
Total number of users who rated all jokes are:  14116
```

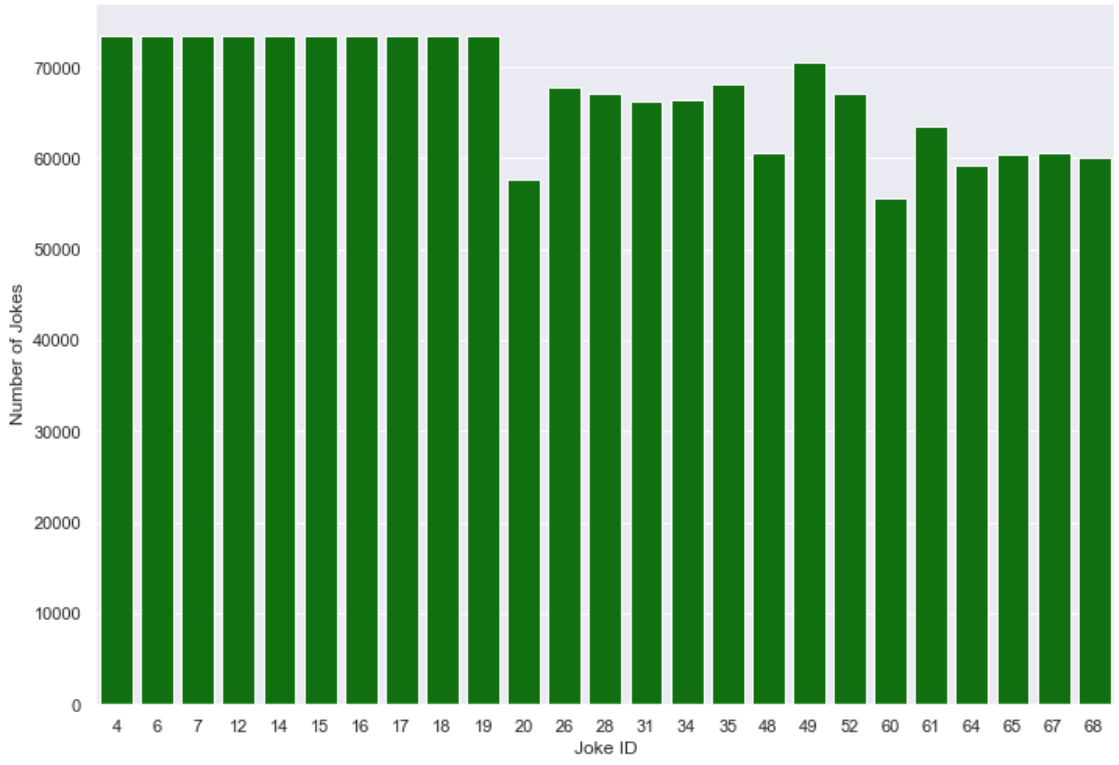
[6]:
```
print('Total number of users who rated no jokes are:␣
 ↪',len(raw_data[raw_data[0]==0]))
```

```
Total number of users who rated no jokes are:  0
```

[7]:
```
jokes_number_of_rating = []
for i in range(1,101):
    jokes_number_of_rating.append(len(raw_data[raw_data[i]!=99]))
#print(len(jokes_number_of_rating))
```

[8]:
```
#sort jokes on number of jokes
jokes_number_of_rating = np.array(jokes_number_of_rating)
jokes_number_of_rating_arg_sort = np.argsort(jokes_number_of_rating)
jokes_number_of_rating_arg_sort = jokes_number_of_rating_arg_sort[::-1]
top_10_joke_id = jokes_number_of_rating_arg_sort[:25]
top_10_joke_id_rating = jokes_number_of_rating[top_10_joke_id]
```

[9]:
```
sns.set(rc={'figure.figsize':(11.7,8.27)})
ax = sns.barplot(top_10_joke_id,top_10_joke_id_rating, color = 'green')
plot_is = ax.set(xlabel='Joke ID', ylabel='Number of Jokes')
```



1.0.2 1.2 Preparing data in format of ['user','joke', 'rating'] and data cleaning

[10]:
```
#column 0 contains the number of ratings given by the user which is not useful.
number_of_rating = raw_data.drop(columns=[0])
```

[11]:
```
raw_data.drop(columns=[0],inplace=True)
raw_data.head()
```

[11]:
```
      1      2      3      4     5     6     7     8      9      10   ...  \
0 -7.82   8.79  -9.66  -8.16 -7.52 -8.50 -9.85  4.17  -8.98  -4.76   ...
1  4.08  -0.29   6.36   4.37 -2.38 -9.66 -0.73 -5.34   8.88   9.22   ...
2 99.00  99.00  99.00  99.00  9.03  9.27  9.03  9.27  99.00  99.00   ...
3 99.00   8.35  99.00  99.00  1.80  8.16 -2.82  6.21  99.00   1.84   ...
4  8.50   4.61  -4.17  -5.39  1.36  1.60  7.04  4.61  -0.44   5.73   ...

     91     92     93     94     95     96     97     98     99     100
0  2.82  99.00  99.00  99.00  99.00  99.00  -5.63  99.00  99.00  99.00
1  2.82  -4.95  -0.29   7.86  -0.19  -2.14   3.06   0.34  -4.32   1.07
2 99.00  99.00  99.00   9.08  99.00  99.00  99.00  99.00  99.00  99.00
3 99.00  99.00  99.00   0.53  99.00  99.00  99.00  99.00  99.00  99.00
4  5.19   5.58   4.27   5.19   5.73   1.55   3.11   6.55   1.80   1.60

[5 rows x 100 columns]
```

[12]:
```
# we will not consider any rating which is 99.00 as it means the user has not␣
 ↪rated the joke previously
list_data=[]
for i, j in raw_data.iterrows():
    #print(i)
    temp=[]
    for p,q in enumerate(j.values):
        #print(p+1)
        #print(q)
        if(q !=99.0):
            temp=[i,p,q]
            list_data.append(temp)
print(len(list_data))
```

```
4136360
```

[13]:
```
formated_data = pd.DataFrame(list_data, columns=['user','joke','rating'])
```

[14]:
```
# we will increase the joke id and user id by 1 as it does not feel good as␣
 ↪user id 0
formated_data['user'] = formated_data['user'] + 1
formated_data['joke'] = formated_data['joke'] + 1
```

1.0.3 2. Trin test split

[15]:
```
#split the data as in a ratio of 70:30
train_df,test_df = train_test_split(formated_data, test_size=0.3,␣
 ↪random_state=42)
```

[16]:
```
print("Train size: ", train_df.shape)
print("test size: ", test_df.shape)
```

```
Train size:  (2895452, 3)
test size:  (1240908, 3)
```

1.0.4 3. Feature engineering

3.1 Finding Global average of all movie ratings, Average rating per user, and Average rating per movie

[17]:
```
#finding global average train
print("global average of train is: ", train_df.rating.mean())
```

```
global average of train is:  0.739790630271198
```

[18]:
```
#finding global average test
print("global average of test is: ", test_df.rating.mean())
```

```
global average of test is:  0.747643548111544
```

[19]:
```
#find average user rating per user train
train_df_grp_user = train_df.groupby(by='user')
train_average_user_rating={}
for i , j in train_df_grp_user:
    train_average_user_rating[i]=j.rating.mean()
print("Total number of train users: ", len(train_df_grp_user))
```

```
Total number of train users:  24983
```

[20]:
```
#find average user rating per user test
test_df_grp_user = test_df.groupby(by='user')
test_average_user_rating={}
for i , j in test_df_grp_user:
    test_average_user_rating[i]=j.rating.mean()
print("Total number of train users: ", len(test_df_grp_user))
```

```
Total number of train users:  24983
```

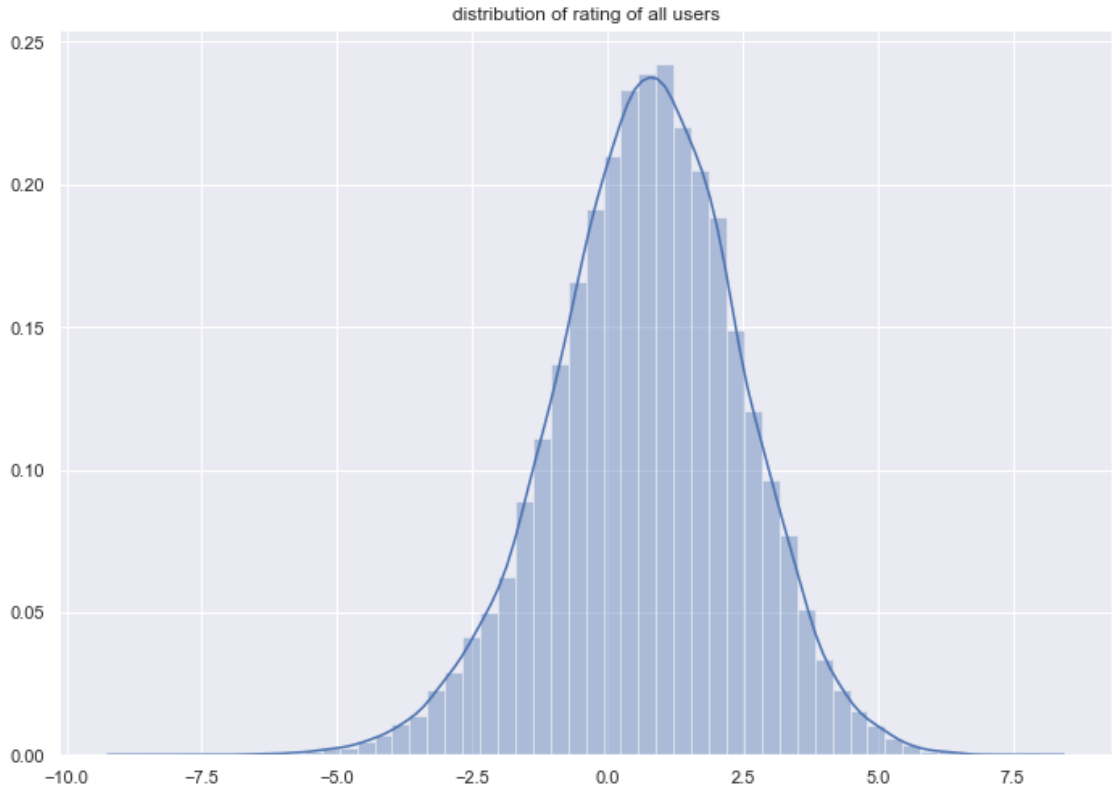
[21]:
```
#find average joke rating per joke train
train_df_grp_joke = train_df.groupby(by='joke')
train_average_joke_rating={}
for i , j in train_df_grp_joke:
    train_average_joke_rating[i]=j.rating.mean()
print("Total number of jokes in train: ", len(train_df_grp_joke))
```

```
Total number of jokes in train:  100
```

[22]:
```
#find average joke rating per joke test
test_df_grp_joke = test_df.groupby(by='joke')
test_average_joke_rating={}
for i , j in test_df_grp_joke:
    test_average_joke_rating[i]=j.rating.mean()
print("Total number of jokes in test: ", len(test_df_grp_joke))
```

```
Total number of jokes in test:  100
```

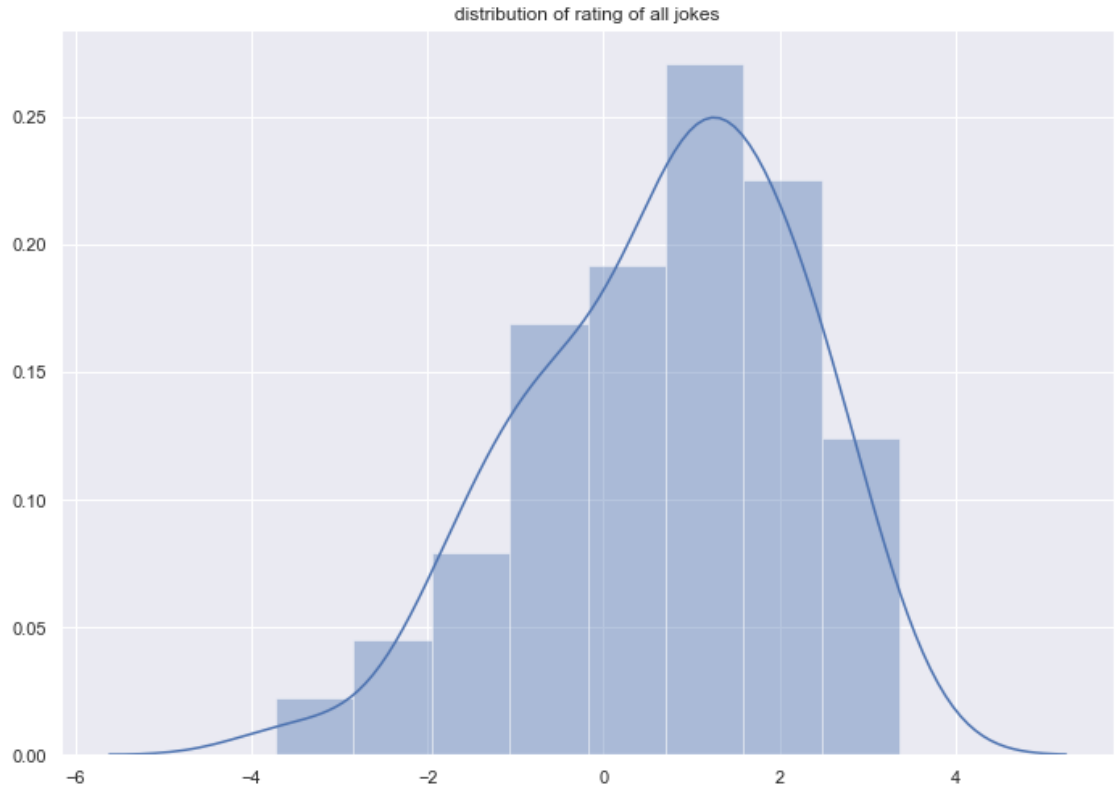
[23]:
```
ax = sns.distplot([*train_average_user_rating.values()])
plot_is = ax.set(title='distribution of rating of all users')
```



[24]:
```
print("Mean value of average rating of users is: ", np.
↪mean([*train_average_user_rating.values()]))
```

```
Mean value of average rating of users is:  0.7277005724312704
```

[25]:
```
ax = sns.distplot([*train_average_joke_rating.values()])
plot_is = ax.set(title='distribution of rating of all jokes')
```



[26]:
```
print("Mean value of average rating of jokes is: ", np.
 ↪mean([*train_average_joke_rating.values()]))
```

```
Mean value of average rating of jokes is:  0.6999030393527355
```

1.0.5 4. create data frame strure to pass through ML models

[27]:
```
# train dataframe
train_df_structured = train_df.copy()
train_df_structured['user_avg'] = train_df_structured.user.apply(lambda x:␣
 ↪train_average_user_rating[x])
train_df_structured['joke_avg'] = train_df_structured.joke.apply(lambda x:␣
 ↪train_average_joke_rating[x])
train_df_structured['gavg'] = 0.73979
train_df_structured.head()
```

[27]:

	user	joke	rating	user_avg	joke_avg	gavg
2064504	3526	47	-0.24	-2.990463	1.322097	0.73979
313132	4371	49	-5.10	-0.362000	2.526823	0.73979
555676	7699	25	5.87	3.893030	0.434044	0.73979
4049155	21371	7	-2.91	1.447450	-0.657305	0.73979
1646072	22719	83	-0.58	3.784375	1.961670	0.73979

[28]:
```
pickle.dump(train_df_structured, open("train_df_structured.pickle","wb"))
train_df_structured.head()
```

[28]:

	user	joke	rating	user_avg	joke_avg	gavg
2064504	3526	47	-0.24	-2.990463	1.322097	0.73979
313132	4371	49	-5.10	-0.362000	2.526823	0.73979
555676	7699	25	5.87	3.893030	0.434044	0.73979
4049155	21371	7	-2.91	1.447450	-0.657305	0.73979
1646072	22719	83	-0.58	3.784375	1.961670	0.73979

[29]:
```
# test dataframe
test_df_structured = test_df.copy()
test_df_structured['user_avg'] = test_df_structured.user.apply(lambda x:␣
 ↪test_average_user_rating[x])
test_df_structured['joke_avg'] = test_df_structured.joke.apply(lambda x:␣
 ↪test_average_joke_rating[x])
test_df_structured['gavg'] = 0.74764
test_df_structured.head()
```

[29]:

	user	joke	rating	user_avg	joke_avg	gavg
1265657	17469	61	6.80	-0.077273	2.113085	0.74764
1297014	17897	45	-0.78	-2.413220	1.018350	0.74764
1567900	21640	47	-8.16	-1.552368	1.374515	0.74764
3232032	19559	48	5.05	-0.282558	1.741960	0.74764
810243	11231	76	3.88	0.034872	2.365746	0.74764

[30]:
```
pickle.dump(test_df_structured, open("test_df_structured.pickle","wb"))
test_df_structured.head()
```

[30]:

	user	joke	rating	user_avg	joke_avg	gavg
1265657	17469	61	6.80	-0.077273	2.113085	0.74764
1297014	17897	45	-0.78	-2.413220	1.018350	0.74764
1567900	21640	47	-8.16	-1.552368	1.374515	0.74764
3232032	19559	48	5.05	-0.282558	1.741960	0.74764
810243	11231	76	3.88	0.034872	2.365746	0.74764

[31]:
```
train_df_structured.columns
```

[31]:
```
Index(['user', 'joke', 'rating', 'user_avg', 'joke_avg', 'gavg'],
dtype='object')
```

[32]:
```
#create target variable for train
train_df_structured_target = train_df_structured.rating
train_df_structured.drop(columns=['rating','user','joke'], inplace = True)
pickle.dump(train_df_structured_target, open("train_df_structured_target.
 ↪pickle","wb"))

