Kaggle_1

September 13, 2021

[2]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import hvplot.pandas
%matplotlib inline
```

[3]:
```
housing_dataset = pd.read_csv("/home/ai/Downloads/Datasets/USA_Housing.csv")
```

[4]:
```
housing_dataset.info()
```

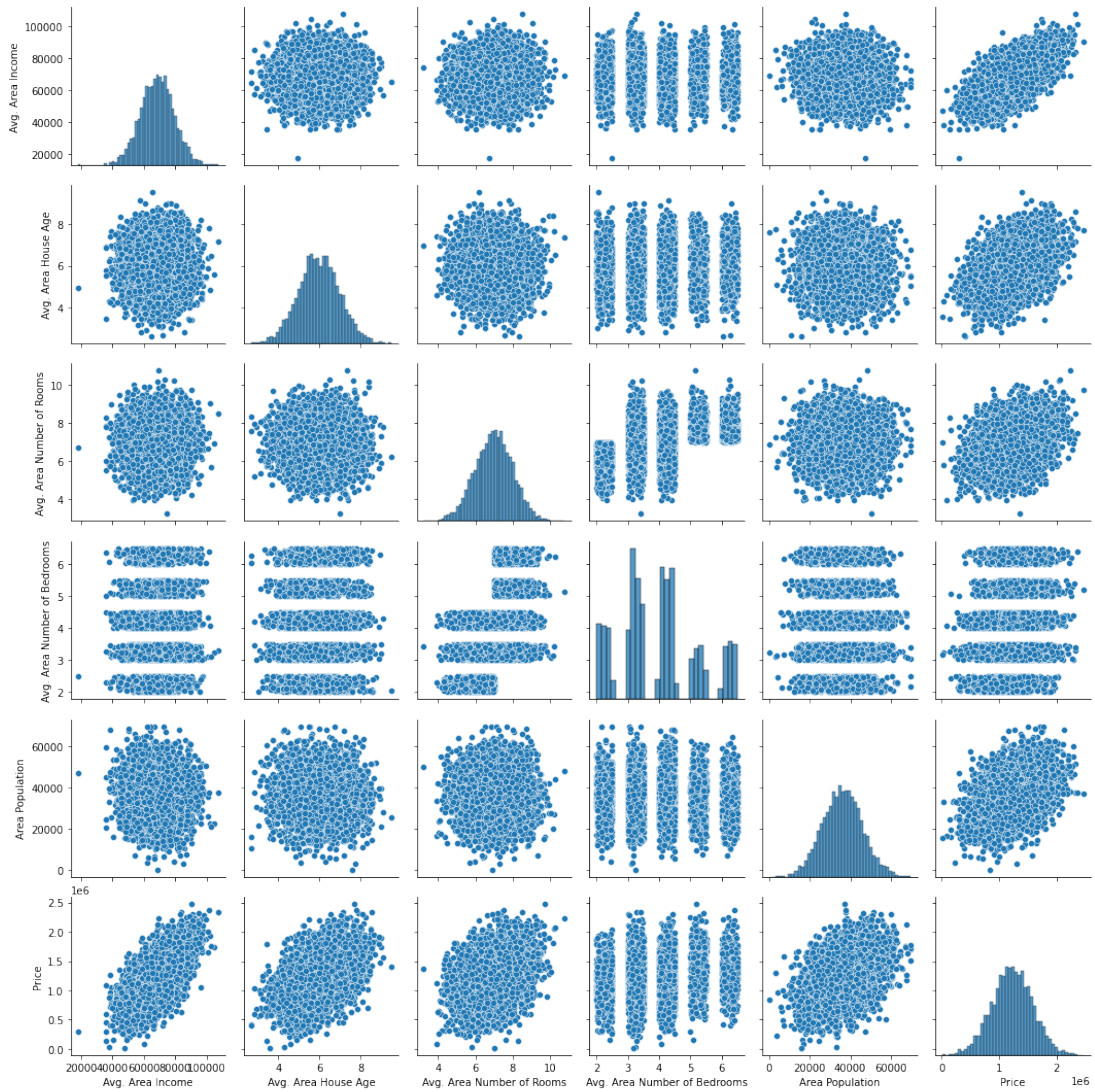
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 7 columns):
 #   Column                        Non-Null Count  Dtype
---  ------                        --------------  -----
 0   Avg. Area Income              5000 non-null   float64
 1   Avg. Area House Age           5000 non-null   float64
 2   Avg. Area Number of Rooms     5000 non-null   float64
 3   Avg. Area Number of Bedrooms  5000 non-null   float64
 4   Area Population               5000 non-null   float64
 5   Price                         5000 non-null   float64
 6   Address                       5000 non-null   object
dtypes: float64(6), object(1)
memory usage: 273.6+ KB
```

