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May 12, 2022

1 Tuning Neural Networks with Normalization - Lab

1.1 Introduction

In this lab you'll build a neural network to perform a regression task.

It is worth noting that getting regression to work with neural networks can be comparatively difficult because the output is unbounded ($\hat{y}$ can technically range from $-\infty$ to $+\infty$), and the models are especially prone to exploding gradients. This issue makes a regression exercise the perfect learning case for tinkering with normalization and optimization strategies to ensure proper convergence!

1.2 Objectives

In this lab you will:

- Fit a neural network to normalized data
- Implement and observe the impact of various initialization techniques
- Implement and observe the impact of various optimization techniques

1.3 Load the data

First, run the following cell to import all the neccessary libraries and classes you will need in this lab.

[1]:
```
# Necessary libraries and classes
import numpy as np
import pandas as pd
from keras.models import Sequential
from keras import initializers
from keras import layers
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import mean_squared_error
from keras import optimizers
from sklearn.model_selection import train_test_split

import warnings
warnings.filterwarnings('ignore')
```

In this lab, you'll be working with the housing prices data you saw in an earlier section. However, we did a lot of preprocessing for you so you can focus on normalizing numeric features and building neural network models! The following preprocessing steps were taken (all the code can be found in the `data_preprocessing.ipynb` notebook in this repository):

- The data was split into the training, validate, and test sets
- All the missing values in numeric columns were replaced by the median of those columns
- All the missing values in catetgorical columns were replaced with the word 'missing'
- All the categorical columns were one-hot encoded

Run the following cells to import the train, validate, and test sets:

[2]:
```
# Load all numeric features
X_train_numeric = pd.read_csv('data/X_train_numeric.csv')
X_val_numeric = pd.read_csv('data/X_val_numeric.csv')
X_test_numeric = pd.read_csv('data/X_test_numeric.csv')

# Load all categorical features
X_train_cat = pd.read_csv('data/X_train_cat.csv')
X_val_cat = pd.read_csv('data/X_val_cat.csv')
X_test_cat = pd.read_csv('data/X_test_cat.csv')

# Load all targets
y_train = pd.read_csv('data/y_train.csv')
y_val = pd.read_csv('data/y_val.csv')
y_test = pd.read_csv('data/y_test.csv')
```

[3]:
```
# Combine all features
X_train = pd.concat([X_train_numeric, X_train_cat], axis=1)
X_val = pd.concat([X_val_numeric, X_val_cat], axis=1)
X_test = pd.concat([X_test_numeric, X_test_cat], axis=1)

# Number of features
n_features = X_train.shape[1]
```

As a refresher, preview the training data:

[4]:
```
# Preview the data
X_train.head()
```

[4]:
```
   MSSubClass  LotFrontage  LotArea  OverallQual  OverallCond  YearBuilt  \
0        80.0         69.0  21453.0          6.0          5.0     1969.0
1        60.0         79.0  12420.0          7.0          5.0     2001.0
2        20.0         75.0   9742.0          8.0          5.0     2002.0
3       120.0         39.0   5389.0          8.0          5.0     1995.0
4        60.0         85.0  11003.0         10.0          5.0     2008.0

   YearRemodAdd  MasVnrArea  BsmtFinSF1  BsmtFinSF2  …  SaleType_ConLw  \
0        1969.0         0.0       938.0         0.0  …             0.0
1        2001.0         0.0       666.0         0.0  …             0.0
2        2002.0       281.0         0.0         0.0  …             0.0
```

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3       1996.0        0.0       1180.0         0.0  …              0.0
4       2008.0      160.0        765.0         0.0  …              0.0

   SaleType_New  SaleType_Oth  SaleType_WD  SaleCondition_Abnorml  \
0           0.0           0.0          1.0                    0.0
1           0.0           0.0          1.0                    0.0
2           0.0           0.0          1.0                    0.0
3           0.0           0.0          1.0                    0.0
4           0.0           0.0          1.0                    0.0

   SaleCondition_AdjLand  SaleCondition_Alloca  SaleCondition_Family  \
0                    0.0                   0.0                   0.0
1                    0.0                   0.0                   0.0
2                    0.0                   0.0                   0.0
3                    0.0                   0.0                   0.0
4                    0.0                   0.0                   0.0