#create target variable for test
test_df_structured_target = test_df_structured.rating
test_df_structured.drop(columns=['rating','user','joke'], inplace = True)
```

```
pickle.dump(test_df_structured_target, open("test_df_structured_target.
 ↪pickle","wb"))
```

1.0.6 5.0 Modeling

[33]:
```
global_model_name={}
```

5.0.1 define erroR metric NAME

[34]:
```
def _error(actual: np.ndarray, predicted: np.ndarray):
    """ Simple error """
    return actual - predicted


def mae(actual: np.ndarray, predicted: np.ndarray):
    """ Mean Absolute Error """
    return np.mean(np.abs(_error(actual, predicted)))

def nmae(actual: np.ndarray, predicted: np.ndarray):
    """ Normalized Mean Absolute Error """
    return mae(actual, predicted) / (actual.max() - actual.min())

# get rating after building model
def get_ratings(predictions):
    actual = np.array([pred.r_ui for pred in predictions])
    pred = np.array([pred.est for pred in predictions])
    return actual, pred
```

5.0.2 prepare data in surprise way

[35]:
```
# It is to specify how to read the dataframe.
# for our dataframe, we don't have to specify anything extra..
reader = Reader(rating_scale=(-10.00 , 10.00))

# create the traindata from the dataframe...
train_data = Dataset.load_from_df(train_df[['user', 'joke', 'rating']], reader)

# build the trainset from traindata.., It is of dataset format from surprise␣
 ↪library..
trainset = train_data.build_full_trainset()
```

[36]:
```
testset = list(zip(test_df.user.values, test_df.joke.values, test_df.rating.
 ↪values))
print("some sample data for test")
testset[:3]
```

```
some sample data for test
```

[36]:
```
[(17469, 61, 6.8), (17897, 45, -0.78), (21640, 47, -8.16)]
```

[37]:
```
#save the mmodel
pickle.dump(train_data, open("train_data_sp.pickle","wb"))
pickle.dump(trainset, open("trainset_sp.pickle","wb"))
pickle.dump(testset, open("testset.pickle","wb"))
```

1.0.7 5.1 Surprise Bseline model

Let's create a baseline model and do some hyperparameter tuning there.

[34]:
```
param_grid  = {
                'bsl_options' :{
                        'method':['sgd'],
                        'learning_rate': [.001,.01,.1],
                        'n_epochs':[5,7,9,10,20]
                              },
                'verbose' : [False]
                }

rs = GridSearchCV(BaselineOnly, param_grid, cv=3, joblib_verbose=4,  n_jobs=-1)
rs.fit(train_data)
print(rs.best_params['mae'])
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 6 concurrent workers.
[Parallel(n_jobs=-1)]: Done  13 tasks      | elapsed:  6.3min

{'bsl_options': {'method': 'sgd', 'learning_rate': 0.01, 'n_epochs': 20},
'verbose': False}

[Parallel(n_jobs=-1)]: Done  45 out of  45 | elapsed: 21.6min finished
```

[38]:
```
bsl_options = {'method': 'sgd',
               'learning_rate': 0.01,
               'n_epochs' : 20
               }
bsl_algo = BaselineOnly(bsl_options=bsl_options)
bsl_algo.fit(trainset)

train_preds = bsl_algo.test(trainset.build_testset())
train_actual_ratings, train_pred_ratings = get_ratings(train_preds)

test_preds = bsl_algo.test(testset)
test_actual_ratings, test_pred_ratings = get_ratings(test_preds)

train_df_structured['BaselineOnly'] = train_pred_ratings
test_df_structured['BaselineOnly'] =  test_pred_ratings

global_model_name['Baseline']= {
```

```
            "Train" : nmae(train_pred_ratings,train_actual_ratings),
            "Test" : nmae(test_pred_ratings,test_actual_ratings)
            }
print('Result of model is: ')
print(global_model_name['Baseline'])
```

```
Estimating biases using sgd...
Result of model is:
{'Train': 0.20336702289913602, 'Test': 0.20505297177649737}
```

This model have 20.5 % of NMAE. We have stored the value we will test the combined effect later.

[39]:
```
#save the mmodel
pickle.dump(bsl_algo, open("bsl_algo.pickle","wb"))
```

1.0.8 5.2 Surprise KNNBseline model

5.2.1 Surprise KNNBseline model joke joke similarity

[37]:
```
param_grid  = {
                'bsl_options' :{'method': ['sgd'],
                   'learning_rate': [0.001]
                   },
                'sim_options' : {'user_based' : [False],
                   'name': ['cosine'],
                   'shrinkage': [100],
                   'min_support': [2]
                  },
                'k' : [40,50,60,70],
                'verbose' : [False]
                }

rs = GridSearchCV(KNNBaseline, param_grid, cv=3, joblib_verbose=1, n_jobs=-1)
rs.fit(train_data)
print(rs.best_params)
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 6 concurrent workers.

{'rmse': {'bsl_options': {'method': 'sgd', 'learning_rate': 0.001},
'sim_options': {'user_based': False, 'name': 'cosine', 'shrinkage': 100,
'min_support': 2}, 'k': 70, 'verbose': False}, 'mae': {'bsl_options': {'method':
'sgd', 'learning_rate': 0.001}, 'sim_options': {'user_based': False, 'name':
'cosine', 'shrinkage': 100, 'min_support': 2}, 'k': 60, 'verbose': False}}

[Parallel(n_jobs=-1)]: Done  12 out of  12 | elapsed:  8.4min finished
```

[38]:
```
print(rs.best_params['mae'])
```

```
{'bsl_options': {'method': 'sgd', 'learning_rate': 0.001}, 'sim_options':
{'user_based': False, 'name': 'cosine', 'shrinkage': 100, 'min_support': 2},
'k': 60, 'verbose': False}
```

As the for error mae the k value 60 is declared as optimum we will use that value and train the model.

[40]:
```
bsl_options = {'method': 'sgd',
               'learning_rate': 0.001
               }
sim_options = {'user_based' : False,
               'name': 'cosine',
               'shrinkage': 100,
               'min_support': 2
              }

knn_bsl_u = KNNBaseline(k=60, sim_options = sim_options, bsl_options =␣
 ↪bsl_options)
knn_bsl_u.fit(trainset)

train_preds = knn_bsl_u.test(trainset.build_testset())
train_actual_ratings, train_pred_ratings = get_ratings(train_preds)

test_preds = knn_bsl_u.test(testset)
test_actual_ratings, test_pred_ratings = get_ratings(test_preds)

train_df_structured['KnnBaseline_joke'] = train_pred_ratings
test_df_structured['KnnBaseline_joke'] =  test_pred_ratings

global_model_name['KnnBaseline_joke']={
        "Train": nmae(train_pred_ratings,train_actual_ratings),
        "Test": nmae(test_pred_ratings,test_actual_ratings)
        }
print('Result of model is: ')
print(global_model_name['KnnBaseline_joke'])
```

```
Estimating biases using sgd...
Computing the cosine similarity matrix...
Done computing similarity matrix.
Result of model is:
{'Train': 0.1825198921435078, 'Test': 0.19609971106367624}
```

This model have 19.6 % of NMAE. We have stored the value we will test the combined effect later.

[41]:
```
#save the mmodel
pickle.dump(knn_bsl_u, open("knn_bsl_u.pickle","wb"))
```

1.0.9 5.3 XGBoost model 1

we will use user average, global average, joke average, output of surprise knn joke joke similarity and output of surprise Baseline

[42]:
```
train_df_structured.head()
```

[42]:

	user_avg	joke_avg	gavg	BaselineOnly	KnnBaseline_joke
2064504	-2.990463	1.322097	0.73979	-2.420203	-1.867690
313132	-0.362000	2.526823	0.73979	-4.659975	-6.338853
555676	3.893030	0.434044	0.73979	-4.530977	-7.089862
4049155	1.447450	-0.657305	0.73979	-2.460071	-1.667773
1646072	3.784375	1.961670	0.73979	-1.465956	0.101095

[42]:
```
from sklearn.model_selection import RandomizedSearchCV
from xgboost import XGBRegressor
params = {
        'min_child_weight': [1, 3, 5, 10],
        'gamma': [0.5, 1, 1.5, 2, 5],
        'subsample': [0.6, 0.8, 1.0],
        'colsample_bytree': [0.6, 0.8, 1.0],
        'max_depth': [3, 4, 5],
        'eta':[0.02,0.01,0.1],
        'n_estimators' : [100, 200, 400, 600, 800],
        'learning_rate' : [0.001,0.001,0.01,0.1]
        }


xgb = XGBRegressor()

random_search = RandomizedSearchCV(xgb, param_distributions=params, n_iter=10,␣
 ↪scoring='neg_mean_squared_error', n_jobs=-1, cv=3, verbose=10,␣
 ↪random_state=42)
random_search.fit(train_df_structured, train_df_structured_target)
print(random_search.best_params_)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 6 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 tasks      | elapsed:  6.5min
[Parallel(n_jobs=-1)]: Done   6 tasks      | elapsed: 16.8min
[Parallel(n_jobs=-1)]: Done  13 tasks      | elapsed: 60.6min
[Parallel(n_jobs=-1)]: Done  23 out of  30 | elapsed: 91.6min remaining: 27.9min
[Parallel(n_jobs=-1)]: Done  27 out of  30 | elapsed: 118.4min remaining:
13.2min
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed: 121.1min finished
C:\Users\user\Anaconda3\lib\site-packages\xgboost\core.py:587: FutureWarning:
Series.base is deprecated and will be removed in a future version
  if getattr(data, 'base', None) is not None and \
C:\Users\user\Anaconda3\lib\site-packages\xgboost\core.py:588: FutureWarning:
```

```
Series.base is deprecated and will be removed in a future version
  data.base is not None and isinstance(data, np.ndarray) \

[00:08:24] WARNING: src/objective/regression_obj.cu:152: reg:linear is now
deprecated in favor of reg:squarederror.
{'subsample': 1.0, 'n_estimators': 200, 'min_child_weight': 5, 'max_depth': 5,
'learning_rate': 0.1, 'gamma': 5, 'eta': 0.1, 'colsample_bytree': 0.8}
```

[43]:
```
# initialize Our first XGBoost model...
xgb_bsl = XGBRegressor(min_child_weight = 5 ,gamma = 5, subsample = 1.
 ↪0,colsample_bytree = 0.8,
            max_depth = 5,eta = 0.1,n_estimators = 200,learning_rate = 0.1,
            objective='reg:squarederror',silent=True, random_state=42)
xgb_bsl.fit(train_df_structured, train_df_structured_target)
test_pred_ratings = xgb_bsl.predict(test_df_structured)
train_pred_ratings = xgb_bsl.predict(train_df_structured)

global_model_name['First_XGB']={
        "Train": nmae(train_pred_ratings,train_df_structured_target),
        "Test": nmae(test_pred_ratings,test_df_structured_target)
        }
print('Result of model')
print(global_model_name['First_XGB'])
```

```
C:\Users\user\Anaconda3\envs\tensorflow2_gpu\lib\site-
packages\xgboost\core.py:587: FutureWarning: Series.base is deprecated and will
be removed in a future version
  if getattr(data, 'base', None) is not None and \
C:\Users\user\Anaconda3\envs\tensorflow2_gpu\lib\site-
packages\xgboost\core.py:588: FutureWarning: Series.base is deprecated and will
be removed in a future version
  data.base is not None and isinstance(data, np.ndarray) \

Result of model
{'Train': 0.217233447214206, 'Test': 0.19280766965994262}
```

This model works well and can have good effects on our model. This is the best model till now.

[44]:
```
#save the model
pickle.dump(xgb_bsl, open("xgb_bsl.pickle","wb"))
```

1.0.10 5.3 Surprise SVD model

[45]:
```
from surprise.model_selection.search import GridSearchCV, RandomizedSearchCV
from surprise import SVD
# initiallize the model
```

```
param_distributions  = {
                'n_factors' : [100,250,500,1000,2000,3000,5000],
                'verbose' : [False],
                'lr_bu' : [0.001,0.01,0.005],
                'lr_bi' : [0.001,0.01,0.005],
                'lr_pu' : [0.001,0.01,0.005],
                'lr_qi' : [0.001,0.01,0.005],
                'reg_bu' : [0.01,0.001],
                'reg_bi' : [0.01,0.001],
                'reg_pu' : [0.01,0.001],
                'reg_qi' : [0.01,0.001]
                }

rs = RandomizedSearchCV(SVD, param_distributions, n_iter=20, cv=3,␣
 ↪joblib_verbose=1, n_jobs=-1,random_state=42)
rs.fit(train_data)
print(rs.best_params)
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 6 concurrent workers.
[Parallel(n_jobs=-1)]: Done  38 tasks      | elapsed: 399.2min

{'rmse': {'n_factors': 2000, 'verbose': False, 'lr_bu': 0.001, 'lr_bi': 0.01,
'lr_pu': 0.01, 'lr_qi': 0.01, 'reg_bu': 0.001, 'reg_bi': 0.001, 'reg_pu': 0.001,
'reg_qi': 0.001}, 'mae': {'n_factors': 2000, 'verbose': False, 'lr_bu': 0.001,
'lr_bi': 0.01, 'lr_pu': 0.01, 'lr_qi': 0.01, 'reg_bu': 0.001, 'reg_bi': 0.001,
'reg_pu': 0.001, 'reg_qi': 0.001}}

[Parallel(n_jobs=-1)]: Done  60 out of  60 | elapsed: 528.4min finished
```

[46]:
```
print(rs.best_params['mae'])
```

```
{'n_factors': 2000, 'verbose': False, 'lr_bu': 0.001, 'lr_bi': 0.01, 'lr_pu':
0.01, 'lr_qi': 0.01, 'reg_bu': 0.001, 'reg_bi': 0.001, 'reg_pu': 0.001,
'reg_qi': 0.001}
```

We will use these optimal values in SVD model

[45]:
```
from surprise import SVD
# initiallize the model
svd = SVD(n_factors=2000,biased=False, random_state=42, verbose=True,
          lr_bu = 0.001, lr_bi = 0.01, lr_pu = 0.01, lr_qi = 0.01,
           reg_bu = 0.001, reg_bi = 0.001, reg_pu = 0.001, reg_qi = 0.001
          )
svd.fit(trainset)


train_preds = svd.test(trainset.build_testset())
```

```
train_actual_ratings, train_pred_ratings = get_ratings(train_preds)

test_preds = svd.test(testset)
test_actual_ratings, test_pred_ratings = get_ratings(test_preds)
train_df_structured['SVD'] = train_pred_ratings
test_df_structured['SVD'] =  test_pred_ratings

global_model_name['SVD']={
    "Train" : nmae(train_pred_ratings,train_actual_ratings),
    "Test" : nmae(test_pred_ratings,test_actual_ratings)
}
print('Result of model is: ')
print(global_model_name['SVD'])
```

```
Processing epoch 0
Processing epoch 1
Processing epoch 2
Processing epoch 3
Processing epoch 4
Processing epoch 5
Processing epoch 6
Processing epoch 7
Processing epoch 8
Processing epoch 9
Processing epoch 10
Processing epoch 11
Processing epoch 12
Processing epoch 13
Processing epoch 14
Processing epoch 15
Processing epoch 16
Processing epoch 17
Processing epoch 18
Processing epoch 19
Result of model is:
{'Train': 0.17327865608074278, 'Test': 0.21539326049482735}
```

[46]:
```
#save the model
pickle.dump(svd, open("svd.pickle","wb"))
```

The model performs bad as the NMAE is 0.2153, which is less than our last model NMAE of 0.1928 We will check the effect of the SVD values later in our final model.

1.0.11 5.4 XGBoost model 2

we will use user average, global average, joke average, output of surprise knn joke joke similarity, output of surprise Baseline and output of SVD

[47]:
```
train_df_structured.head()
```

[47]:

	user_avg	joke_avg	gavg	BaselineOnly	KnnBaseline_joke	SVD
2064504	-2.990463	1.322097	0.73979	-2.420203	-1.867690	-2.192427
313132	-0.362000	2.526823	0.73979	-4.659975	-6.338853	-5.915707
555676	3.893030	0.434044	0.73979	-4.530977	-7.089862	-7.983773
4049155	1.447450	-0.657305	0.73979	-2.460071	-1.667773	3.404231
1646072	3.784375	1.961670	0.73979	-1.465956	0.101095	-4.184272

[51]:
```
from sklearn.model_selection import RandomizedSearchCV
from xgboost import XGBRegressor
params = {
        'min_child_weight': [1, 3, 5, 10],
        'gamma': [0.5, 1, 1.5, 2, 5],
        'subsample': [0.6, 0.8, 1.0],
        'colsample_bytree': [0.6, 0.8, 1.0],
        'max_depth': [3, 4, 5],
        'eta':[0.02,0.01,0.1],
        'n_estimators' : [100, 200, 400, 600, 800],
        'learning_rate' : [0.001,0.001,0.01,0.1]
        }


xgb = XGBRegressor()

random_search = RandomizedSearchCV(xgb, param_distributions=params, n_iter=10,␣
 ↪scoring='neg_mean_squared_error', n_jobs=-1, cv=3, verbose=10,␣
 ↪random_state=42)
random_search.fit(train_df_structured, train_df_structured_target)
print(random_search.best_params_)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 6 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 tasks      | elapsed:  6.4min
[Parallel(n_jobs=-1)]: Done   6 tasks      | elapsed: 16.5min
[Parallel(n_jobs=-1)]: Done  13 tasks      | elapsed: 64.3min
[Parallel(n_jobs=-1)]: Done  23 out of  30 | elapsed: 93.0min remaining: 28.3min
[Parallel(n_jobs=-1)]: Done  27 out of  30 | elapsed: 121.2min remaining:
13.5min
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed: 121.8min finished