[5]:
```
housing_dataset.columns
```

[5]:
```
Index(['Avg. Area Income', 'Avg. Area House Age', 'Avg. Area Number of Rooms',
       'Avg. Area Number of Bedrooms', 'Area Population', 'Price', 'Address'],
      dtype='object')
```

[6]:
```
sns.pairplot(housing_dataset)
```

[6]:
```
<seaborn.axisgrid.PairGrid at 0x7f250465c9d0>
```



[7]:
```
housing_dataset.hvplot.hist(by='Price', subplots=False, width=1000)
```

[7]:
```
:NdOverlay   [Element]
   :Histogram   [Area Population]   (Area Population_count)
```

[8]:
```
housing_dataset.hvplot.hist("Price")
```

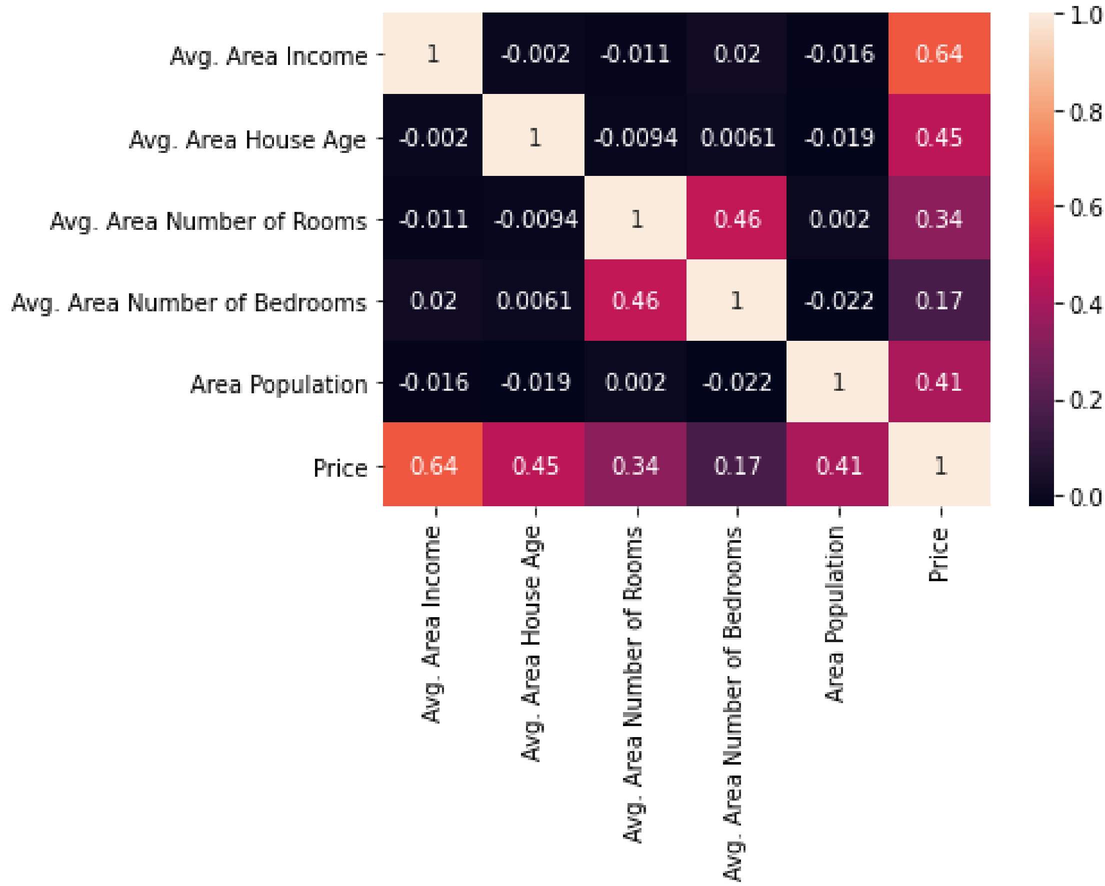
[8]:
```
:Histogram   [Price]   (Price_count)
```