   SaleCondition_Normal  SaleCondition_Partial
0                   1.0                    0.0
1                   1.0                    0.0
2                   1.0                    0.0
3                   1.0                    0.0
4                   1.0                    0.0

[5 rows x 296 columns]
```

1.4 Build a Baseline Model

Building a naive baseline model to compare performance against is a helpful reference point. From there, you can then observe the impact of various tunning procedures which will iteratively improve your model. So, let's do just that!

In the cell below:

- Add an input layer with `n_features` units
- Add two hidden layers, one with 100 and the other with 50 units (make sure you use the `'relu'` activation function)
- Add an output layer with 1 unit and `'linear'` activation
- Compile and fit the model

[6]:
```
np.random.seed(123)
baseline_model = Sequential()

# Hidden layer with 100 units
baseline_model.add(layers.Dense(100,
                                activation = "relu",
                                input_shape = (X_train.shape[1],)))
```

```python
# Hidden layer with 50 units

baseline_model.add(layers.Dense(50, activation = "relu"))
# Output layer
baseline_model.add(layers.Dense(1, activation = "linear"))

# Compile the model
baseline_model.compile(optimizer='SGD',
                       loss='mse',
                       metrics=['mse'])

# Train the model
baseline_model.fit(X_train,
                   y_train,
                   batch_size=32,
                   epochs=150,
                   validation_data=(X_val, y_val))
```

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33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 137/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 138/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
```

```
val_loss: nan - val_mse: nan
Epoch 139/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 140/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 141/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 142/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 143/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 144/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 145/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 146/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 147/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 148/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 149/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 150/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
```

```
[6]: <tensorflow.python.keras.callbacks.History at 0x7ff1b7937370>
```

Notice this extremely problematic behavior: all the values for training and validation loss are "nan". This indicates that the algorithm did not converge. The first solution to this is to normalize the input. From there, if convergence is not achieved, normalizing the output may also be required.

1.5 Normalize the Input Data

It's now time to normalize the input data. In the cell below:

- Assign the column names of all numeric columns to `numeric_columns`
- Instantiate a `StandardScaler`
- Fit and transform `X_train_numeric`. Make sure you convert the result into a DataFrame (use `numeric_columns` as the column names)
- Transform validate and test sets (`X_val_numeric` and `X_test_numeric`), and convert these results into DataFrames as well
- Use the provided to combine the scaled numerical and categorical features

[9]:
```
# Numeric column names
numeric_columns = X_train_numeric.columns

# Instantiate StandardScaler
ss_X = StandardScaler()

# Fit and transform train data
X_train_scaled = pd.DataFrame(ss_X.fit_transform(X_train[numeric_columns]))

# Transform validate and test data
X_val_scaled  = pd.DataFrame(ss_X.transform(X_val[numeric_columns]))
X_test_scaled = pd.DataFrame(ss_X.transform(X_test[numeric_columns]))

# Combine the scaled numerical features and categorical features
X_train = pd.concat([X_train_scaled, X_train_cat], axis=1)
X_val = pd.concat([X_val_scaled, X_val_cat], axis=1)
X_test = pd.concat([X_test_scaled, X_test_cat], axis=1)
```

Now run the following cell to compile a neural network model (with the same architecture as before):

[10]:
```
# Model with all normalized inputs
np.random.seed(123)
normalized_input_model = Sequential()
normalized_input_model.add(layers.Dense(100, activation='relu',␣
 ↪input_shape=(n_features,)))
normalized_input_model.add(layers.Dense(50, activation='relu'))
normalized_input_model.add(layers.Dense(1, activation='linear'))

# Compile the model
normalized_input_model.compile(optimizer='SGD',
                               loss='mse',
                               metrics=['mse'])
```

In the cell below: - Train the `normalized_input_model` on normalized input (`X_train`) and output (`y_train`) - Set a batch size of 32 and train for 150 epochs - Specify the `validation_data` argument as `(X_val, y_val)`