[12:19:58] WARNING: src/objective/regression_obj.cu:152: reg:linear is now
deprecated in favor of reg:squarederror.
{'subsample': 1.0, 'n_estimators': 200, 'min_child_weight': 5, 'max_depth': 5,
'learning_rate': 0.1, 'gamma': 5, 'eta': 0.1, 'colsample_bytree': 0.8}
```

Lets use the best parameters to train the model

[48]:
```
# initialize Our first XGBoost model...
xgb_svd = XGBRegressor(min_child_weight = 5 ,gamma = 5, subsample = 1.
 ↪0,colsample_bytree = 0.8,
            max_depth = 5,eta = 0.1,n_estimators = 200,learning_rate = 0.1,
            objective='reg:squarederror',silent=True, random_state=42)

xgb_svd.fit(train_df_structured, train_df_structured_target)
test_pred_ratings = xgb_svd.predict(test_df_structured)
train_pred_ratings = xgb_svd.predict(train_df_structured)

global_model_name['Second_XGB']={
        "Train": nmae(train_pred_ratings,train_df_structured_target),
        "Test": nmae(test_pred_ratings,test_df_structured_target)
        }
print('Result of model is: ')
print(global_model_name['Second_XGB'])
```

```
Result of model is:
{'Train': 0.2174202221795477, 'Test': 0.18833252907421943}
```

This model works well and is the best model till now.

[49]:
```
#save the model
pickle.dump(xgb_svd, open("xgb_svd.pickle","wb"))
```

Lets check the feature importance. This will help us determining the important features. We will decide whether to keep the feature engineered features or not.

[50]:
```
print(xgb_bsl.feature_importances_)
print(train_df_structured.columns)
```

```
[0.5250122  0.4710521  0.         0.00193619 0.00199951]
Index(['user_avg', 'joke_avg', 'gavg', 'BaselineOnly', 'KnnBaseline_joke',
       'SVD'],
      dtype='object')
```

user_avg and joke_avg features seems most important features

1.0.12 Lets try some feature engineering

feature engineering 1 We will try a special feature as (user_avg + joke_avg - gavg)

[51]:
```
train_df_structured['special_feature'] =␣
 ↪train_df_structured['user_avg']+train_df_structured['joke_avg']-train_df_structured['gavg']
test_df_structured['special_feature'] =␣
 ↪test_df_structured['user_avg']+test_df_structured['joke_avg']-test_df_structured['gavg']
train_df_structured.head()
```

[51]:

	user_avg	joke_avg	gavg	BaselineOnly	KnnBaseline_joke	\
2064504	-2.990463	1.322097	0.73979	-2.420203	-1.867690	

```
313132  -0.362000  2.526823  0.73979     -4.659975         -6.338853
555676   3.893030  0.434044  0.73979     -4.530977         -7.089862
4049155  1.447450 -0.657305  0.73979     -2.460071         -1.667773
1646072  3.784375  1.961670  0.73979     -1.465956          0.101095

              SVD  special_feature
2064504 -2.192427        -2.408156
313132  -5.915707         1.425033
555676  -7.983773         3.587284
4049155  3.404231         0.050355
1646072 -4.184272         5.006255
```

[56]:
```
from sklearn.model_selection import RandomizedSearchCV
from xgboost import XGBRegressor
params = {
        'min_child_weight': [1, 3, 5, 10],
        'gamma': [0.5, 1, 1.5, 2, 5],
        'subsample': [0.6, 0.8, 1.0],
        'colsample_bytree': [0.6, 0.8, 1.0],
        'max_depth': [3, 4, 5],
        'eta':[0.02,0.01,0.1],
        'n_estimators' : [100, 200, 400, 600, 800],
        'learning_rate' : [0.001,0.001,0.01,0.1]
        }


xgb = XGBRegressor()

random_search = RandomizedSearchCV(xgb, param_distributions=params, n_iter=10,␣
 ↪scoring='neg_mean_squared_error', n_jobs=-1, cv=3, verbose=10,␣
 ↪random_state=42)
random_search.fit(train_df_structured, train_df_structured_target)
print(random_search.best_params_)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 6 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 tasks      | elapsed:  7.8min
[Parallel(n_jobs=-1)]: Done   6 tasks      | elapsed: 19.9min
[Parallel(n_jobs=-1)]: Done  13 tasks      | elapsed: 75.7min
[Parallel(n_jobs=-1)]: Done  23 out of  30 | elapsed: 110.8min remaining:
33.7min
[Parallel(n_jobs=-1)]: Done  27 out of  30 | elapsed: 143.3min remaining:
15.9min
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed: 145.7min finished

[16:13:03] WARNING: src/objective/regression_obj.cu:152: reg:linear is now
deprecated in favor of reg:squarederror.
```

```
{'subsample': 1.0, 'n_estimators': 200, 'min_child_weight': 5, 'max_depth': 5,
'learning_rate': 0.1, 'gamma': 5, 'eta': 0.1, 'colsample_bytree': 0.8}
```

[52]:
```
# initialize Our first XGBoost model...
xgb_bsl_fe_1 = XGBRegressor(min_child_weight = 5 ,gamma = 5, subsample = 1.
 ↪0,colsample_bytree = 0.8,
            max_depth = 5,eta = 0.1,n_estimators = 200,learning_rate = 0.1,
            objective='reg:squarederror',silent=True, random_state=42)
xgb_bsl_fe_1.fit(train_df_structured, train_df_structured_target)
test_pred_ratings = xgb_bsl_fe_1.predict(test_df_structured)
train_pred_ratings = xgb_bsl_fe_1.predict(train_df_structured)

global_model_name['First_XGB_FE_1']={
        "Train": nmae(train_pred_ratings,train_df_structured_target),
        "Test": nmae(test_pred_ratings,test_df_structured_target)
        }
print('Result of model')
print(global_model_name['First_XGB_FE_1'])
```

```
Result of model
{'Train': 0.22321715705636846, 'Test': 0.20289328398328535}
```

The feature engineering did not improve any thing on the model as the test NMAE was previously 0.1883 and is 0.2028 now.

[53]:
```
print(xgb_bsl_fe_1.feature_importances_)
print(train_df_structured.columns)
```

```
[0.1351127  0.13147087 0.         0.00140833 0.00140642 0.00138204
 0.72921973]
Index(['user_avg', 'joke_avg', 'gavg', 'BaselineOnly', 'KnnBaseline_joke',
       'SVD', 'special_feature'],
      dtype='object')
```

feature engineering 2 We will try a special feature as (user_avg + joke_avg - gavg)^2

[54]:
```
train_df_structured['special_feature_1'] =␣
 ↪train_df_structured['special_feature']**2
test_df_structured['special_feature_1'] =␣
 ↪test_df_structured['special_feature']**2
train_df_structured.head()
```

[54]:

	user_avg	joke_avg	gavg	BaselineOnly	KnnBaseline_joke	\
2064504	-2.990463	1.322097	0.73979	-2.420203	-1.867690	
313132	-0.362000	2.526823	0.73979	-4.659975	-6.338853	
555676	3.893030	0.434044	0.73979	-4.530977	-7.089862	
4049155	1.447450	-0.657305	0.73979	-2.460071	-1.667773	
1646072	3.784375	1.961670	0.73979	-1.465956	0.101095	

```
              SVD  special_feature  special_feature_1
2064504 -2.192427        -2.408156           5.799214
313132  -5.915707         1.425033           2.030718
555676  -7.983773         3.587284          12.868608
4049155  3.404231         0.050355           0.002536
1646072 -4.184272         5.006255          25.062584
```

[163]:
```
from sklearn.model_selection import RandomizedSearchCV
from xgboost import XGBRegressor
params = {
        'min_child_weight': [1, 3, 5, 10],
        'gamma': [0.5, 1, 1.5, 2, 5],
        'subsample': [0.6, 0.8, 1.0],
        'colsample_bytree': [0.6, 0.8, 1.0],
        'max_depth': [3, 4, 5],
        'eta':[0.02,0.01,0.1],
        'n_estimators' : [100, 200, 400, 600, 800],
        'learning_rate' : [0.001,0.001,0.01,0.1]
        }


xgb = XGBRegressor()

random_search = RandomizedSearchCV(xgb, param_distributions=params, n_iter=10,␣
 ↪scoring='neg_mean_squared_error', n_jobs=-1, cv=3, verbose=10,␣
 ↪random_state=42)
random_search.fit(train_df_structured, train_df_structured_target)
print(random_search.best_params_)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 6 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 tasks      | elapsed:  9.0min
[Parallel(n_jobs=-1)]: Done   6 tasks      | elapsed: 21.5min
[Parallel(n_jobs=-1)]: Done  13 tasks      | elapsed: 88.4min
[Parallel(n_jobs=-1)]: Done  23 out of  30 | elapsed: 131.0min remaining:
39.9min
[Parallel(n_jobs=-1)]: Done  27 out of  30 | elapsed: 164.9min remaining:
18.3min
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed: 167.1min finished

[23:06:32] WARNING: src/objective/regression_obj.cu:152: reg:linear is now
deprecated in favor of reg:squarederror.
{'subsample': 1.0, 'n_estimators': 200, 'min_child_weight': 5, 'max_depth': 5,
'learning_rate': 0.1, 'gamma': 5, 'eta': 0.1, 'colsample_bytree': 0.8}
```

[55]:
```
# initialize Our first XGBoost model...
xgb_bsl_fe_2 = XGBRegressor(min_child_weight = 5 ,gamma = 5, subsample = 1.
 ↪0,colsample_bytree = 0.8,
            max_depth = 5,eta = 0.1,n_estimators = 200,learning_rate = 0.1,
            objective='reg:squarederror',silent=True, random_state=42)
xgb_bsl_fe_2.fit(train_df_structured, train_df_structured_target)
test_pred_ratings = xgb_bsl_fe_2.predict(test_df_structured)
train_pred_ratings = xgb_bsl_fe_2.predict(train_df_structured)

global_model_name['First_XGB_FE_2']={
        "Train": nmae(train_pred_ratings,train_df_structured_target),
        "Test": nmae(test_pred_ratings,test_df_structured_target)
        }
print('Result of model')
print(global_model_name['First_XGB_FE_2'])
```

```
Result of model
{'Train': 0.22556924102141873, 'Test': 0.20872101921358918}
```

This feature engineering also did not improve any thing on the model as the test NMAE was previously 0.1883 and is 0.2087 now.

1.0.13 5.5 Surprise SVD plus plus model

Hyper parameter tuning takes more than 2 days. so i have stopped that code and removed that from notebok.

1.1 Feature engineering is not helping much. So lets try some Deep Neural Network Model.

1.1.1 6. Deep learning model 1

[93]:
```
import tensorflow as tf
#define DL model
first_model = tf.keras.Sequential([
    tf.keras.layers.Dense(32, activation=tf.nn.relu, input_shape=[8]),
    tf.keras.layers.Dense(16, activation=tf.nn.relu),
    tf.keras.layers.Dense(8, activation=tf.nn.relu),
    tf.keras.layers.Dense(1)
  ])
```

[94]:
```
#define call backs
filepath="weights-improvement.hdf5"
checkpoint = tf.keras.callbacks.ModelCheckpoint(filepath, monitor='val_loss',␣
 ↪verbose=1, save_best_only=True, mode='min')
tbCallBack = tf.keras.callbacks.TensorBoard(log_dir='./logs',profile_batch =␣
 ↪100000000)
```

```
es = tf.keras.callbacks.EarlyStopping(monitor='val_loss', mode='min',␣
 ↪verbose=1, patience=40)
callbacks=[checkpoint,tbCallBack,es]
```

[95]:
```
if os.path.isfile('weights-improvement.hdf5'):
    pass
else:
    #define optimizer and train model
    optimizer = tf.keras.optimizers.Adam()
    first_model.compile(loss='mean_absolute_error',optimizer=optimizer)
    first_model.
 ↪fit(train_df_structured,train_df_structured_target,epochs=1000,batch_size=512,validation_sp
 ↪3,callbacks=callbacks)
```

```
WARNING:tensorflow:Falling back from v2 loop because of error: Failed to find
data adapter that can handle input: <class 'pandas.core.frame.DataFrame'>,
<class 'NoneType'>
Train on 2026816 samples, validate on 868636 samples
Epoch 1/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8601
Epoch 00001: val_loss improved from inf to 3.85437, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8602
- val_loss: 3.8544
Epoch 2/1000
2013696/2026816 [============================>.] - ETA: 0s - loss: 3.8515
Epoch 00002: val_loss improved from 3.85437 to 3.84818, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8515
- val_loss: 3.8482
Epoch 3/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8503
Epoch 00003: val_loss improved from 3.84818 to 3.84769, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8504
- val_loss: 3.8477
Epoch 4/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8499
Epoch 00004: val_loss improved from 3.84769 to 3.84744, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8499
- val_loss: 3.8474
Epoch 5/1000
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00005: val_loss did not improve from 3.84744
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8493
- val_loss: 3.8484
Epoch 6/1000
```

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2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00006: val_loss improved from 3.84744 to 3.84681, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8493
- val_loss: 3.8468
Epoch 7/1000
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8491
Epoch 00007: val_loss did not improve from 3.84681
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8491
- val_loss: 3.8488
Epoch 8/1000
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00008: val_loss improved from 3.84681 to 3.84592, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8490
- val_loss: 3.8459
Epoch 9/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00009: val_loss did not improve from 3.84592
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8488
- val_loss: 3.8470
Epoch 10/1000
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00010: val_loss did not improve from 3.84592
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8485
- val_loss: 3.8464
Epoch 11/1000
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00011: val_loss did not improve from 3.84592
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8485
- val_loss: 3.8466
Epoch 12/1000
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00012: val_loss did not improve from 3.84592
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8483
- val_loss: 3.8485
Epoch 13/1000
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8482
Epoch 00013: val_loss did not improve from 3.84592
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8482
- val_loss: 3.8464
Epoch 14/1000
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8480
Epoch 00014: val_loss improved from 3.84592 to 3.84590, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8481
- val_loss: 3.8459
Epoch 15/1000
```

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2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00015: val_loss did not improve from 3.84590
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8480
- val_loss: 3.8461
Epoch 16/1000
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8479
Epoch 00016: val_loss improved from 3.84590 to 3.84574, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8479
- val_loss: 3.8457
Epoch 17/1000
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8477
Epoch 00017: val_loss did not improve from 3.84574
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8476
- val_loss: 3.8482
Epoch 18/1000
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8474
Epoch 00018: val_loss improved from 3.84574 to 3.84562, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8473
- val_loss: 3.8456
Epoch 19/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8470
Epoch 00019: val_loss did not improve from 3.84562
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8471
- val_loss: 3.8468
Epoch 20/1000
2014720/2026816 [============================>.] - ETA: 0s - loss: 3.8472
Epoch 00020: val_loss improved from 3.84562 to 3.84503, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8470
- val_loss: 3.8450
Epoch 21/1000
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8469
Epoch 00021: val_loss did not improve from 3.84503
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8469
- val_loss: 3.8457
Epoch 22/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8470
Epoch 00022: val_loss did not improve from 3.84503
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8468
- val_loss: 3.8454
Epoch 23/1000
2013184/2026816 [============================>.] - ETA: 0s - loss: 3.8466
Epoch 00023: val_loss improved from 3.84503 to 3.84436, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8466
- val_loss: 3.8444
```

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Epoch 24/1000
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8465
Epoch 00024: val_loss did not improve from 3.84436
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8466
- val_loss: 3.8450
Epoch 25/1000
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8463
Epoch 00025: val_loss did not improve from 3.84436
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8463
- val_loss: 3.8455
Epoch 26/1000
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8462
Epoch 00026: val_loss did not improve from 3.84436
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8462
- val_loss: 3.8456
Epoch 27/1000
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8463
Epoch 00027: val_loss improved from 3.84436 to 3.84381, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8461
- val_loss: 3.8438
Epoch 28/1000
2013184/2026816 [============================>.] - ETA: 0s - loss: 3.8457
Epoch 00028: val_loss did not improve from 3.84381
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8460
- val_loss: 3.8443
Epoch 29/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8457
Epoch 00029: val_loss did not improve from 3.84381
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8458
- val_loss: 3.8443
Epoch 30/1000
2013696/2026816 [============================>.] - ETA: 0s - loss: 3.8458
Epoch 00030: val_loss improved from 3.84381 to 3.84355, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8458
- val_loss: 3.8435
Epoch 31/1000
2013184/2026816 [============================>.] - ETA: 0s - loss: 3.8454
Epoch 00031: val_loss did not improve from 3.84355
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8458
- val_loss: 3.8437
Epoch 32/1000
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8456
Epoch 00032: val_loss did not improve from 3.84355
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8456
- val_loss: 3.8449
Epoch 33/1000
```