[9]:
```
housing_dataset.hvplot.scatter(x='Avg. Area House Age', y = 'Price')
```

[9]:
```
:Scatter   [Avg. Area House Age]   (Price)
```

[10]:
```
sns.heatmap(housing_dataset.corr(), annot=True)
```

[10]: <matplotlib.axes._subplots.AxesSubplot at 0x7f2500bdc1d0>



[11]:
```
X = housing_dataset.iloc[:, 0:5]
y = housing_dataset.iloc[:, 5:6]
len(X)
```

[11]: 5000

[12]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.25, )
```

[13]:
```
from sklearn import metrics
from sklearn.model_selection import cross_val_score

def cross_val(model):
    pred = cross_val_score(model, X, y, cv=10)
```

```
    return pred.mean()

def print_evaluate(true, predicted):
    mae = metrics.mean_absolute_error(true, predicted)
    mse = metrics.mean_squared_error(true, predicted)
    rmse = np.sqrt(metrics.mean_squared_error(true, predicted))
    r2_square = metrics.r2_score(true, predicted)
    print('MAE:', mae)
    print('MSE:', mse)
    print('RMSE:', rmse)
    print('R2 Square', r2_square)
    print('__________________________________')

def evaluate(true, predicted):
    mae = metrics.mean_absolute_error(true, predicted)
    mse = metrics.mean_squared_error(true, predicted)
    rmse = np.sqrt(metrics.mean_squared_error(true, predicted))
    r2_square = metrics.r2_score(true, predicted)
    return mae, mse, rmse, r2_square
```

[14]:
```
from sklearn.preprocessing import StandardScaler
from sklearn.pipeline import Pipeline

pipeline = Pipeline([
    ('std_scalar', StandardScaler())
])

X_train = pipeline.fit_transform(X_train)
X_test = pipeline.transform(X_test)
```

[15]:
```
from sklearn.linear_model import LinearRegression

lin_reg = LinearRegression(normalize=True)
lin_reg.fit(X_train, y_train)
```

[15]:
```
LinearRegression(normalize=True)
```

[16]:
```
print(lin_reg.intercept_)
```

```
[1233555.4251904]
```

[17]:
```
from collections import Iterable
def flatten(lis):
     for item in lis:
            if isinstance(item, Iterable) and not isinstance(item, str):
                for x in flatten(item):
                    yield x
```

```
        else:
            yield item
```

```
/home/ai/anaconda3/envs/gputest/lib/python3.7/site-
packages/ipykernel_launcher.py:1: DeprecationWarning: Using or importing the
ABCs from 'collections' instead of from 'collections.abc' is deprecated since
Python 3.3,and in 3.9 it will stop working
  """Entry point for launching an IPython kernel.
```

[20]:

```
pd.DataFrame( list(flatten(lin_reg.coef_)), X.columns, columns=['Coefficient'])
```

[20]:

	Coefficient
Avg. Area Income	231500.026152
Avg. Area House Age	163269.456192
Avg. Area Number of Rooms	121568.596453
Avg. Area Number of Bedrooms	1751.847967
Area Population	151653.388548

[21]:

```
pred = lin_reg.predict(X_test)
```

[39]:

```
type(y_test)
```

[39]:

```
pandas.core.frame.DataFrame
```

[50]:

```
y_test.values.tolist()
```

[50]:

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```

[53]:
```
pd.DataFrame({'True Values': list(flatten(y_test))})
```

[53]:

	True Values
0	Price

[54]:
```
pd.DataFrame({'True Values': y_test.values.tolist(), 'Predicted Values':␣
↪list(flatten(pred))}).hvplot.scatter(
    x='True Values', y='Predicted Values')
```

[54]:
```
:Scatter   [True Values]   (Predicted Values)
```

[58]:
```
sol = np.array(y_test.values.tolist()) - np.array(list(flatten(pred)))
```

[60]:
```
sol
```

[60]:
```
array([[ 1.08256340e+04, -8.63986249e+05, -4.60225345e+05, …,
        -4.80311513e+05, -3.71033963e+05, -9.04158878e+05],
       [ 9.14621721e+05,  3.98098381e+04,  4.43570742e+05, …,
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         8.62997240e+04,  1.95577274e+05, -3.37547641e+05],
       …,
       [ 4.65514514e+05, -4.09297368e+05, -5.53646415e+03, …,
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```

[62]:
```
pd.DataFrame({'Error Values': list(flatten(sol))}).hvplot.kde()
```

[62]:
```
:Distribution   [Error Values]   (Density)
```

[63]:
```
test_pred = lin_reg.predict(X_test)
train_pred = lin_reg.predict(X_train)

print('Test set evaluation:\n_____________________________________')
print_evaluate(y_test, test_pred)
print('Train set evaluation:\n_____________________________________')
print_evaluate(y_train, train_pred)
```

```
Test set evaluation:
_____________________________________
MAE: 81528.47728239739
MSE: 10022058835.578112
RMSE: 100110.23342085519
R2 Square 0.9219960572792769
__________________________________
Train set evaluation:
_____________________________________
MAE: 81322.83077092048
MSE: 10294345335.798096
```

```
RMSE: 101461.05329533148
R2 Square 0.9165685616082142
__________________________________
```

[64]:
```
results_df = pd.DataFrame(data=[["Linear Regression", *evaluate(y_test,␣
↪test_pred) , cross_val(LinearRegression())]],
                          columns=['Model', 'MAE', 'MSE', 'RMSE', 'R2 Square',␣
↪"Cross Validation"])
results_df
```

[64]:
```
               Model           MAE           MSE           RMSE  R2 Square  \
0  Linear Regression  81528.477282  1.002206e+10  100110.233421   0.921996

   Cross Validation
0          0.917379
```

[65]:
```
from sklearn.linear_model import RANSACRegressor

model = RANSACRegressor(base_estimator=LinearRegression(), max_trials=100)
model.fit(X_train, y_train)

test_pred = model.predict(X_test)
train_pred = model.predict(X_train)

print('Test set evaluation:\n_____________________________________')
print_evaluate(y_test, test_pred)
print('====================================')
print('Train set evaluation:\n_____________________________________')
print_evaluate(y_train, train_pred)
```

```
Test set evaluation:
_____________________________________
MAE: 84290.81855671547
MSE: 10750719912.971506
RMSE: 103685.67843714727
R2 Square 0.9163247238859785
__________________________________
====================================
Train set evaluation:
_____________________________________
MAE: 82822.92967306884
MSE: 10759679098.102133
RMSE: 103728.87302049575
R2 Square 0.9127972226978824
__________________________________
```

[66]:
```
results_df_2 = pd.DataFrame(data=[["Robust Regression", *evaluate(y_test,␣
↪test_pred) , cross_val(RANSACRegressor())]],
                            columns=['Model', 'MAE', 'MSE', 'RMSE', 'R2␣
↪Square', "Cross Validation"])
results_df = results_df.append(results_df_2, ignore_index=True)
results_df
```

[66]:
```
               Model           MAE           MSE           RMSE  R2 Square  \
0  Linear Regression  81528.477282  1.002206e+10  100110.233421   0.921996
1  Robust Regression  84290.818557  1.075072e+10  103685.678437   0.916325

   Cross Validation
0          0.917379
1          0.909424
```