[12]:
```
# Train the model
normalized_input_model.fit(X_train, y_train,
                           epochs = 150, batch_size = 32,
```

```
                                    validation_data = (X_val, y_val))
```

```
Epoch 1/150
33/33 [==============================] - 0s 4ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 2/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 3/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 4/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 5/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 6/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 7/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 8/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 9/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 10/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 11/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 12/150
33/33 [==============================] - 0s 2ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 13/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 14/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 15/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
```

```
Epoch 16/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 17/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 18/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 19/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 20/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 21/150
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val_loss: nan - val_mse: nan
Epoch 22/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 23/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 24/150
33/33 [==============================] - 0s 2ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 25/150
33/33 [==============================] - 0s 2ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 26/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 27/150
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val_loss: nan - val_mse: nan
Epoch 28/150
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val_loss: nan - val_mse: nan
Epoch 29/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 30/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 31/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
```

```
Epoch 32/150
33/33 [==============================] - 0s 2ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 33/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 34/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 35/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 36/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 37/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 38/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 39/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 40/150
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val_loss: nan - val_mse: nan
Epoch 41/150
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val_loss: nan - val_mse: nan
Epoch 42/150
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
Epoch 46/150
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val_loss: nan - val_mse: nan
Epoch 47/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
```

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Epoch 48/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 49/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 50/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
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Epoch 52/150
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
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Epoch 64/150
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Epoch 65/150
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val_loss: nan - val_mse: nan
Epoch 67/150
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
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Epoch 82/150
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
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Epoch 97/150
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val_loss: nan - val_mse: nan
Epoch 98/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 99/150
33/33 [==============================] - 0s 2ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 100/150
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val_loss: nan - val_mse: nan
Epoch 101/150
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val_loss: nan - val_mse: nan
Epoch 102/150
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val_loss: nan - val_mse: nan
Epoch 103/150
33/33 [==============================] - 0s 3ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 104/150
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
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val_loss: nan - val_mse: nan
Epoch 108/150
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val_loss: nan - val_mse: nan
Epoch 109/150
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val_loss: nan - val_mse: nan
Epoch 110/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 111/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
```

```
Epoch 112/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 113/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 114/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 115/150
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val_loss: nan - val_mse: nan
Epoch 116/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 117/150
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val_loss: nan - val_mse: nan
Epoch 118/150
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val_loss: nan - val_mse: nan
Epoch 119/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 120/150
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val_loss: nan - val_mse: nan
Epoch 121/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 122/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 123/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 124/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 125/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 126/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 127/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
```

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Epoch 128/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 129/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 130/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 131/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 132/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 133/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 134/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 135/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 136/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 137/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 138/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 139/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 140/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 141/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 142/150
33/33 [==============================] - 0s 2ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 143/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
```

```
Epoch 144/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 145/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 146/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 147/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 148/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 149/150
33/33 [==============================] - 0s 2ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
Epoch 150/150
33/33 [==============================] - 0s 1ms/step - loss: nan - mse: nan -
val_loss: nan - val_mse: nan
```

[12]:
```
<tensorflow.python.keras.callbacks.History at 0x7ff198d98fa0>
```

> ***Note that you still haven't achieved convergence! From here, it's time to normalize the output data.***

1.6 Normalizing the output

Again, use `StandardScaler()` to:

- Fit and transform `y_train`
- Transform `y_val` and `y_test`

[13]:
```python
# Instantiate StandardScaler
ss_y = StandardScaler()

# Fit and transform train labels
y_train_scaled = ss_y.fit_transform(y_train)

# Transform validate and test labels
y_val_scaled  = ss_y.transform(y_val)
y_test_scaled = ss_y.transform(y_test)
```

In the cell below: - Train the `normalized_model` on normalized input (`X_train`) and output (`y_train_scaled`) - Set a batch size of 32 and train for 150 epochs - Specify the `validation_data` as `(X_val, y_val_scaled)`