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2014720/2026816 [============================>.] - ETA: 0s - loss: 3.8457
Epoch 00033: val_loss did not improve from 3.84355
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8455
- val_loss: 3.8451
Epoch 34/1000
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8456
Epoch 00034: val_loss did not improve from 3.84355
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8455
- val_loss: 3.8441
Epoch 35/1000
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8454
Epoch 00035: val_loss did not improve from 3.84355
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8454
- val_loss: 3.8440
Epoch 36/1000
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8451
Epoch 00036: val_loss did not improve from 3.84355
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8452
- val_loss: 3.8444
Epoch 37/1000
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8454
Epoch 00037: val_loss did not improve from 3.84355
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8453
- val_loss: 3.8438
Epoch 38/1000
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8452
Epoch 00038: val_loss improved from 3.84355 to 3.84322, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8452
- val_loss: 3.8432
Epoch 39/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8451
Epoch 00039: val_loss did not improve from 3.84322
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8451
- val_loss: 3.8436
Epoch 40/1000
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8449
Epoch 00040: val_loss did not improve from 3.84322
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8448
- val_loss: 3.8443
Epoch 41/1000
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8450
Epoch 00041: val_loss did not improve from 3.84322
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8449
- val_loss: 3.8438
Epoch 42/1000
2013184/2026816 [============================>.] - ETA: 0s - loss: 3.8450
Epoch 00042: val_loss did not improve from 3.84322
```

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2026816/2026816 [==============================] - 9s 4us/sample - loss: 3.8450
- val_loss: 3.8434
Epoch 43/1000
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8447
Epoch 00043: val_loss improved from 3.84322 to 3.84219, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8448
- val_loss: 3.8422
Epoch 44/1000
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8446
Epoch 00044: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8446
- val_loss: 3.8452
Epoch 45/1000
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8445
Epoch 00045: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8445
- val_loss: 3.8439
Epoch 46/1000
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8443
Epoch 00046: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8446
- val_loss: 3.8432
Epoch 47/1000
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8445
Epoch 00047: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8444
- val_loss: 3.8439
Epoch 48/1000
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8443
Epoch 00048: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8444
- val_loss: 3.8438
Epoch 49/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8444
Epoch 00049: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8442
- val_loss: 3.8428
Epoch 50/1000
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8443
Epoch 00050: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8444
- val_loss: 3.8431
Epoch 51/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8441
Epoch 00051: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8442
- val_loss: 3.8431
```

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Epoch 52/1000
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8442
Epoch 00052: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8441
- val_loss: 3.8423
Epoch 53/1000
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8441
Epoch 00053: val_loss did not improve from 3.84219
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8441
- val_loss: 3.8443
Epoch 54/1000
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8442
Epoch 00054: val_loss improved from 3.84219 to 3.84204, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8441
- val_loss: 3.8420
Epoch 55/1000
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8439
Epoch 00055: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8439
- val_loss: 3.8427
Epoch 56/1000
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8439
Epoch 00056: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8439
- val_loss: 3.8424
Epoch 57/1000
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8439
Epoch 00057: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8439
- val_loss: 3.8426
Epoch 58/1000
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8438
Epoch 00058: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8438
- val_loss: 3.8422
Epoch 59/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8441
Epoch 00059: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8439
- val_loss: 3.8424
Epoch 60/1000
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00060: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8438
- val_loss: 3.8429
Epoch 61/1000
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8438
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Epoch 00061: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8438
- val_loss: 3.8428
Epoch 62/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00062: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8437
- val_loss: 3.8444
Epoch 63/1000
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8439
Epoch 00063: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8439
- val_loss: 3.8426
Epoch 64/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8436
Epoch 00064: val_loss did not improve from 3.84204
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8435
- val_loss: 3.8436
Epoch 65/1000
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8434
Epoch 00065: val_loss improved from 3.84204 to 3.84193, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8436
- val_loss: 3.8419
Epoch 66/1000
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8436
Epoch 00066: val_loss did not improve from 3.84193
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8436
- val_loss: 3.8426
Epoch 67/1000
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8435
Epoch 00067: val_loss did not improve from 3.84193
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8435
- val_loss: 3.8423
Epoch 68/1000
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8434
Epoch 00068: val_loss did not improve from 3.84193
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8434
- val_loss: 3.8430
Epoch 69/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00069: val_loss did not improve from 3.84193
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8433
- val_loss: 3.8429
Epoch 70/1000
2013184/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00070: val_loss did not improve from 3.84193
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8434
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- val_loss: 3.8430
Epoch 71/1000
2012672/2026816 [============================>.] - ETA: 0s - loss: 3.8434
Epoch 00071: val_loss improved from 3.84193 to 3.84175, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8434
- val_loss: 3.8418
Epoch 72/1000
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8433
Epoch 00072: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8433
- val_loss: 3.8432
Epoch 73/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00073: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8433
- val_loss: 3.8424
Epoch 74/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00074: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8432
- val_loss: 3.8423
Epoch 75/1000
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8433
Epoch 00075: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8433
- val_loss: 3.8447
Epoch 76/1000
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00076: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8431
- val_loss: 3.8427
Epoch 77/1000
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8435
Epoch 00077: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8435
- val_loss: 3.8443
Epoch 78/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00078: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8432
- val_loss: 3.8435
Epoch 79/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8434
Epoch 00079: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8434
- val_loss: 3.8432
Epoch 80/1000
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2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8434
Epoch 00080: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8434
- val_loss: 3.8421
Epoch 81/1000
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8435
Epoch 00081: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8433
- val_loss: 3.8422
Epoch 82/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8435
Epoch 00082: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8434
- val_loss: 3.8425
Epoch 83/1000
2012160/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00083: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 4us/sample - loss: 3.8434
- val_loss: 3.8428
Epoch 84/1000
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8436
Epoch 00084: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8433
- val_loss: 3.8424
Epoch 85/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8433
Epoch 00085: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8431
- val_loss: 3.8439
Epoch 86/1000
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00086: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8432
- val_loss: 3.8427
Epoch 87/1000
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00087: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8433
- val_loss: 3.8430
Epoch 88/1000
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00088: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8431
- val_loss: 3.8421
Epoch 89/1000
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00089: val_loss did not improve from 3.84175
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8432
```

```
- val_loss: 3.8419
Epoch 90/1000
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00090: val_loss improved from 3.84175 to 3.84146, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8431
- val_loss: 3.8415
Epoch 91/1000
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00091: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8455
Epoch 92/1000
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00092: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8431
- val_loss: 3.8418
Epoch 93/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00093: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8438
Epoch 94/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00094: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8432
- val_loss: 3.8416
Epoch 95/1000
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00095: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8431
- val_loss: 3.8433
Epoch 96/1000
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00096: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8432
- val_loss: 3.8417
Epoch 97/1000
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00097: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8452
Epoch 98/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00098: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8433
Epoch 99/1000
```

```
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00099: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8431
- val_loss: 3.8418
Epoch 100/1000
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00100: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8431
- val_loss: 3.8421
Epoch 101/1000
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00101: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8421
Epoch 102/1000
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00102: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8432
Epoch 103/1000
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00103: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8424
Epoch 104/1000
2012672/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00104: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8422
Epoch 105/1000
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00105: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8429
- val_loss: 3.8428
Epoch 106/1000
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00106: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8428
- val_loss: 3.8441
Epoch 107/1000
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00107: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8419
Epoch 108/1000
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00108: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
```

```
- val_loss: 3.8419
Epoch 109/1000
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00109: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8429
- val_loss: 3.8422
Epoch 110/1000
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00110: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8429
- val_loss: 3.8463
Epoch 111/1000
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00111: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8430
- val_loss: 3.8427
Epoch 112/1000
2014720/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00112: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8429
- val_loss: 3.8424
Epoch 113/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00113: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8429
- val_loss: 3.8426
Epoch 114/1000
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00114: val_loss did not improve from 3.84146
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8429
- val_loss: 3.8419
Epoch 115/1000
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00115: val_loss improved from 3.84146 to 3.84141, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8428
- val_loss: 3.8414
Epoch 116/1000
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00116: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8428
- val_loss: 3.8416
Epoch 117/1000
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00117: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8428
- val_loss: 3.8423
Epoch 118/1000
```

```
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00118: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8429
- val_loss: 3.8420
Epoch 119/1000
2013696/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00119: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8429
- val_loss: 3.8422
Epoch 120/1000
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00120: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8428
- val_loss: 3.8421
Epoch 121/1000
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00121: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8427
- val_loss: 3.8441
Epoch 122/1000
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00122: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8429
- val_loss: 3.8434
Epoch 123/1000
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00123: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8429
- val_loss: 3.8426
Epoch 124/1000
2014720/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00124: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8430
- val_loss: 3.8423
Epoch 125/1000
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00125: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8429
- val_loss: 3.8432
Epoch 126/1000
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00126: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8427
- val_loss: 3.8419
Epoch 127/1000
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00127: val_loss did not improve from 3.84141
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8429
```

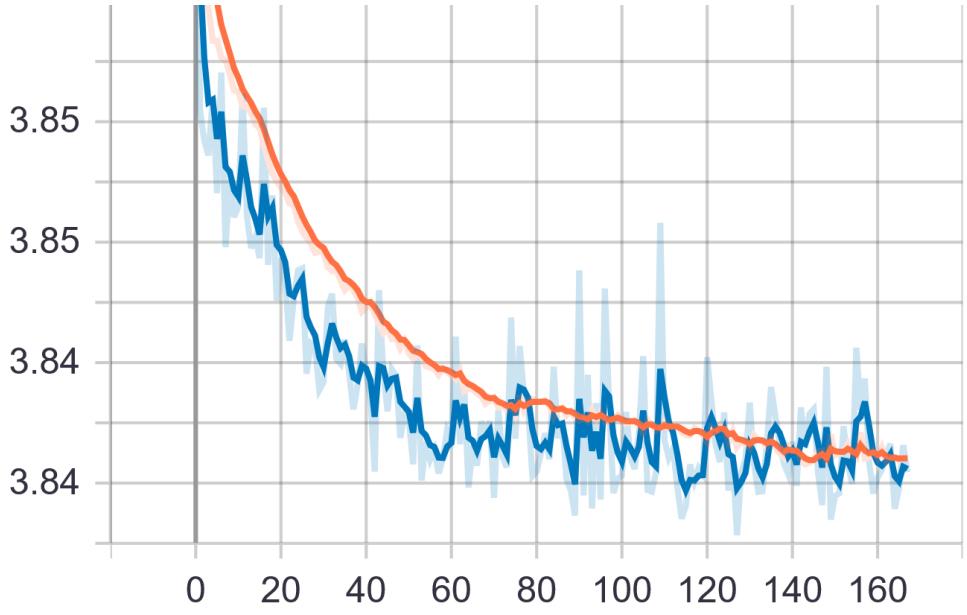
```
- val_loss: 3.8424
Epoch 128/1000
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00128: val_loss improved from 3.84141 to 3.84113, saving model to weights-
improvement.hdf5
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8426
- val_loss: 3.8411
Epoch 129/1000
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00129: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8427
- val_loss: 3.8422
Epoch 130/1000
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00130: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8427
- val_loss: 3.8424
Epoch 131/1000
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00131: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8426
- val_loss: 3.8433
Epoch 132/1000
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00132: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8428
- val_loss: 3.8423
Epoch 133/1000
2013696/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00133: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8427
- val_loss: 3.8419
Epoch 134/1000
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00134: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8427
- val_loss: 3.8419
Epoch 135/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00135: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8426
- val_loss: 3.8426
Epoch 136/1000
2014720/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00136: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8427
- val_loss: 3.8436
Epoch 137/1000
```

```
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00137: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8426
- val_loss: 3.8431
Epoch 138/1000
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00138: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8425
- val_loss: 3.8427
Epoch 139/1000
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00139: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8423
Epoch 140/1000
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00140: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8426
- val_loss: 3.8422
Epoch 141/1000
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00141: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8425
- val_loss: 3.8427
Epoch 142/1000
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00142: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8425
- val_loss: 3.8420
Epoch 143/1000
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00143: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8424
- val_loss: 3.8433
Epoch 144/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00144: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8423
- val_loss: 3.8426
Epoch 145/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00145: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8423
- val_loss: 3.8431
Epoch 146/1000
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8422
Epoch 00146: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
```

```
- val_loss: 3.8432
Epoch 147/1000
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00147: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8425
- val_loss: 3.8422
Epoch 148/1000
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00148: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8425
- val_loss: 3.8416
Epoch 149/1000
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00149: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8423
- val_loss: 3.8439
Epoch 150/1000
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00150: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8428
- val_loss: 3.8414
Epoch 151/1000
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00151: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8425
- val_loss: 3.8418
Epoch 152/1000
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00152: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8425
- val_loss: 3.8418
Epoch 153/1000
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00153: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8425
- val_loss: 3.8429
Epoch 154/1000
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00154: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8426
- val_loss: 3.8423
Epoch 155/1000
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00155: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8425
- val_loss: 3.8420
Epoch 156/1000
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8423
```

```
Epoch 00156: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8442
Epoch 157/1000
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00157: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8428
- val_loss: 3.8432
Epoch 158/1000
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00158: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8437
Epoch 159/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00159: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8423
Epoch 160/1000
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00160: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8425
- val_loss: 3.8418
Epoch 161/1000
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8422
Epoch 00161: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8421
Epoch 162/1000
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00162: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8426
- val_loss: 3.8422
Epoch 163/1000
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00163: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8425
Epoch 164/1000
2014208/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00164: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8427
Epoch 165/1000
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8422
Epoch 00165: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8416
```

```
Epoch 166/1000
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00166: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8419
Epoch 167/1000
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00167: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 9s 5us/sample - loss: 3.8424
- val_loss: 3.8426
Epoch 168/1000
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00168: val_loss did not improve from 3.84113
2026816/2026816 [==============================] - 10s 5us/sample - loss: 3.8424
- val_loss: 3.8422
Epoch 00168: early stopping
```



title

[96]:
```
#load model and predict
first_best_model = tf.keras.models.load_model('weights-improvement.hdf5')
test_pred_ratings = first_best_model.predict(np.asarray(test_df_structured))
train_pred_ratings = first_best_model.predict(np.
 ↪asanyarray(train_df_structured))
```

[97]:
```
# i am getting ther error as: MemoryError: Unable to allocate array with shape␣
 ↪(1240908, 1240908) and data type float64
# while calculating NMAE
# this is happenning as numpy can't put so many float64 values to memory.
```

So lets try the python forloop way for calculating NMAE

[98]:
```
test_pred_ratings = test_pred_ratings.tolist()
train_pred_ratings = train_pred_ratings.tolist()
```

[99]:
```
test_pred_ratings_list = [i[0] for i in test_pred_ratings]
train_pred_ratings_list = [i[0] for i in train_pred_ratings]
```

[100]:
```
test_df_structured_target_list=test_df_structured_target.values
train_df_structured_target_list=train_df_structured_target.values
```

[101]:
```
test_df_structured_target_list = test_df_structured_target_list.tolist()
train_df_structured_target_list = train_df_structured_target_list.tolist()
```

1.1.2 redefine error to accept python list

[102]:
```
# re define error metric same as for ML models
def _error(actual, predicted):
    """ Simple error """
    temp = []
    for i in range(len(actual)):
        temp.append(actual[i] - predicted[i])
    return temp


def mae(actual, predicted):
    """ Mean Absolute Error """
    temp = _error(actual, predicted)
    sum_error = 0
    for i in temp:
        sum_error += abs(i)
    return sum_error/len(temp)

def nmae(actual, predicted):
    """ Normalized Mean Absolute Error """
    return mae(actual, predicted) / (max(actual) - min(actual))
```

[103]:
```
global_model_name['First_NN']={
        "Test": nmae(test_pred_ratings_list,test_df_structured_target_list),
        "Train": nmae(train_pred_ratings_list,train_df_structured_target_list)
        }
print('Result of model')
print(global_model_name['First_NN'])
```