[67]:
```
from sklearn.linear_model import Ridge

model = Ridge(alpha=100, solver='cholesky', tol=0.0001, random_state=42)
model.fit(X_train, y_train)
pred = model.predict(X_test)

test_pred = model.predict(X_test)
train_pred = model.predict(X_train)

print('Test set evaluation:\n_____________________________________')
print_evaluate(y_test, test_pred)
print('====================================')
print('Train set evaluation:\n_____________________________________')
print_evaluate(y_train, train_pred)
```

```
Test set evaluation:
_____________________________________
MAE: 82021.38350548885
MSE: 10092519264.127617
RMSE: 100461.53126509479
R2 Square 0.9214476478832812
__________________________________
====================================
Train set evaluation:
_____________________________________
MAE: 81686.58642106052
MSE: 10379940489.376337
RMSE: 101881.9929593858
R2 Square 0.9158748480645695
__________________________________
```

[68]:
```
results_df_2 = pd.DataFrame(data=[["Ridge Regression", *evaluate(y_test,␣
↪test_pred) , cross_val(Ridge())]],
                            columns=['Model', 'MAE', 'MSE', 'RMSE', 'R2␣
↪Square', "Cross Validation"])
results_df = results_df.append(results_df_2, ignore_index=True)
results_df
```

[68]:
```
               Model           MAE           MSE           RMSE  R2 Square  \
0  Linear Regression  81528.477282  1.002206e+10  100110.233421   0.921996
1  Robust Regression  84290.818557  1.075072e+10  103685.678437   0.916325
2   Ridge Regression  82021.383505  1.009252e+10  100461.531265   0.921448

   Cross Validation
0          0.917379
1          0.909424
2          0.917379
```

[69]:
```
from sklearn.preprocessing import PolynomialFeatures

poly_reg = PolynomialFeatures(degree=2)

X_train_2_d = poly_reg.fit_transform(X_train)
X_test_2_d = poly_reg.transform(X_test)

lin_reg = LinearRegression(normalize=True)
lin_reg.fit(X_train_2_d,y_train)

test_pred = lin_reg.predict(X_test_2_d)
train_pred = lin_reg.predict(X_train_2_d)

print('Test set evaluation:\n_____________________________________')
print_evaluate(y_test, test_pred)
print('====================================')
print('Train set evaluation:\n_____________________________________')
print_evaluate(y_train, train_pred)
```

```
Test set evaluation:
_____________________________________
MAE: 81487.593488941
MSE: 10034501727.806126
RMSE: 100172.36009901197
R2 Square 0.9218992114446477
__________________________________
====================================
Train set evaluation:
_____________________________________
MAE: 81148.95768250916
```

```
MSE: 10268693780.678932
RMSE: 101334.56360333788
R2 Square 0.9167764569207151
__________________________________
```

[70]:

```
results_df_2 = pd.DataFrame(data=[["Polynomail Regression", *evaluate(y_test,␣
↪test_pred), 0]],
                            columns=['Model', 'MAE', 'MSE', 'RMSE', 'R2␣
↪Square', 'Cross Validation'])
results_df = results_df.append(results_df_2, ignore_index=True)
results_df
```

[70]:

```
                   Model           MAE           MSE           RMSE  \
0      Linear Regression  81528.477282  1.002206e+10  100110.233421
1      Robust Regression  84290.818557  1.075072e+10  103685.678437
2       Ridge Regression  82021.383505  1.009252e+10  100461.531265
3  Polynomail Regression  81487.593489  1.003450e+10  100172.360099

   R2 Square  Cross Validation
0   0.921996          0.917379
1   0.916325          0.909424
2   0.921448          0.917379
3   0.921899          0.000000
```