[14]:
```python
# Model with all normalized inputs and outputs
np.random.seed(123)
normalized_model = Sequential()
normalized_model.add(layers.Dense(100, activation='relu',␣
 ↪input_shape=(n_features,)))
normalized_model.add(layers.Dense(50, activation='relu'))
normalized_model.add(layers.Dense(1, activation='linear'))

# Compile the model
normalized_model.compile(optimizer='SGD',
                         loss='mse',
                         metrics=['mse'])

# Train the model

normalized_model.fit(X_train, y_train_scaled,
                     epochs = 150, batch_size = 32,
                     validation_data = (X_val, y_val_scaled))
```

```
Epoch 1/150
33/33 [==============================] - 0s 4ms/step - loss: 0.5117 - mse:
0.5117 - val_loss: 0.2658 - val_mse: 0.2658
Epoch 2/150
33/33 [==============================] - 0s 2ms/step - loss: 0.2252 - mse:
0.2252 - val_loss: 0.2162 - val_mse: 0.2162
Epoch 3/150
33/33 [==============================] - 0s 2ms/step - loss: 0.1920 - mse:
0.1920 - val_loss: 0.1976 - val_mse: 0.1976
Epoch 4/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1657 - mse:
0.1657 - val_loss: 0.1797 - val_mse: 0.1797
Epoch 5/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1510 - mse:
0.1510 - val_loss: 0.1756 - val_mse: 0.1756
Epoch 6/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1395 - mse:
0.1395 - val_loss: 0.1702 - val_mse: 0.1702
Epoch 7/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1260 - mse:
0.1260 - val_loss: 0.1651 - val_mse: 0.1651
Epoch 8/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1182 - mse:
0.1182 - val_loss: 0.1642 - val_mse: 0.1642
Epoch 9/150
33/33 [==============================] - 0s 2ms/step - loss: 0.1096 - mse:
0.1096 - val_loss: 0.1680 - val_mse: 0.1680
Epoch 10/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.1046 - mse:
0.1046 - val_loss: 0.1678 - val_mse: 0.1678
Epoch 11/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0979 - mse:
0.0979 - val_loss: 0.1652 - val_mse: 0.1652
Epoch 12/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0952 - mse:
0.0952 - val_loss: 0.1632 - val_mse: 0.1632
Epoch 13/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0860 - mse:
0.0860 - val_loss: 0.1667 - val_mse: 0.1667
Epoch 14/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0840 - mse:
0.0840 - val_loss: 0.1585 - val_mse: 0.1585
Epoch 15/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0810 - mse:
0.0810 - val_loss: 0.1627 - val_mse: 0.1627
Epoch 16/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0752 - mse:
0.0752 - val_loss: 0.1691 - val_mse: 0.1691
Epoch 17/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0747 - mse:
0.0747 - val_loss: 0.1664 - val_mse: 0.1664
Epoch 18/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0715 - mse:
0.0715 - val_loss: 0.1631 - val_mse: 0.1631
Epoch 19/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0696 - mse:
0.0696 - val_loss: 0.1663 - val_mse: 0.1663
Epoch 20/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0641 - mse:
0.0641 - val_loss: 0.1689 - val_mse: 0.1689
Epoch 21/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0638 - mse:
0.0638 - val_loss: 0.1697 - val_mse: 0.1697
Epoch 22/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0620 - mse:
0.0620 - val_loss: 0.1723 - val_mse: 0.1723
Epoch 23/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0595 - mse:
0.0595 - val_loss: 0.1733 - val_mse: 0.1733
Epoch 24/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0568 - mse:
0.0568 - val_loss: 0.1738 - val_mse: 0.1738
Epoch 25/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0550 - mse:
0.0550 - val_loss: 0.1732 - val_mse: 0.1732
Epoch 26/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0550 - mse:
0.0550 - val_loss: 0.1699 - val_mse: 0.1699
Epoch 27/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0516 - mse:
0.0516 - val_loss: 0.1828 - val_mse: 0.1828
Epoch 28/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0516 - mse:
0.0516 - val_loss: 0.1733 - val_mse: 0.1733
Epoch 29/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0497 - mse:
0.0497 - val_loss: 0.1757 - val_mse: 0.1757
Epoch 30/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0482 - mse:
0.0482 - val_loss: 0.1742 - val_mse: 0.1742
Epoch 31/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0473 - mse:
0.0473 - val_loss: 0.1745 - val_mse: 0.1745
Epoch 32/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0450 - mse:
0.0450 - val_loss: 0.1787 - val_mse: 0.1787
Epoch 33/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0446 - mse:
0.0446 - val_loss: 0.1783 - val_mse: 0.1783