```
Result of model
{'Test': 0.19394950246246248, 'Train': 0.19275586777667447}
```

1.1.3 6. Deep learning model 2

[72]:
```
import pandas as pd
from sklearn import preprocessing
min_max_scaler_X = preprocessing.MinMaxScaler()
train_df_structured_scaled = min_max_scaler_X.fit_transform(train_df_structured)
test_df_structured_scaled = min_max_scaler_X.transform(test_df_structured)
```

[108]:
```
import tensorflow as tf
#define DL model
first_model = tf.keras.Sequential([
    tf.keras.layers.Dense(64, activation=tf.nn.relu, input_shape=[8]),
    tf.keras.layers.Dense(32, activation=tf.nn.relu),
    tf.keras.layers.Dense(16, activation=tf.nn.relu),
    tf.keras.layers.Dense(8, activation=tf.nn.relu),
    tf.keras.layers.Dense(4, activation=tf.nn.relu),
    tf.keras.layers.Dense(2, activation=tf.nn.relu),
    tf.keras.layers.Dense(1)
  ])
```

[109]:
```
#define call backs
filepath="weights-improvement-1.hdf5"
checkpoint = tf.keras.callbacks.ModelCheckpoint(filepath, monitor='val_loss',␣
 ↪verbose=1, save_best_only=True, mode='min')
tbCallBack = tf.keras.callbacks.TensorBoard(log_dir='./logs',profile_batch =␣
 ↪100000001)
es = tf.keras.callbacks.EarlyStopping(monitor='val_loss', mode='min',␣
 ↪verbose=1, patience=40)
callbacks=[checkpoint,tbCallBack,es]
```

[110]:
```
if os.path.isfile('weights-improvement-1.hdf5'):
    pass
else:
    #define optimizer and train model
    optimizer = tf.keras.optimizers.Adam()
    first_model.compile(loss='mean_absolute_error',optimizer=optimizer)
    first_model.fit(np.asarray(train_df_structured_scaled),np.
 ↪asarray(train_df_structured_target),epochs=500,batch_size=512,validation_split=0.
 ↪3,callbacks=callbacks)
```

```
Train on 2026816 samples, validate on 868636 samples
Epoch 1/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 4.0947
Epoch 00001: val_loss improved from inf to 3.92380, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 12s 6us/sample - loss: 4.0941
- val_loss: 3.9238
Epoch 2/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8909
```

```
Epoch 00002: val_loss improved from 3.92380 to 3.86586, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 12s 6us/sample - loss: 3.8909
- val_loss: 3.8659
Epoch 3/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8633
Epoch 00003: val_loss improved from 3.86586 to 3.85627, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 12s 6us/sample - loss: 3.8633
- val_loss: 3.8563
Epoch 4/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8576
Epoch 00004: val_loss did not improve from 3.85627
2026816/2026816 [==============================] - 13s 6us/sample - loss: 3.8574
- val_loss: 3.8582
Epoch 5/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8552
Epoch 00005: val_loss improved from 3.85627 to 3.85119, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8552
- val_loss: 3.8512
Epoch 6/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8540- ETA:
0s - loss:
Epoch 00006: val_loss improved from 3.85119 to 3.85077, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8541
- val_loss: 3.8508
Epoch 7/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8532
Epoch 00007: val_loss improved from 3.85077 to 3.84969, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8533
- val_loss: 3.8497
Epoch 8/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8527
Epoch 00008: val_loss improved from 3.84969 to 3.84860, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8528
- val_loss: 3.8486
Epoch 9/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8523
Epoch 00009: val_loss did not improve from 3.84860
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8526
- val_loss: 3.8499
Epoch 10/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8517
Epoch 00010: val_loss improved from 3.84860 to 3.84683, saving model to weights-
```

```
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8515
- val_loss: 3.8468
Epoch 11/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8520
Epoch 00011: val_loss did not improve from 3.84683
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8520
- val_loss: 3.8507
Epoch 12/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8512
Epoch 00012: val_loss did not improve from 3.84683
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8513
- val_loss: 3.8504
Epoch 13/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8513
Epoch 00013: val_loss did not improve from 3.84683
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8513
- val_loss: 3.8473
Epoch 14/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8507
Epoch 00014: val_loss improved from 3.84683 to 3.84639, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8508
- val_loss: 3.8464
Epoch 15/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8509
Epoch 00015: val_loss did not improve from 3.84639
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8508
- val_loss: 3.8479
Epoch 16/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8504
Epoch 00016: val_loss did not improve from 3.84639
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8505
- val_loss: 3.8469
Epoch 17/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8505
Epoch 00017: val_loss did not improve from 3.84639
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8503
- val_loss: 3.8478
Epoch 18/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8505
Epoch 00018: val_loss did not improve from 3.84639
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8505
- val_loss: 3.8482
Epoch 19/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8502
Epoch 00019: val_loss did not improve from 3.84639
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8500
```

```
- val_loss: 3.8466
Epoch 20/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8500
Epoch 00020: val_loss did not improve from 3.84639
2026816/2026816 [==============================] - 12s 6us/sample - loss: 3.8500
- val_loss: 3.8465
Epoch 21/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8499
Epoch 00021: val_loss improved from 3.84639 to 3.84552, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8500
- val_loss: 3.8455
Epoch 22/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8496
Epoch 00022: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8498
- val_loss: 3.8468
Epoch 23/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8499
Epoch 00023: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8498
- val_loss: 3.8473
Epoch 24/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00024: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8497
- val_loss: 3.8481
Epoch 25/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8496
Epoch 00025: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8497
- val_loss: 3.8482
Epoch 26/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8497
Epoch 00026: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8496
- val_loss: 3.8470
Epoch 27/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00027: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8495
- val_loss: 3.8487
Epoch 28/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8495- ETA:
0
Epoch 00028: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8495
- val_loss: 3.8461
```

```
Epoch 29/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00029: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8495
- val_loss: 3.8459
Epoch 30/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00030: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8495
- val_loss: 3.8491
Epoch 31/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00031: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8492
- val_loss: 3.8468
Epoch 32/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8491
Epoch 00032: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8482
Epoch 33/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8491
Epoch 00033: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8491
- val_loss: 3.8482
Epoch 34/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00034: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8473
Epoch 35/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00035: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8465
Epoch 36/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8491
Epoch 00036: val_loss did not improve from 3.84552
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8512
Epoch 37/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00037: val_loss improved from 3.84552 to 3.84550, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8455
Epoch 38/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8491
```

```
Epoch 00038: val_loss did not improve from 3.84550
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8485
Epoch 39/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00039: val_loss did not improve from 3.84550
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8456
Epoch 40/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00040: val_loss did not improve from 3.84550
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8503
Epoch 41/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00041: val_loss did not improve from 3.84550
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8485
- val_loss: 3.8459
Epoch 42/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00042: val_loss did not improve from 3.84550
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8487
- val_loss: 3.8469
Epoch 43/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00043: val_loss did not improve from 3.84550
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8463
Epoch 44/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00044: val_loss did not improve from 3.84550
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8486
- val_loss: 3.8456
Epoch 45/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00045: val_loss improved from 3.84550 to 3.84513, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8451
Epoch 46/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8480
Epoch 00046: val_loss did not improve from 3.84513
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8481
- val_loss: 3.8480
Epoch 47/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00047: val_loss did not improve from 3.84513
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8481
```

```
- val_loss: 3.8460
Epoch 48/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8480
Epoch 00048: val_loss did not improve from 3.84513
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8481
- val_loss: 3.8478
Epoch 49/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00049: val_loss did not improve from 3.84513
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8453
Epoch 50/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8480
Epoch 00050: val_loss improved from 3.84513 to 3.84487, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8480
- val_loss: 3.8449
Epoch 51/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8480
Epoch 00051: val_loss did not improve from 3.84487
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8480
- val_loss: 3.8474
Epoch 52/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8480
Epoch 00052: val_loss did not improve from 3.84487
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8479
- val_loss: 3.8471
Epoch 53/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8480
Epoch 00053: val_loss improved from 3.84487 to 3.84479, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8478
- val_loss: 3.8448
Epoch 54/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8476
Epoch 00054: val_loss did not improve from 3.84479
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8477
- val_loss: 3.8450
Epoch 55/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8478
Epoch 00055: val_loss did not improve from 3.84479
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8477
- val_loss: 3.8460
Epoch 56/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8478
Epoch 00056: val_loss did not improve from 3.84479
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8477
- val_loss: 3.8472
```

```
Epoch 57/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8476
Epoch 00057: val_loss did not improve from 3.84479
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8477
- val_loss: 3.8453
Epoch 58/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8473
Epoch 00058: val_loss did not improve from 3.84479
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8473
- val_loss: 3.8459
Epoch 59/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8473
Epoch 00059: val_loss did not improve from 3.84479
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8474
- val_loss: 3.8449
Epoch 60/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8474
Epoch 00060: val_loss did not improve from 3.84479
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8475
- val_loss: 3.8459
Epoch 61/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8474
Epoch 00061: val_loss improved from 3.84479 to 3.84470, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8473
- val_loss: 3.8447
Epoch 62/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8473
Epoch 00062: val_loss did not improve from 3.84470
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8473
- val_loss: 3.8474
Epoch 63/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8473
Epoch 00063: val_loss did not improve from 3.84470
2026816/2026816 [==============================] - 12s 6us/sample - loss: 3.8473
- val_loss: 3.8460
Epoch 64/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8471
Epoch 00064: val_loss did not improve from 3.84470
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8472
- val_loss: 3.8459
Epoch 65/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8471
Epoch 00065: val_loss did not improve from 3.84470
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8471
- val_loss: 3.8461
Epoch 66/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8472
```

```
Epoch 00066: val_loss did not improve from 3.84470
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8471
- val_loss: 3.8481
Epoch 67/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8472
Epoch 00067: val_loss improved from 3.84470 to 3.84465, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8472
- val_loss: 3.8446
Epoch 68/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8469
Epoch 00068: val_loss improved from 3.84465 to 3.84441, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8469
- val_loss: 3.8444
Epoch 69/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8469
Epoch 00069: val_loss did not improve from 3.84441
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8469
- val_loss: 3.8459
Epoch 70/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8470
Epoch 00070: val_loss did not improve from 3.84441
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8470
- val_loss: 3.8447
Epoch 71/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8469
Epoch 00071: val_loss improved from 3.84441 to 3.84406, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8469
- val_loss: 3.8441
Epoch 72/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8467
Epoch 00072: val_loss did not improve from 3.84406
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8468
- val_loss: 3.8473
Epoch 73/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8470
Epoch 00073: val_loss did not improve from 3.84406
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8470
- val_loss: 3.8446
Epoch 74/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8467
Epoch 00074: val_loss did not improve from 3.84406
2026816/2026816 [==============================] - 12s 6us/sample - loss: 3.8468
- val_loss: 3.8441
Epoch 75/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8468
```

```
Epoch 00075: val_loss did not improve from 3.84406
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8467
- val_loss: 3.8445
Epoch 76/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8467
Epoch 00076: val_loss improved from 3.84406 to 3.84386, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8467
- val_loss: 3.8439
Epoch 77/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8464
Epoch 00077: val_loss did not improve from 3.84386
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8464
- val_loss: 3.8462
Epoch 78/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8465- ETA:
0s - loss:
Epoch 00078: val_loss did not improve from 3.84386
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8467
- val_loss: 3.8442
Epoch 79/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8465
Epoch 00079: val_loss did not improve from 3.84386
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8466
- val_loss: 3.8445
Epoch 80/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8465
Epoch 00080: val_loss did not improve from 3.84386
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8465
- val_loss: 3.8443
Epoch 81/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8466
Epoch 00081: val_loss improved from 3.84386 to 3.84317, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8467
- val_loss: 3.8432
Epoch 82/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8465
Epoch 00082: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8463
- val_loss: 3.8446
Epoch 83/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8460
Epoch 00083: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8462
- val_loss: 3.8449
Epoch 84/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8461
```

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Epoch 00084: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8464
- val_loss: 3.8452
Epoch 85/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8459
Epoch 00085: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8463
- val_loss: 3.8438
Epoch 86/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8467
Epoch 00086: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8465
- val_loss: 3.8446
Epoch 87/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8461
Epoch 00087: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8461
- val_loss: 3.8432
Epoch 88/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8461
Epoch 00088: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8461
- val_loss: 3.8450
Epoch 89/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8462
Epoch 00089: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8461
- val_loss: 3.8434
Epoch 90/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8460
Epoch 00090: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8460
- val_loss: 3.8495
Epoch 91/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8457
Epoch 00091: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8459
- val_loss: 3.8432
Epoch 92/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8457
Epoch 00092: val_loss did not improve from 3.84317
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8459
- val_loss: 3.8449
Epoch 93/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8461
Epoch 00093: val_loss improved from 3.84317 to 3.84304, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8459
```

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- val_loss: 3.8430
Epoch 94/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8460
Epoch 00094: val_loss did not improve from 3.84304
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8459
- val_loss: 3.8444
Epoch 95/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8458
Epoch 00095: val_loss did not improve from 3.84304
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8459
- val_loss: 3.8437
Epoch 96/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8459
Epoch 00096: val_loss did not improve from 3.84304
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8459
- val_loss: 3.8446
Epoch 97/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8458
Epoch 00097: val_loss did not improve from 3.84304
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8457
- val_loss: 3.8441
Epoch 98/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8456
Epoch 00098: val_loss did not improve from 3.84304
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8457
- val_loss: 3.8443
Epoch 99/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8460
Epoch 00099: val_loss did not improve from 3.84304
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8457
- val_loss: 3.8450
Epoch 100/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8458
Epoch 00100: val_loss did not improve from 3.84304
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8458
- val_loss: 3.8442
Epoch 101/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8457
Epoch 00101: val_loss did not improve from 3.84304
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8457
- val_loss: 3.8456
Epoch 102/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8453
Epoch 00102: val_loss did not improve from 3.84304
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8454
- val_loss: 3.8473
Epoch 103/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8458
```

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Epoch 00103: val_loss improved from 3.84304 to 3.84259, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8458
- val_loss: 3.8426
Epoch 104/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8457
Epoch 00104: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8456
- val_loss: 3.8449
Epoch 105/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8454
Epoch 00105: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8455
- val_loss: 3.8431
Epoch 106/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8455
Epoch 00106: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8456
- val_loss: 3.8472
Epoch 107/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8456
Epoch 00107: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8456
- val_loss: 3.8453
Epoch 108/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8455- ETA:
0s - loss: 3
Epoch 00108: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8456
- val_loss: 3.8441
Epoch 109/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8453
Epoch 00109: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8454
- val_loss: 3.8441
Epoch 110/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8454
Epoch 00110: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8454
- val_loss: 3.8428
Epoch 111/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8454
Epoch 00111: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8454
- val_loss: 3.8429
Epoch 112/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8455
Epoch 00112: val_loss did not improve from 3.84259
```

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2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8454
- val_loss: 3.8485
Epoch 113/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8453
Epoch 00113: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8453
- val_loss: 3.8460
Epoch 114/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8454
Epoch 00114: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8453
- val_loss: 3.8434
Epoch 115/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8453
Epoch 00115: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8452
- val_loss: 3.8432
Epoch 116/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8454
Epoch 00116: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8453
- val_loss: 3.8474
Epoch 117/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8451
Epoch 00117: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 12s 6us/sample - loss: 3.8452
- val_loss: 3.8430
Epoch 118/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8451
Epoch 00118: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8451
- val_loss: 3.8445
Epoch 119/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8453
Epoch 00119: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8453
- val_loss: 3.8446
Epoch 120/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8452
Epoch 00120: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8452
- val_loss: 3.8450
Epoch 121/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8450
Epoch 00121: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8451
- val_loss: 3.8429
Epoch 122/500
```

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2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8451
Epoch 00122: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8452
- val_loss: 3.8444
Epoch 123/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8451
Epoch 00123: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8452
- val_loss: 3.8435
Epoch 124/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8451
Epoch 00124: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8450
- val_loss: 3.8450
Epoch 125/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8453
Epoch 00125: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8452
- val_loss: 3.8453
Epoch 126/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8451
Epoch 00126: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8451
- val_loss: 3.8448
Epoch 127/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8449
Epoch 00127: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8450
- val_loss: 3.8441
Epoch 128/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8452
Epoch 00128: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8450
- val_loss: 3.8440
Epoch 129/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8453
Epoch 00129: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8452
- val_loss: 3.8427
Epoch 130/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8449
Epoch 00130: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8448
- val_loss: 3.8457
Epoch 131/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8450
Epoch 00131: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8450
```