[71]:

```
from sklearn.linear_model import SGDRegressor

sgd_reg = SGDRegressor(n_iter_no_change=250, penalty=None, eta0=0.0001,␣
↪max_iter=100000)
sgd_reg.fit(X_train, y_train)

test_pred = sgd_reg.predict(X_test)
train_pred = sgd_reg.predict(X_train)

print('Test set evaluation:\n_____________________________________')
print_evaluate(y_test, test_pred)
print('====================================')
print('Train set evaluation:\n_____________________________________')
print_evaluate(y_train, train_pred)
```

```
/home/ai/anaconda3/envs/gputest/lib/python3.7/site-
packages/sklearn/utils/validation.py:73: DataConversionWarning: A column-vector
y was passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
  return f(**kwargs)

Test set evaluation:
_____________________________________
MAE: 81528.48983509491
```

```
MSE: 10022061953.013712
RMSE: 100110.24899086863
R2 Square 0.921996033015573
__________________________________
====================================
Train set evaluation:
_____________________________________
MAE: 81322.82658669332
MSE: 10294345335.953741
RMSE: 101461.0532960985
R2 Square 0.9165685616069528
__________________________________
```

[72]:
```
results_df_2 = pd.DataFrame(data=[["Stochastic Gradient Descent",␣
↪*evaluate(y_test, test_pred), 0]],
                            columns=['Model', 'MAE', 'MSE', 'RMSE', 'R2␣
↪Square', 'Cross Validation'])
results_df = results_df.append(results_df_2, ignore_index=True)
results_df
```

[72]:
```
                         Model           MAE           MSE           RMSE  \
0            Linear Regression  81528.477282  1.002206e+10  100110.233421
1            Robust Regression  84290.818557  1.075072e+10  103685.678437
2             Ridge Regression  82021.383505  1.009252e+10  100461.531265
3         Polynomail Regression  81487.593489  1.003450e+10  100172.360099
4  Stochastic Gradient Descent  81528.489835  1.002206e+10  100110.248991

   R2 Square  Cross Validation
0   0.921996          0.917379
1   0.916325          0.909424
2   0.921448          0.917379
3   0.921899          0.000000
4   0.921996          0.000000
```

[73]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Input, Dense, Activation, Dropout
from tensorflow.keras.optimizers import Adam

X_train = np.array(X_train)
X_test = np.array(X_test)
y_train = np.array(y_train)
y_test = np.array(y_test)

model = Sequential()

model.add(Dense(X_train.shape[1], activation='relu'))
model.add(Dense(32, activation='relu'))
```

```
# model.add(Dropout(0.2))

model.add(Dense(64, activation='relu'))
# model.add(Dropout(0.2))

model.add(Dense(128, activation='relu'))
# model.add(Dropout(0.2))

model.add(Dense(512, activation='relu'))
model.add(Dropout(0.1))
model.add(Dense(1))

model.compile(optimizer=Adam(0.00001), loss='mse')

r = model.fit(X_train, y_train,
              validation_data=(X_test,y_test),
              batch_size=1,
              epochs=100)
```

```
Train on 3750 samples, validate on 1250 samples
Epoch 1/100
3750/3750 [==============================] - 9s 2ms/sample - loss:
1645011221832.2261 - val_loss: 1635384633501.4656
Epoch 2/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
1644111549819.5627 - val_loss: 1633159231935.6160
Epoch 3/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
1638650176479.2319 - val_loss: 1623126614041.7505
Epoch 4/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
1620233921620.1045 - val_loss: 1594027084268.1597
Epoch 5/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
1573934456872.4138 - val_loss: 1527222060114.8416
Epoch 6/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
1478568384204.1003 - val_loss: 1399156169318.6047
Epoch 7/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
1309945184051.1357 - val_loss: 1186604432128.3250
Epoch 8/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
1052174057382.0272 - val_loss: 888430125329.8519
Epoch 9/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
730868955302.6221 - val_loss: 565682944134.4716
```

```
Epoch 10/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
443362301239.5915 - val_loss: 346021754450.4661
Epoch 11/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
299598334345.9880 - val_loss: 275694459083.8212
Epoch 12/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
256707490892.1989 - val_loss: 251676776451.4203
Epoch 13/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
235936299151.4466 - val_loss: 234089969815.4346
Epoch 14/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
218921184426.8048 - val_loss: 218126958755.2028
Epoch 15/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
202971857334.3851 - val_loss: 203065281108.7159
Epoch 16/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
188627786744.3731 - val_loss: 188981114039.9154
Epoch 17/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
175087413838.6863 - val_loss: 175599196753.7520
Epoch 18/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
161834531938.6763 - val_loss: 163210906024.5396
Epoch 19/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
150567285921.6369 - val_loss: 151586497766.2021
Epoch 20/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
139585740740.3875 - val_loss: 140853718683.2468
Epoch 21/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
129219562361.1924 - val_loss: 130660716589.5126
Epoch 22/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
119487003620.8424 - val_loss: 121397918948.7557
Epoch 23/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
110820460034.8183 - val_loss: 112653657045.3199
Epoch 24/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
102589478501.4527 - val_loss: 104726786007.7076
Epoch 25/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
94478156359.9436 - val_loss: 97359566155.2182
```