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- val_loss: 3.8437
Epoch 132/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8448
Epoch 00132: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8448
- val_loss: 3.8446
Epoch 133/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8450
Epoch 00133: val_loss did not improve from 3.84259
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8450
- val_loss: 3.8432
Epoch 134/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8448
Epoch 00134: val_loss improved from 3.84259 to 3.84232, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8448
- val_loss: 3.8423
Epoch 135/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8449
Epoch 00135: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8449
- val_loss: 3.8427
Epoch 136/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8448
Epoch 00136: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8448
- val_loss: 3.8443
Epoch 137/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8449
Epoch 00137: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8447
- val_loss: 3.8425
Epoch 138/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8449
Epoch 00138: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8449
- val_loss: 3.8454
Epoch 139/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8450
Epoch 00139: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8450
- val_loss: 3.8432
Epoch 140/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8447
Epoch 00140: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8447
- val_loss: 3.8438
Epoch 141/500
```

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2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8447
Epoch 00141: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8446
- val_loss: 3.8432
Epoch 142/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8449
Epoch 00142: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8448
- val_loss: 3.8436
Epoch 143/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8449
Epoch 00143: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8447
- val_loss: 3.8469
Epoch 144/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8446
Epoch 00144: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8446
- val_loss: 3.8442
Epoch 145/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8449
Epoch 00145: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8447
- val_loss: 3.8436
Epoch 146/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8447
Epoch 00146: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8447
- val_loss: 3.8423
Epoch 147/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8447
Epoch 00147: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8445
- val_loss: 3.8447
Epoch 148/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8446
Epoch 00148: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8446
- val_loss: 3.8435
Epoch 149/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8445
Epoch 00149: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8446
- val_loss: 3.8425
Epoch 150/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8447
Epoch 00150: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8447
```

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- val_loss: 3.8435
Epoch 151/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8446- ETA:
0s - l
Epoch 00151: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8445
- val_loss: 3.8442
Epoch 152/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8445
Epoch 00152: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8445
- val_loss: 3.8443
Epoch 153/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8445
Epoch 00153: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8445
- val_loss: 3.8424
Epoch 154/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8444
Epoch 00154: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8444
- val_loss: 3.8433
Epoch 155/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8444
Epoch 00155: val_loss did not improve from 3.84232
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8444
- val_loss: 3.8432
Epoch 156/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8446
Epoch 00156: val_loss improved from 3.84232 to 3.84218, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8444
- val_loss: 3.8422
Epoch 157/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8445
Epoch 00157: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8444
- val_loss: 3.8433
Epoch 158/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8445
Epoch 00158: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8445
- val_loss: 3.8425
Epoch 159/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8444
Epoch 00159: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8444
- val_loss: 3.8430
```

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Epoch 160/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8443
Epoch 00160: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8444
- val_loss: 3.8424
Epoch 161/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8446
Epoch 00161: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8445
- val_loss: 3.8434
Epoch 162/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8447
Epoch 00162: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8443
- val_loss: 3.8428
Epoch 163/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00163: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8442
- val_loss: 3.8452
Epoch 164/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8443
Epoch 00164: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8443
- val_loss: 3.8424
Epoch 165/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8442
Epoch 00165: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8442
- val_loss: 3.8451
Epoch 166/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8442
Epoch 00166: val_loss did not improve from 3.84218
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8442
- val_loss: 3.8433
Epoch 167/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8442
Epoch 00167: val_loss improved from 3.84218 to 3.84211, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8442
- val_loss: 3.8421
Epoch 168/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8442
Epoch 00168: val_loss did not improve from 3.84211
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8443
- val_loss: 3.8425
Epoch 169/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8439
```

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Epoch 00169: val_loss did not improve from 3.84211
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8440
- val_loss: 3.8427
Epoch 170/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8443
Epoch 00170: val_loss did not improve from 3.84211
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8441
- val_loss: 3.8447
Epoch 171/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8441
Epoch 00171: val_loss improved from 3.84211 to 3.84176, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8441
- val_loss: 3.8418
Epoch 172/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00172: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8441
- val_loss: 3.8426
Epoch 173/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00173: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8441
- val_loss: 3.8440
Epoch 174/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00174: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8441
- val_loss: 3.8437
Epoch 175/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8443
Epoch 00175: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8442
- val_loss: 3.8442
Epoch 176/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8442
Epoch 00176: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8441
- val_loss: 3.8449
Epoch 177/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8442
Epoch 00177: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8441
- val_loss: 3.8430
Epoch 178/500
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00178: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8439
```

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- val_loss: 3.8430
Epoch 179/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8439
Epoch 00179: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8440
- val_loss: 3.8431
Epoch 180/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00180: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8440
- val_loss: 3.8436
Epoch 181/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8441
Epoch 00181: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8441
- val_loss: 3.8421
Epoch 182/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00182: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8440
- val_loss: 3.8426
Epoch 183/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8438
Epoch 00183: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8440
- val_loss: 3.8421
Epoch 184/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8439
Epoch 00184: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8439
- val_loss: 3.8425
Epoch 185/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00185: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8439
- val_loss: 3.8429
Epoch 186/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00186: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8438
- val_loss: 3.8429
Epoch 187/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8438
Epoch 00187: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8438
- val_loss: 3.8418
Epoch 188/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8439
```

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Epoch 00188: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8438
- val_loss: 3.8420
Epoch 189/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00189: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8439
- val_loss: 3.8429
Epoch 190/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00190: val_loss did not improve from 3.84176
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8440
- val_loss: 3.8425
Epoch 191/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00191: val_loss improved from 3.84176 to 3.84171, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8438
- val_loss: 3.8417
Epoch 192/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8436
Epoch 00192: val_loss did not improve from 3.84171
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8437
- val_loss: 3.8428
Epoch 193/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8440
Epoch 00193: val_loss did not improve from 3.84171
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8439
- val_loss: 3.8429
Epoch 194/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8441
Epoch 00194: val_loss improved from 3.84171 to 3.84165, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8440
- val_loss: 3.8416
Epoch 195/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00195: val_loss did not improve from 3.84165
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8438
- val_loss: 3.8433
Epoch 196/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8436
Epoch 00196: val_loss did not improve from 3.84165
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8438
- val_loss: 3.8420
Epoch 197/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8435
Epoch 00197: val_loss improved from 3.84165 to 3.84154, saving model to weights-
```

```
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8436
- val_loss: 3.8415
Epoch 198/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8436
Epoch 00198: val_loss did not improve from 3.84154
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8437
- val_loss: 3.8528
Epoch 199/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00199: val_loss did not improve from 3.84154
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8438
- val_loss: 3.8421
Epoch 200/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00200: val_loss did not improve from 3.84154
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8436
- val_loss: 3.8435
Epoch 201/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8436
Epoch 00201: val_loss did not improve from 3.84154
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8436
- val_loss: 3.8432
Epoch 202/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8434
Epoch 00202: val_loss did not improve from 3.84154
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8435
- val_loss: 3.8426
Epoch 203/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00203: val_loss did not improve from 3.84154
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8437
- val_loss: 3.8426
Epoch 204/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00204: val_loss did not improve from 3.84154
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8436
- val_loss: 3.8434
Epoch 205/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8435
Epoch 00205: val_loss did not improve from 3.84154
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8435
- val_loss: 3.8471
Epoch 206/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8437
Epoch 00206: val_loss improved from 3.84154 to 3.84140, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8436
```

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- val_loss: 3.8414
Epoch 207/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8434
Epoch 00207: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8436
- val_loss: 3.8423
Epoch 208/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8433
Epoch 00208: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8434
- val_loss: 3.8430
Epoch 209/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8434
Epoch 00209: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8434
- val_loss: 3.8416
Epoch 210/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8433
Epoch 00210: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8434
- val_loss: 3.8422
Epoch 211/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8435
Epoch 00211: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8434
- val_loss: 3.8421
Epoch 212/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00212: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8432
- val_loss: 3.8441
Epoch 213/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00213: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8432
- val_loss: 3.8427
Epoch 214/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8435
Epoch 00214: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8433
- val_loss: 3.8419
Epoch 215/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8434
Epoch 00215: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8432
- val_loss: 3.8428
Epoch 216/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8434
```

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Epoch 00216: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8433
- val_loss: 3.8428
Epoch 217/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00217: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8432
- val_loss: 3.8442
Epoch 218/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00218: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8431
- val_loss: 3.8451
Epoch 219/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00219: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8432
- val_loss: 3.8419
Epoch 220/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8433
Epoch 00220: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8431
- val_loss: 3.8424
Epoch 221/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00221: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8432
- val_loss: 3.8448
Epoch 222/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00222: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8430
- val_loss: 3.8439
Epoch 223/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00223: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8432
- val_loss: 3.8425
Epoch 224/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00224: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8431
- val_loss: 3.8446
Epoch 225/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00225: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8432
- val_loss: 3.8439
```

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Epoch 226/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00226: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8431
- val_loss: 3.8419
Epoch 227/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00227: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8430
- val_loss: 3.8418
Epoch 228/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00228: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8430
- val_loss: 3.8417
Epoch 229/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00229: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8430
- val_loss: 3.8437
Epoch 230/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8432
Epoch 00230: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8430
- val_loss: 3.8469
Epoch 231/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8433
Epoch 00231: val_loss did not improve from 3.84140
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8431
- val_loss: 3.8422
Epoch 232/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00232: val_loss improved from 3.84140 to 3.84106, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8430
- val_loss: 3.8411
Epoch 233/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00233: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8429
- val_loss: 3.8427
Epoch 234/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00234: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8429
- val_loss: 3.8425
Epoch 235/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8429
```

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Epoch 00235: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8428
- val_loss: 3.8432
Epoch 236/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00236: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8430
- val_loss: 3.8412
Epoch 237/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00237: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8428
- val_loss: 3.8427
Epoch 238/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00238: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8430
- val_loss: 3.8422
Epoch 239/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00239: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8429
- val_loss: 3.8413
Epoch 240/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00240: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8429
- val_loss: 3.8426
Epoch 241/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00241: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8428
- val_loss: 3.8413
Epoch 242/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00242: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8426
- val_loss: 3.8418
Epoch 243/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00243: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8428
- val_loss: 3.8426
Epoch 244/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00244: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8428
- val_loss: 3.8435
```

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Epoch 245/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8429
Epoch 00245: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8427
- val_loss: 3.8478
Epoch 246/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00246: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8427
- val_loss: 3.8419
Epoch 247/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00247: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8427
- val_loss: 3.8422
Epoch 248/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00248: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8428
- val_loss: 3.8436
Epoch 249/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00249: val_loss did not improve from 3.84106
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8428
- val_loss: 3.8415
Epoch 250/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00250: val_loss improved from 3.84106 to 3.84068, saving model to weights-
improvement-1.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8427
- val_loss: 3.8407
Epoch 251/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00251: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8426
- val_loss: 3.8488
Epoch 252/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00252: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8427
- val_loss: 3.8417
Epoch 253/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00253: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8427
- val_loss: 3.8417
Epoch 254/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8425
```

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Epoch 00254: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8425
- val_loss: 3.8424
Epoch 255/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00255: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8427
- val_loss: 3.8451
Epoch 256/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00256: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8428
- val_loss: 3.8408
Epoch 257/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00257: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8428
- val_loss: 3.8417
Epoch 258/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00258: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8426
- val_loss: 3.8432
Epoch 259/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00259: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8425
- val_loss: 3.8420
Epoch 260/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00260: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8425
- val_loss: 3.8416
Epoch 261/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00261: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8425
- val_loss: 3.8420
Epoch 262/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00262: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8425
- val_loss: 3.8424
Epoch 263/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00263: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8426
- val_loss: 3.8419
```
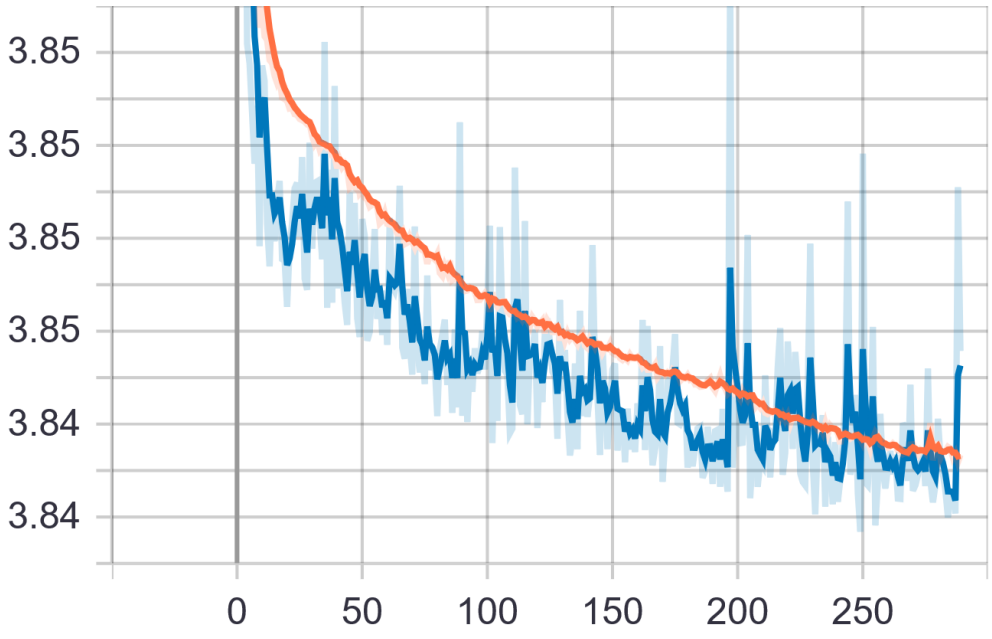

```
Epoch 264/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00264: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8425
- val_loss: 3.8423
Epoch 265/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00265: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8424
- val_loss: 3.8414
Epoch 266/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00266: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8424
- val_loss: 3.8414
Epoch 267/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00267: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8424
- val_loss: 3.8430
Epoch 268/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00268: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8424
- val_loss: 3.8429
Epoch 269/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8422
Epoch 00269: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8424
- val_loss: 3.8418
Epoch 270/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8430
Epoch 00270: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8426
- val_loss: 3.8438
Epoch 271/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8428
Epoch 00271: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8426
- val_loss: 3.8416
Epoch 272/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00272: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8424
- val_loss: 3.8417
Epoch 273/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00273: val_loss did not improve from 3.84068
```

```
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8424
- val_loss: 3.8419
Epoch 274/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00274: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8425
- val_loss: 3.8422
Epoch 275/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00275: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8424
- val_loss: 3.8424
Epoch 276/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00276: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8424
- val_loss: 3.8417
Epoch 277/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8427
Epoch 00277: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8426
- val_loss: 3.8442
Epoch 278/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8431
Epoch 00278: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8430
- val_loss: 3.8418
Epoch 279/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8422
Epoch 00279: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8422
- val_loss: 3.8413
Epoch 280/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00280: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8424
- val_loss: 3.8417
Epoch 281/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8426
Epoch 00281: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8426
- val_loss: 3.8431
Epoch 282/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00282: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8423
- val_loss: 3.8423
Epoch 283/500
```

```
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8422
Epoch 00283: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8424
- val_loss: 3.8419
Epoch 284/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00284: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8424
- val_loss: 3.8416
Epoch 285/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00285: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8425
- val_loss: 3.8410
Epoch 286/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8425
Epoch 00286: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8425
- val_loss: 3.8415
Epoch 287/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8423
Epoch 00287: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8423
- val_loss: 3.8415
Epoch 288/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00288: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8424
- val_loss: 3.8411
Epoch 289/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8424
Epoch 00289: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8422
- val_loss: 3.8481
Epoch 290/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8422
Epoch 00290: val_loss did not improve from 3.84068
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8423
- val_loss: 3.8446
Epoch 00290: early stopping
```



title

[111]:
```
#load model and predict
first_best_model = tf.keras.models.load_model('weights-improvement-1.hdf5')
test_pred_ratings = first_best_model.predict(np.
 ↪asarray(test_df_structured_scaled))
train_pred_ratings = first_best_model.predict(np.
 ↪asanyarray(train_df_structured_scaled))
```

[112]:
```
# i am getting ther error as: MemoryError: Unable to allocate array with shape␣
 ↪(1240908, 1240908) and data type float64
# while calculating NMAE
# this is happenning as numpy can't put so many float64 values to memory.
```

So lets try the python forloop way for calculating NMAE

[113]:
```
test_pred_ratings = test_pred_ratings.tolist()
train_pred_ratings = train_pred_ratings.tolist()
```

[114]:
```
test_pred_ratings_list = [i[0] for i in test_pred_ratings]
train_pred_ratings_list = [i[0] for i in train_pred_ratings]
```

[115]:
```
test_df_structured_target_list=test_df_structured_target.values
train_df_structured_target_list=train_df_structured_target.values
```

[116]:
```
test_df_structured_target_list = test_df_structured_target_list.tolist()
train_df_structured_target_list = train_df_structured_target_list.tolist()
```

[117]:
```
global_model_name['Second_NN']={
        "Test": nmae(test_pred_ratings_list,test_df_structured_target_list),
        "Train": nmae(train_pred_ratings_list,train_df_structured_target_list)
        }
```

```
print('Result of model')
print(global_model_name['Second_NN'])
```

```
Result of model
{'Test': 0.1493320631675459, 'Train': 0.18082728958955502}
```

This model has shown best performance till now.

1.1.4 6. Deep learning model 3

[141]:
```
import pandas as pd
from sklearn import preprocessing
min_max_scaler_X = preprocessing.MinMaxScaler()
train_df_structured_scaled = min_max_scaler_X.fit_transform(train_df_structured)
test_df_structured_scaled = min_max_scaler_X.transform(test_df_structured)
```

[153]:
```
pickle.dump(min_max_scaler_X, open("min_max_scaler_X.pickle","wb"))
```

[142]:
```
import tensorflow as tf
#define DL model
first_model = tf.keras.Sequential([
    tf.keras.layers.Dense(64, activation=tf.nn.relu, input_shape=[8]),
    tf.keras.layers.Dense(32, activation=tf.nn.relu),
    tf.keras.layers.Dropout(0.2),
    tf.keras.layers.Dense(16, activation=tf.nn.relu),
    tf.keras.layers.Dense(8, activation=tf.nn.relu),
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.Dense(4, activation=tf.nn.relu),
    tf.keras.layers.Dropout(0.2),
    tf.keras.layers.Dense(2, activation=tf.nn.relu),
    tf.keras.layers.Dense(1)
  ])
```

[144]:
```
#define call backs
filepath="weights-improvement-2.hdf5"
checkpoint = tf.keras.callbacks.ModelCheckpoint(filepath, monitor='val_loss',␣
 ↪verbose=1, save_best_only=True, mode='min')
tbCallBack = tf.keras.callbacks.TensorBoard(log_dir='./logs',profile_batch =␣
 ↪100000002)
es = tf.keras.callbacks.EarlyStopping(monitor='val_loss', mode='min',␣
 ↪verbose=1, patience=40)
callbacks=[checkpoint,tbCallBack,es]
```

[145]:
```
if os.path.isfile('weights-improvement-2.hdf5'):
    pass
else:
    #define optimizer and train model
    optimizer = tf.keras.optimizers.Adam()
    first_model.compile(loss='mean_absolute_error',optimizer=optimizer)
```

```
    first_model.fit(np.asarray(train_df_structured_scaled),np.
↪asarray(train_df_structured_target),epochs=500,batch_size=512,validation_split=0.
↪3,callbacks=callbacks)
```

```
Train on 2026816 samples, validate on 868636 samples
Epoch 1/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 4.1534
Epoch 00001: val_loss improved from inf to 3.96076, saving model to weights-
improvement-2.hdf5
2026816/2026816 [==============================] - 16s 8us/sample - loss: 4.1527
- val_loss: 3.9608
Epoch 2/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.9451
Epoch 00002: val_loss improved from 3.96076 to 3.89359, saving model to weights-
improvement-2.hdf5
2026816/2026816 [==============================] - 15s 7us/sample - loss: 3.9450
- val_loss: 3.8936
Epoch 3/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.9202
Epoch 00003: val_loss did not improve from 3.89359
2026816/2026816 [==============================] - 15s 7us/sample - loss: 3.9202
- val_loss: 3.9050
Epoch 4/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.9177
Epoch 00004: val_loss did not improve from 3.89359
2026816/2026816 [==============================] - 15s 7us/sample - loss: 3.9177
- val_loss: 3.9101
Epoch 5/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.9152
Epoch 00005: val_loss did not improve from 3.89359
2026816/2026816 [==============================] - 15s 7us/sample - loss: 3.9153
- val_loss: 3.9476
Epoch 6/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.9137
Epoch 00006: val_loss improved from 3.89359 to 3.89012, saving model to weights-
improvement-2.hdf5
2026816/2026816 [==============================] - 15s 7us/sample - loss: 3.9137
- val_loss: 3.8901
Epoch 7/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.9144
Epoch 00007: val_loss did not improve from 3.89012
2026816/2026816 [==============================] - 15s 7us/sample - loss: 3.9145
- val_loss: 3.8963
Epoch 8/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.9130
Epoch 00008: val_loss did not improve from 3.89012
2026816/2026816 [==============================] - 15s 8us/sample - loss: 3.9131
```

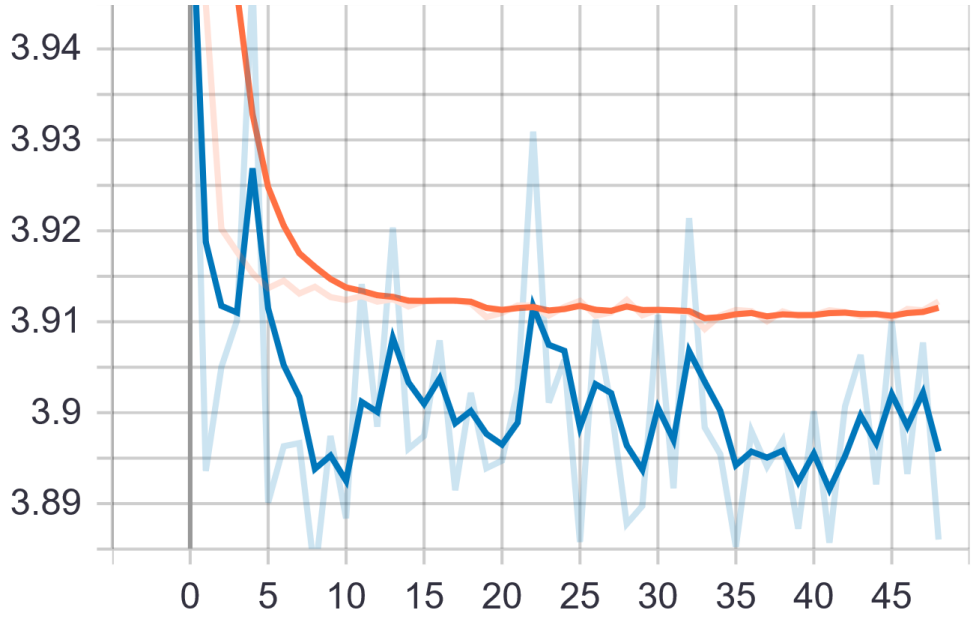
```
- val_loss: 3.8967
Epoch 9/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.9138
Epoch 00009: val_loss improved from 3.89012 to 3.88214, saving model to weights-
improvement-2.hdf5
2026816/2026816 [==============================] - 15s 8us/sample - loss: 3.9138
- val_loss: 3.8821
Epoch 10/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.9128
Epoch 00010: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 14s 7us/sample - loss: 3.9127
- val_loss: 3.8974
Epoch 11/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.9125
Epoch 00011: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 14s 7us/sample - loss: 3.9124
- val_loss: 3.8884
Epoch 12/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.9128
Epoch 00012: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 15s 7us/sample - loss: 3.9128
- val_loss: 3.9142
Epoch 13/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.9124
Epoch 00013: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 15s 7us/sample - loss: 3.9122
- val_loss: 3.8985
Epoch 14/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.9126
Epoch 00014: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 15s 7us/sample - loss: 3.9125
- val_loss: 3.9204
Epoch 15/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.9118
Epoch 00015: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 15s 8us/sample - loss: 3.9117
- val_loss: 3.8960
Epoch 16/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.9123
Epoch 00016: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 16s 8us/sample - loss: 3.9123
- val_loss: 3.8974
Epoch 17/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.9123
Epoch 00017: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 39s 19us/sample - loss:
3.9124 - val_loss: 3.9080
Epoch 18/500
```

```
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.9123
Epoch 00018: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9123 - val_loss: 3.8915
Epoch 19/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.9121
Epoch 00019: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9120 - val_loss: 3.9022
Epoch 20/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.9105
Epoch 00020: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9105 - val_loss: 3.8939
Epoch 21/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.9111
Epoch 00021: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9110 - val_loss: 3.8947
Epoch 22/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.9119
Epoch 00022: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9118 - val_loss: 3.9025
Epoch 23/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.9119
Epoch 00023: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9118 - val_loss: 3.9309
Epoch 24/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.9108
Epoch 00024: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9107 - val_loss: 3.9011
Epoch 25/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.9115
Epoch 00025: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9116 - val_loss: 3.9058
Epoch 26/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.9123
Epoch 00026: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9123 - val_loss: 3.8858
Epoch 27/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.9107
Epoch 00027: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
```

```
3.9107 - val_loss: 3.9102
Epoch 28/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.9110
Epoch 00028: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9110 - val_loss: 3.9007
Epoch 29/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.9126
Epoch 00029: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9124 - val_loss: 3.8878
Epoch 30/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.9107
Epoch 00030: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9107 - val_loss: 3.8897
Epoch 31/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.9114
Epoch 00031: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9113 - val_loss: 3.9108
Epoch 32/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.9112
Epoch 00032: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9112 - val_loss: 3.8917
Epoch 33/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.9111
Epoch 00033: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9111 - val_loss: 3.9214
Epoch 34/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.9092
Epoch 00034: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9092 - val_loss: 3.8984
Epoch 35/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.9107
Epoch 00035: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9107 - val_loss: 3.8954
Epoch 36/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.9114
Epoch 00036: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9113 - val_loss: 3.8852
Epoch 37/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.9112
```

```
Epoch 00037: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 23s 11us/sample - loss:
3.9112 - val_loss: 3.8980
Epoch 38/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.9100
Epoch 00038: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 22s 11us/sample - loss:
3.9100 - val_loss: 3.8941
Epoch 39/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.9112
Epoch 00039: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9111 - val_loss: 3.8969
Epoch 40/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.9107
Epoch 00040: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9106 - val_loss: 3.8872
Epoch 41/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.9106
Epoch 00041: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9107 - val_loss: 3.9002
Epoch 42/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.9112
Epoch 00042: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9113 - val_loss: 3.8857
Epoch 43/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.9113
Epoch 00043: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9111 - val_loss: 3.9007
Epoch 44/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.9106
Epoch 00044: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9106 - val_loss: 3.9064
Epoch 45/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.9108
Epoch 00045: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9108 - val_loss: 3.8921
Epoch 46/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.9104
Epoch 00046: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 20s 10us/sample - loss:
3.9104 - val_loss: 3.9101
```

```
Epoch 47/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.9114
Epoch 00047: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9114 - val_loss: 3.8933
Epoch 48/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.9112
Epoch 00048: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9113 - val_loss: 3.9077
Epoch 49/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.9123
Epoch 00049: val_loss did not improve from 3.88214
2026816/2026816 [==============================] - 21s 10us/sample - loss:
3.9122 - val_loss: 3.8860
Epoch 00049: early stopping
```



title

[146]:
```
#load model and predict
first_best_model = tf.keras.models.load_model('weights-improvement-2.hdf5')
test_pred_ratings = first_best_model.predict(np.
 ↪asarray(test_df_structured_scaled))
train_pred_ratings = first_best_model.predict(np.
 ↪asarray(train_df_structured_scaled))
```

[147]:
```
test_pred_ratings = test_pred_ratings.tolist()
train_pred_ratings = train_pred_ratings.tolist()
```

[148]:
```
test_pred_ratings_list = [i[0] for i in test_pred_ratings]
train_pred_ratings_list = [i[0] for i in train_pred_ratings]
```

[149]:
```
test_df_structured_target_list=test_df_structured_target.values
train_df_structured_target_list=train_df_structured_target.values
```

[150]:
```
test_df_structured_target_list = test_df_structured_target_list.tolist()
train_df_structured_target_list = train_df_structured_target_list.tolist()
```

[151]:
```
global_model_name['Third_NN']={
        "Test": nmae(test_pred_ratings_list,test_df_structured_target_list),
        "Train": nmae(train_pred_ratings_list,train_df_structured_target_list)
        }
print('Result of model')
print(global_model_name['Third_NN'])
```

```
Result of model
{'Test': 0.3205020373401373, 'Train': 0.31207603380814686}
```

As this model was having less variance of data using Dropout backfired.
As this model was having less number of deep layers using BatchNormalization backfired

1.1.5 Lets try one model with allsimple features

1.1.6 6. Deep learning model 4

[156]:
```
train_df_structured_simple =␣
 ↪train_df_structured[['user_avg','joke_avg','special_feature','gavg']]
test_df_structured_simple =␣
 ↪test_df_structured[['user_avg','joke_avg','special_feature','gavg']]
```

[159]:
```
import pandas as pd
from sklearn import preprocessing
min_max_scaler_X_simple = preprocessing.MinMaxScaler()
train_df_structured_simple_scaled = min_max_scaler_X.
 ↪fit_transform(train_df_structured_simple)
test_df_structured_simple_scaled = min_max_scaler_X.
 ↪transform(test_df_structured_simple)
```

[160]:
```
pickle.dump(min_max_scaler_X_simple, open("min_max_scaler_X_simple.
 ↪pickle","wb"))
```

[163]:
```
import tensorflow as tf
#define DL model
first_model = tf.keras.Sequential([
    tf.keras.layers.Dense(16, activation=tf.nn.relu, input_shape=[4]),
    tf.keras.layers.Dense(8, activation=tf.nn.relu),
    tf.keras.layers.Dense(4, activation=tf.nn.relu),
    tf.keras.layers.Dense(2, activation=tf.nn.relu),
    tf.keras.layers.Dense(1)
```

```
])
```

[164]:
```
#define call backs
filepath="weights-improvement-3.hdf5"
checkpoint = tf.keras.callbacks.ModelCheckpoint(filepath, monitor='val_loss',␣
↪verbose=1, save_best_only=True, mode='min')
tbCallBack = tf.keras.callbacks.TensorBoard(log_dir='./logs',profile_batch =␣
↪100000003)
es = tf.keras.callbacks.EarlyStopping(monitor='val_loss', mode='min',␣
↪verbose=1, patience=40)
callbacks=[checkpoint,tbCallBack,es]
```

[165]:
```
if os.path.isfile('weights-improvement-3.hdf5'):
    pass
else:
    #define optimizer and train model
    optimizer = tf.keras.optimizers.Adam()
    first_model.compile(loss='mean_absolute_error',optimizer=optimizer)
    first_model.fit(np.asarray(train_df_structured_simple_scaled),np.
↪asarray(train_df_structured_target),epochs=500,batch_size=512,validation_split=0.
↪3,callbacks=callbacks)
```

```
Train on 2026816 samples, validate on 868636 samples
Epoch 1/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.9094
Epoch 00001: val_loss improved from inf to 3.85266, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 12s 6us/sample - loss: 3.9091
- val_loss: 3.8527
Epoch 2/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8561
Epoch 00002: val_loss did not improve from 3.85266
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8560
- val_loss: 3.8530
Epoch 3/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8550
Epoch 00003: val_loss improved from 3.85266 to 3.85072, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8549
- val_loss: 3.8507
Epoch 4/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8550
Epoch 00004: val_loss did not improve from 3.85072
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8549
- val_loss: 3.8523
Epoch 5/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8543
Epoch 00005: val_loss improved from 3.85072 to 3.85045, saving model to weights-
```

```
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8542
- val_loss: 3.8505
Epoch 6/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8538
Epoch 00006: val_loss did not improve from 3.85045
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8540
- val_loss: 3.8512
Epoch 7/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8538
Epoch 00007: val_loss did not improve from 3.85045
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8538
- val_loss: 3.8603
Epoch 8/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8538
Epoch 00008: val_loss did not improve from 3.85045
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8539
- val_loss: 3.8539
Epoch 9/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8535
Epoch 00009: val_loss did not improve from 3.85045
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8535
- val_loss: 3.8586
Epoch 10/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8535
Epoch 00010: val_loss improved from 3.85045 to 3.84906, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8536
- val_loss: 3.8491
Epoch 11/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8534
Epoch 00011: val_loss did not improve from 3.84906
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8534
- val_loss: 3.8495
Epoch 12/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8536
Epoch 00012: val_loss did not improve from 3.84906
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8535
- val_loss: 3.8578
Epoch 13/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8535
Epoch 00013: val_loss did not improve from 3.84906
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8535
- val_loss: 3.8530
Epoch 14/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8533
Epoch 00014: val_loss did not improve from 3.84906
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8531
```

```
- val_loss: 3.8501
Epoch 15/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8533
Epoch 00015: val_loss did not improve from 3.84906
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8533
- val_loss: 3.8497
Epoch 16/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8534
Epoch 00016: val_loss did not improve from 3.84906
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8531
- val_loss: 3.8491
Epoch 17/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8529
Epoch 00017: val_loss did not improve from 3.84906
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8529
- val_loss: 3.8492
Epoch 18/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8529
Epoch 00018: val_loss did not improve from 3.84906
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8529
- val_loss: 3.8501
Epoch 19/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8518
Epoch 00019: val_loss improved from 3.84906 to 3.84781, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8517
- val_loss: 3.8478
Epoch 20/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8510
Epoch 00020: val_loss improved from 3.84781 to 3.84722, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8510
- val_loss: 3.8472
Epoch 21/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8506
Epoch 00021: val_loss did not improve from 3.84722
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8508
- val_loss: 3.8486
Epoch 22/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8505
Epoch 00022: val_loss improved from 3.84722 to 3.84720, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8506
- val_loss: 3.8472
Epoch 23/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8505
Epoch 00023: val_loss did not improve from 3.84720
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8505
```

```
- val_loss: 3.8487
Epoch 24/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8502
Epoch 00024: val_loss did not improve from 3.84720
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8504
- val_loss: 3.8511
Epoch 25/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8504
Epoch 00025: val_loss improved from 3.84720 to 3.84707, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8504
- val_loss: 3.8471
Epoch 26/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8503
Epoch 00026: val_loss did not improve from 3.84707
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8503
- val_loss: 3.8503
Epoch 27/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8505
Epoch 00027: val_loss improved from 3.84707 to 3.84663, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8505
- val_loss: 3.8466
Epoch 28/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8498
Epoch 00028: val_loss did not improve from 3.84663
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8501
- val_loss: 3.8485
Epoch 29/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8501
Epoch 00029: val_loss improved from 3.84663 to 3.84651, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8502
- val_loss: 3.8465
Epoch 30/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8502
Epoch 00030: val_loss did not improve from 3.84651
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8502
- val_loss: 3.8472
Epoch 31/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8500
Epoch 00031: val_loss did not improve from 3.84651
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8502
- val_loss: 3.8480
Epoch 32/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8503
Epoch 00032: val_loss did not improve from 3.84651
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8503
```