```
Epoch 26/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
88192120617.3756 - val_loss: 90450376649.7863
Epoch 27/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
81487903978.5276 - val_loss: 84266620714.8715
Epoch 28/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
76252296633.4162 - val_loss: 78631932733.6203
Epoch 29/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
70865929461.1983 - val_loss: 73675350831.1541
Epoch 30/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
66231786207.5985 - val_loss: 69020007161.7298
Epoch 31/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
62053427538.0887 - val_loss: 64943240686.6493
Epoch 32/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
58527162565.4326 - val_loss: 61211352908.7847
Epoch 33/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
54685520842.1915 - val_loss: 57924572476.0930
Epoch 34/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
51788048028.5576 - val_loss: 54826443894.9727
Epoch 35/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
49141897299.4021 - val_loss: 52152889104.7891
Epoch 36/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
47030143373.8252 - val_loss: 49884710491.7800
Epoch 37/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
44828391032.6391 - val_loss: 47666203067.0596
Epoch 38/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
43517051412.2218 - val_loss: 45750516540.9983
Epoch 39/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
41354103922.9317 - val_loss: 44135337877.3657
Epoch 40/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
40387154127.5639 - val_loss: 42661729031.7819
Epoch 41/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
39004337165.8222 - val_loss: 41248256377.0208
```

```
Epoch 42/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
37871480944.8369 - val_loss: 40078781181.7467
Epoch 43/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
36912247927.6783 - val_loss: 38874481436.7543
Epoch 44/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
35881446417.8559 - val_loss: 37821308395.8920
Epoch 45/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
35016261587.8102 - val_loss: 36876120546.9743
Epoch 46/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
34175345612.7916 - val_loss: 36009781886.0239
Epoch 47/100
3750/3750 [==============================] - 4s 1ms/sample - loss:
33297880993.2050 - val_loss: 35121148193.0421
Epoch 48/100
3750/3750 [==============================] - 4s 1ms/sample - loss:
32606556160.4551 - val_loss: 34306464200.6651
Epoch 49/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
32025618355.6080 - val_loss: 33617151192.9297
Epoch 50/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
31051855755.5010 - val_loss: 32869033189.1942
Epoch 51/100
3750/3750 [==============================] - 4s 1ms/sample - loss:
30610208864.4135 - val_loss: 32128095012.1506
Epoch 52/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
30001465354.1950 - val_loss: 31462279811.7975
Epoch 53/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
29555932365.0695 - val_loss: 30915481295.0542
Epoch 54/100
3750/3750 [==============================] - 4s 1ms/sample - loss:
28632349903.3767 - val_loss: 30289330782.2692
Epoch 55/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
28622110292.0116 - val_loss: 29723876044.4669
Epoch 56/100
3750/3750 [==============================] - 4s 1ms/sample - loss:
27950715939.2294 - val_loss: 29169539963.8105
Epoch 57/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
27433121418.1529 - val_loss: 28599910258.1587
```

```
Epoch 58/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
26917477115.8706 - val_loss: 28059722665.3292
Epoch 59/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
26439626483.7611 - val_loss: 27593364490.5045
Epoch 60/100
3750/3750 [==============================] - 4s 1ms/sample - loss:
26136182428.1467 - val_loss: 27059995997.6096
Epoch 61/100
3750/3750 [==============================] - 4s 1ms/sample - loss:
25579110730.6295 - val_loss: 26550143156.4183
Epoch 62/100
3750/3750 [==============================] - 4s 1ms/sample - loss:
25153242054.4432 - val_loss: 26243036570.4955
Epoch 63/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
24674340023.0935 - val_loss: 25784783137.4879
Epoch 64/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
24520607759.3302 - val_loss: 25250597357.8677
Epoch 65/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
24131140635.8410 - val_loss: 24886142117.1399
Epoch 66/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
23484612717.5341 - val_loss: 24519765866.2540
Epoch 67/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
23340953138.7429 - val_loss: 24060398297.5614
Epoch 68/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
22879659819.4470 - val_loss: 23690631303.1496
Epoch 69/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
22679756944.8186 - val_loss: 23322424558.2063
Epoch 70/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
22228570482.0951 - val_loss: 22972429783.7407
Epoch 71/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
22071594373.7687 - val_loss: 22681682113.0295
Epoch 72/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
21443544090.9248 - val_loss: 22335733000.9896
Epoch 73/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
21438727055.3090 - val_loss: 22027554742.1772
```

```
Epoch 74/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
21099365454.3829 - val_loss: 21698968507.3483
Epoch 75/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
20904163976.7863 - val_loss: 21437286991.3694
Epoch 76/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
20409710610.1618 - val_loss: 21167442120.6133
Epoch 77/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
20496735916.6194 - val_loss: 20922356915.3711
Epoch 78/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
20109176423.3906 - val_loss: 20648921624.0706
Epoch 79/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
19741266142.2567 - val_loss: 20378445395.6966
Epoch 80/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
19649727429.8518 - val_loss: 20140318040.4399
Epoch 81/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
19626618292.1871 - val_loss: 19890450867.4310
Epoch 82/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
19316079378.7028 - val_loss: 19658271751.2137
Epoch 83/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
18931874991.2881 - val_loss: 19409373402.4451
Epoch 84/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
18960815463.4678 - val_loss: 19181496279.5640
Epoch 85/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
18484176559.3801 - val_loss: 18956720865.4312
Epoch 86/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
18585703306.4921 - val_loss: 18748773853.8683
Epoch 87/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
18294984430.8272 - val_loss: 18594847227.8874
Epoch 88/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
18128920476.2852 - val_loss: 18415953266.3600
Epoch 89/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
18097334044.5695 - val_loss: 18215937396.1826
```

```
Epoch 90/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
17934898477.6272 - val_loss: 18124597981.6971
Epoch 91/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
17726429623.2591 - val_loss: 17939115067.6198
Epoch 92/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
17582098581.8906 - val_loss: 17730811276.8088
Epoch 93/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
17088822595.4930 - val_loss: 17564127314.6064
Epoch 94/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
17025575506.3072 - val_loss: 17351329460.5691
Epoch 95/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
16992228691.3439 - val_loss: 17248361139.7766
Epoch 96/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
16906260257.4238 - val_loss: 17100072629.8632
Epoch 97/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
16994846568.3757 - val_loss: 17009352127.3486
Epoch 98/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
16873500050.7127 - val_loss: 16841243958.8149
Epoch 99/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
16665831336.8889 - val_loss: 16639723686.5436
Epoch 100/100
3750/3750 [==============================] - 5s 1ms/sample - loss:
16402260027.3531 - val_loss: 16500752288.3134
```

[75]:
```
pd.DataFrame(r.history)
```

[75]:

	loss	val_loss
0	1.645011e+12	1.635385e+12
1	1.644112e+12	1.633159e+12
2	1.638650e+12	1.623127e+12
3	1.620234e+12	1.594027e+12
4	1.573934e+12	1.527222e+12
..	…	…
95	1.690626e+10	1.710007e+10
96	1.699485e+10	1.700935e+10
97	1.687350e+10	1.684124e+10
98	1.666583e+10	1.663972e+10

```
99  1.640226e+10  1.650075e+10

[100 rows x 2 columns]
```

[76]:

```
pd.DataFrame(r.history).hvplot.line(y=['loss', 'val_loss'])
```

[76]:

```
:NdOverlay   [Variable]
   :Curve   [index]   (value)
```