```
- val_loss: 3.8467
Epoch 33/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8501
Epoch 00033: val_loss did not improve from 3.84651
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8501
- val_loss: 3.8490
Epoch 34/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8500
Epoch 00034: val_loss improved from 3.84651 to 3.84649, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8500
- val_loss: 3.8465
Epoch 35/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8499
Epoch 00035: val_loss did not improve from 3.84649
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8499
- val_loss: 3.8538
Epoch 36/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8500
Epoch 00036: val_loss did not improve from 3.84649
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8499
- val_loss: 3.8490
Epoch 37/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8497
Epoch 00037: val_loss did not improve from 3.84649
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8497
- val_loss: 3.8474
Epoch 38/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00038: val_loss did not improve from 3.84649
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8497
- val_loss: 3.8506
Epoch 39/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8496
Epoch 00039: val_loss improved from 3.84649 to 3.84641, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8496
- val_loss: 3.8464
Epoch 40/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00040: val_loss improved from 3.84641 to 3.84619, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8497
- val_loss: 3.8462
Epoch 41/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8496
Epoch 00041: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8497
```

```
- val_loss: 3.8472
Epoch 42/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00042: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8496
- val_loss: 3.8464
Epoch 43/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00043: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8496
- val_loss: 3.8500
Epoch 44/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00044: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8496
- val_loss: 3.8467
Epoch 45/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00045: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8496
- val_loss: 3.8477
Epoch 46/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8496
Epoch 00046: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8495
- val_loss: 3.8512
Epoch 47/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00047: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8495
- val_loss: 3.8547
Epoch 48/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8496
Epoch 00048: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8494
- val_loss: 3.8481
Epoch 49/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8497
Epoch 00049: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8497
- val_loss: 3.8465
Epoch 50/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00050: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8494
- val_loss: 3.8477
Epoch 51/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8494
```

```
Epoch 00051: val_loss did not improve from 3.84619
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8494
- val_loss: 3.8468
Epoch 52/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00052: val_loss improved from 3.84619 to 3.84612, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8495
- val_loss: 3.8461
Epoch 53/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00053: val_loss did not improve from 3.84612
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8494
- val_loss: 3.8471
Epoch 54/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8496
Epoch 00054: val_loss did not improve from 3.84612
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8495
- val_loss: 3.8472
Epoch 55/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8495
Epoch 00055: val_loss did not improve from 3.84612
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8495
- val_loss: 3.8468
Epoch 56/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00056: val_loss did not improve from 3.84612
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8493
- val_loss: 3.8506
Epoch 57/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8493
Epoch 00057: val_loss did not improve from 3.84612
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8494
- val_loss: 3.8462
Epoch 58/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8493
Epoch 00058: val_loss did not improve from 3.84612
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8493
- val_loss: 3.8467
Epoch 59/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8493
Epoch 00059: val_loss improved from 3.84612 to 3.84607, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8461
Epoch 60/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8493
Epoch 00060: val_loss did not improve from 3.84607
```

```
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8494
- val_loss: 3.8466
Epoch 61/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8493
Epoch 00061: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8493
- val_loss: 3.8462
Epoch 62/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00062: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8477
Epoch 63/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00063: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8493
- val_loss: 3.8467
Epoch 64/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8493
Epoch 00064: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8494
- val_loss: 3.8472
Epoch 65/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00065: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8465
Epoch 66/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00066: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8491
- val_loss: 3.8462
Epoch 67/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8493
Epoch 00067: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8503
Epoch 68/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8494
Epoch 00068: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8493
- val_loss: 3.8461
Epoch 69/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00069: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8468
Epoch 70/500
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2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00070: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8462
Epoch 71/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00071: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8465
Epoch 72/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00072: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8491
- val_loss: 3.8464
Epoch 73/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8491
Epoch 00073: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8463
Epoch 74/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00074: val_loss did not improve from 3.84607
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8491
- val_loss: 3.8465
Epoch 75/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00075: val_loss improved from 3.84607 to 3.84606, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8461
Epoch 76/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00076: val_loss did not improve from 3.84606
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8491
- val_loss: 3.8486
Epoch 77/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00077: val_loss did not improve from 3.84606
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8491
- val_loss: 3.8472
Epoch 78/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00078: val_loss did not improve from 3.84606
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8462
Epoch 79/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00079: val_loss did not improve from 3.84606
```

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2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8472
Epoch 80/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00080: val_loss did not improve from 3.84606
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8492
- val_loss: 3.8463
Epoch 81/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8491
Epoch 00081: val_loss did not improve from 3.84606
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8491
- val_loss: 3.8462
Epoch 82/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00082: val_loss improved from 3.84606 to 3.84601, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8491
- val_loss: 3.8460
Epoch 83/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00083: val_loss did not improve from 3.84601
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8461
Epoch 84/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8491
Epoch 00084: val_loss did not improve from 3.84601
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8490
Epoch 85/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00085: val_loss did not improve from 3.84601
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8510
Epoch 86/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8491
Epoch 00086: val_loss did not improve from 3.84601
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8474
Epoch 87/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00087: val_loss did not improve from 3.84601
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8468
Epoch 88/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00088: val_loss did not improve from 3.84601
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8465
```

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Epoch 89/500
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8492
Epoch 00089: val_loss did not improve from 3.84601
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8491
- val_loss: 3.8472
Epoch 90/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00090: val_loss did not improve from 3.84601
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8462
Epoch 91/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00091: val_loss improved from 3.84601 to 3.84583, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8458
Epoch 92/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00092: val_loss did not improve from 3.84583
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8463
Epoch 93/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00093: val_loss improved from 3.84583 to 3.84583, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8458
Epoch 94/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00094: val_loss did not improve from 3.84583
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8461
Epoch 95/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00095: val_loss did not improve from 3.84583
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8473
Epoch 96/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00096: val_loss did not improve from 3.84583
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8490
- val_loss: 3.8461
Epoch 97/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00097: val_loss did not improve from 3.84583
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8464
Epoch 98/500
```

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2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00098: val_loss did not improve from 3.84583
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8499
Epoch 99/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00099: val_loss did not improve from 3.84583
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8465
Epoch 100/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00100: val_loss improved from 3.84583 to 3.84572, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8457
Epoch 101/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00101: val_loss did not improve from 3.84572
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8461
Epoch 102/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00102: val_loss did not improve from 3.84572
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8459
Epoch 103/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8489
Epoch 00103: val_loss did not improve from 3.84572
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8463
Epoch 104/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00104: val_loss improved from 3.84572 to 3.84554, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8455
Epoch 105/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00105: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8487
- val_loss: 3.8469
Epoch 106/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00106: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8468
Epoch 107/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8488
```

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Epoch 00107: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8473
Epoch 108/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8490
Epoch 00108: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8489
- val_loss: 3.8460
Epoch 109/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8488
Epoch 00109: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8463
Epoch 110/500
2022400/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00110: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8487
- val_loss: 3.8463
Epoch 111/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00111: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8488
- val_loss: 3.8460
Epoch 112/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00112: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8487
- val_loss: 3.8462
Epoch 113/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00113: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8487
- val_loss: 3.8456
Epoch 114/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00114: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8487
- val_loss: 3.8458
Epoch 115/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00115: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8487
- val_loss: 3.8458
Epoch 116/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00116: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8486
- val_loss: 3.8462
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Epoch 117/500
2021376/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00117: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8487
- val_loss: 3.8467
Epoch 118/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00118: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8476
Epoch 119/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00119: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8486
- val_loss: 3.8532
Epoch 120/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00120: val_loss did not improve from 3.84554
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8486
- val_loss: 3.8460
Epoch 121/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00121: val_loss improved from 3.84554 to 3.84547, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8487
- val_loss: 3.8455
Epoch 122/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00122: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8486
- val_loss: 3.8456
Epoch 123/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00123: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8486
- val_loss: 3.8465
Epoch 124/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00124: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8487
- val_loss: 3.8455
Epoch 125/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00125: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8458
Epoch 126/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8486
```

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Epoch 00126: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8486
- val_loss: 3.8456
Epoch 127/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00127: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8470
Epoch 128/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00128: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8472
Epoch 129/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00129: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8460
Epoch 130/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00130: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8460
Epoch 131/500
2017792/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00131: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8465
Epoch 132/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00132: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8464
Epoch 133/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00133: val_loss did not improve from 3.84547
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8486
- val_loss: 3.8488
Epoch 134/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00134: val_loss improved from 3.84547 to 3.84540, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8454
Epoch 135/500
2026496/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00135: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
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- val_loss: 3.8457
Epoch 136/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00136: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8461
Epoch 137/500
2015744/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00137: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8470
Epoch 138/500
2019328/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00138: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8465
Epoch 139/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00139: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8458
Epoch 140/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00140: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8455
Epoch 141/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8482
Epoch 00141: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8457
Epoch 142/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00142: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8456
Epoch 143/500
2018304/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00143: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8481
Epoch 144/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00144: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8456
Epoch 145/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8482
```

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Epoch 00145: val_loss did not improve from 3.84540
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8454
Epoch 146/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00146: val_loss improved from 3.84540 to 3.84525, saving model to weights-
improvement-3.hdf5
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8452
Epoch 147/500
2015232/2026816 [============================>.] - ETA: 0s - loss: 3.8487
Epoch 00147: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8472
Epoch 148/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8482
Epoch 00148: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8457
Epoch 149/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00149: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8525
Epoch 150/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00150: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8453
Epoch 151/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00151: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8454
Epoch 152/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00152: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8463
Epoch 153/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00153: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8462
Epoch 154/500
2024960/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00154: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
```
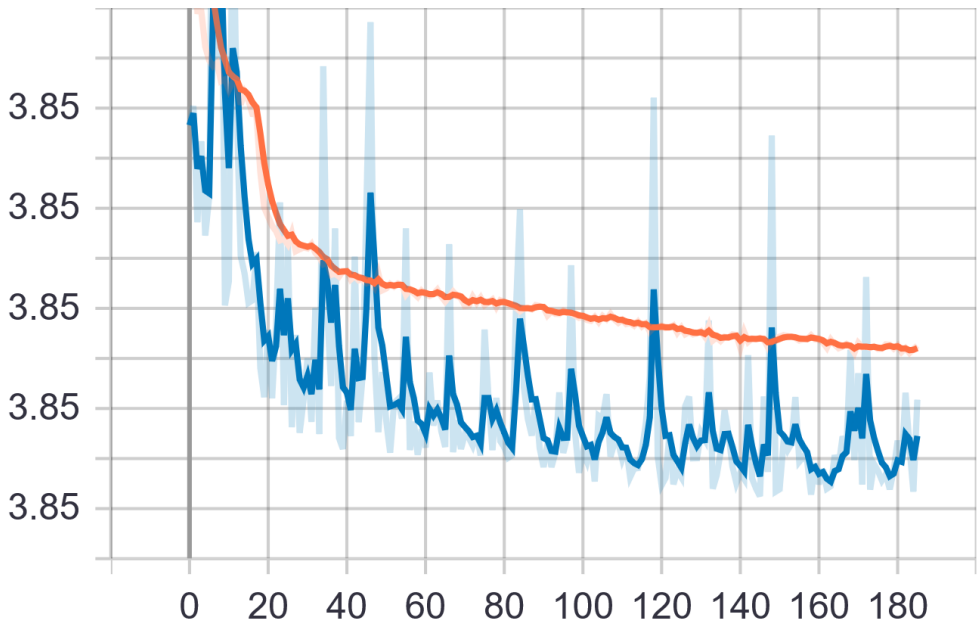

```
- val_loss: 3.8463
Epoch 155/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00155: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8472
Epoch 156/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00156: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8459
Epoch 157/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00157: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8460
Epoch 158/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00158: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8459
Epoch 159/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8486
Epoch 00159: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8485
- val_loss: 3.8453
Epoch 160/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8485
Epoch 00160: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8459
Epoch 161/500
2025472/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00161: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8455
Epoch 162/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00162: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8458
Epoch 163/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8482
Epoch 00163: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8454
Epoch 164/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8484
```

```
Epoch 00164: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8484
- val_loss: 3.8455
Epoch 165/500
2018816/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00165: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8461
Epoch 166/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8484
Epoch 00166: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8458
Epoch 167/500
2017280/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00167: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8464
Epoch 168/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00168: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8462
Epoch 169/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8482
Epoch 00169: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8482
Epoch 170/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00170: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8481
- val_loss: 3.8460
Epoch 171/500
2014720/2026816 [============================>.] - ETA: 0s - loss: 3.8479
Epoch 00171: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8477
Epoch 172/500
2023936/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00172: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8455
Epoch 173/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8482
Epoch 00173: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8496
```

```
Epoch 174/500
2020352/2026816 [============================>.] - ETA: 0s - loss: 3.8480
Epoch 00174: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8454
Epoch 175/500
2024448/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00175: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8459
Epoch 176/500
2019840/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00176: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8458
Epoch 177/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00177: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8456
Epoch 178/500
2022912/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00178: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8457
Epoch 179/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00179: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8454
Epoch 180/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00180: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8458
Epoch 181/500
2020864/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00181: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8483
- val_loss: 3.8464
Epoch 182/500
2023424/2026816 [============================>.] - ETA: 0s - loss: 3.8480
Epoch 00182: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8481
- val_loss: 3.8459
Epoch 183/500
2021888/2026816 [============================>.] - ETA: 0s - loss: 3.8482
Epoch 00183: val_loss did not improve from 3.84525
```

```
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8473
Epoch 184/500
2016256/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00184: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8481
- val_loss: 3.8462
Epoch 185/500
2025984/2026816 [============================>.] - ETA: 0s - loss: 3.8481
Epoch 00185: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 5us/sample - loss: 3.8482
- val_loss: 3.8453
Epoch 186/500
2016768/2026816 [============================>.] - ETA: 0s - loss: 3.8483
Epoch 00186: val_loss did not improve from 3.84525
2026816/2026816 [==============================] - 11s 6us/sample - loss: 3.8483
- val_loss: 3.8472
Epoch 00186: early stopping
```



title

[168]:
```
#load model and predict
first_best_model = tf.keras.models.load_model('weights-improvement-3.hdf5')
test_pred_ratings = first_best_model.predict(np.
 ↪asarray(test_df_structured_simple_scaled))
train_pred_ratings = first_best_model.predict(np.
 ↪asarray(train_df_structured_simple_scaled))
```

[169]:
```
test_pred_ratings = test_pred_ratings.tolist()
train_pred_ratings = train_pred_ratings.tolist()
```

[170]:
```
test_pred_ratings_list = [i[0] for i in test_pred_ratings]
train_pred_ratings_list = [i[0] for i in train_pred_ratings]
```

[171]:
```
test_df_structured_target_list=test_df_structured_target.values
train_df_structured_target_list=train_df_structured_target.values
```

[172]:
```
test_df_structured_target_list = test_df_structured_target_list.tolist()
train_df_structured_target_list = train_df_structured_target_list.tolist()
```

[173]:
```
global_model_name['Fourth_NN']={
        "Test": nmae(test_pred_ratings_list,test_df_structured_target_list),
        "Train": nmae(train_pred_ratings_list,train_df_structured_target_list)
        }
print('Result of model')
print(global_model_name['Fourth_NN'])
```

```
Result of model
{'Test': 0.19761617961530226, 'Train': 0.19061504214534597}
```

Though this model dont have 14.9 % NMAE it has very similar accuracy both in train and test similar to First NN

1.1.7 7 Results of ML models

[174]:
```
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Model", "Trin error", "Test error"]
for i in global_model_name:
    x.add_row([ i , global_model_name[i]['Train'] ,␣
 ↪global_model_name[i]['Test']])
x.border=True
print(x)
```

```
+------------------+---------------------+---------------------+
|      Model       |      Trin error     |      Test error     |
+------------------+---------------------+---------------------+
|     Baseline     | 0.20336702289913602 | 0.20505297177649737 |
| KnnBaseline_joke |  0.1825198921435078 | 0.19609971106367624 |
|    First_XGB     |  0.217233447214206  | 0.19280766965994262 |
|       SVD        | 0.17327865608074278 | 0.21539326049482735 |
|    Second_XGB    |  0.2174202221795477 | 0.18833252907421943 |
|  First_XGB_FE_1  | 0.22321715705636846 | 0.20289328398328535 |
|  First_XGB_FE_2  | 0.22556924102141873 | 0.20872101921358918 |
|    Second_NN     | 0.18082728958955502 |  0.1493320631675459 |
|     First_NN     | 0.19275586777667447 | 0.19394950246246248 |
```

Third_NN	0.31207603380814686	0.3205020373401373
Fourth_NN	0.19061504214534597	0.19761617961530226

As we can see the Second_NN model is the best model with NMAE as 14.9 percentage.