Epoch 34/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0435 - mse:
0.0435 - val_loss: 0.1828 - val_mse: 0.1828
Epoch 35/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0422 - mse:
0.0422 - val_loss: 0.1789 - val_mse: 0.1789
Epoch 36/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0416 - mse:
0.0416 - val_loss: 0.1803 - val_mse: 0.1803
Epoch 37/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0389 - mse:
0.0389 - val_loss: 0.1816 - val_mse: 0.1816
Epoch 38/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0400 - mse:
0.0400 - val_loss: 0.1800 - val_mse: 0.1800
Epoch 39/150
33/33 [==============================] - 0s 3ms/step - loss: 0.0390 - mse:
0.0390 - val_loss: 0.1810 - val_mse: 0.1810
Epoch 40/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0385 - mse:
0.0385 - val_loss: 0.1817 - val_mse: 0.1817
Epoch 41/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0364 - mse:
0.0364 - val_loss: 0.1799 - val_mse: 0.1799
Epoch 42/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0362 - mse:
0.0362 - val_loss: 0.1815 - val_mse: 0.1815
Epoch 43/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0352 - mse:
0.0352 - val_loss: 0.1882 - val_mse: 0.1882
Epoch 44/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0344 - mse:
0.0344 - val_loss: 0.1827 - val_mse: 0.1827
Epoch 45/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0333 - mse:
0.0333 - val_loss: 0.1848 - val_mse: 0.1848
Epoch 46/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0334 - mse:
0.0334 - val_loss: 0.1829 - val_mse: 0.1829
Epoch 47/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0333 - mse:
0.0333 - val_loss: 0.1854 - val_mse: 0.1854
Epoch 48/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0320 - mse:
0.0320 - val_loss: 0.1838 - val_mse: 0.1838
Epoch 49/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0312 - mse:
0.0312 - val_loss: 0.1849 - val_mse: 0.1849
Epoch 50/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0309 - mse:
0.0309 - val_loss: 0.1841 - val_mse: 0.1841
Epoch 51/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0300 - mse:
0.0300 - val_loss: 0.1832 - val_mse: 0.1832
Epoch 52/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0296 - mse:
0.0296 - val_loss: 0.1860 - val_mse: 0.1860
Epoch 53/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0291 - mse:
0.0291 - val_loss: 0.1828 - val_mse: 0.1828
Epoch 54/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0295 - mse:
0.0295 - val_loss: 0.1866 - val_mse: 0.1866
Epoch 55/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0282 - mse:
0.0282 - val_loss: 0.1860 - val_mse: 0.1860
Epoch 56/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0276 - mse:
0.0276 - val_loss: 0.1859 - val_mse: 0.1859
Epoch 57/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0267 - mse:
0.0267 - val_loss: 0.1867 - val_mse: 0.1867
Epoch 58/150
```

```
33/33 [==============================] - 0s 3ms/step - loss: 0.0267 - mse:
0.0267 - val_loss: 0.1880 - val_mse: 0.1880
Epoch 59/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0263 - mse:
0.0263 - val_loss: 0.1892 - val_mse: 0.1892
Epoch 60/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0259 - mse:
0.0259 - val_loss: 0.1889 - val_mse: 0.1889
Epoch 61/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0254 - mse:
0.0254 - val_loss: 0.1858 - val_mse: 0.1858
Epoch 62/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0246 - mse:
0.0246 - val_loss: 0.1855 - val_mse: 0.1855
Epoch 63/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0244 - mse:
0.0244 - val_loss: 0.1887 - val_mse: 0.1887
Epoch 64/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0240 - mse:
0.0240 - val_loss: 0.1881 - val_mse: 0.1881
Epoch 65/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0241 - mse:
0.0241 - val_loss: 0.1865 - val_mse: 0.1865
Epoch 66/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0230 - mse:
0.0230 - val_loss: 0.1876 - val_mse: 0.1876
Epoch 67/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0229 - mse:
0.0229 - val_loss: 0.1895 - val_mse: 0.1895
Epoch 68/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0224 - mse:
0.0224 - val_loss: 0.1887 - val_mse: 0.1887
Epoch 69/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0219 - mse:
0.0219 - val_loss: 0.1898 - val_mse: 0.1898
Epoch 70/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0221 - mse:
0.0221 - val_loss: 0.1867 - val_mse: 0.1867
Epoch 71/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0212 - mse:
0.0212 - val_loss: 0.1902 - val_mse: 0.1902
Epoch 72/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0209 - mse:
0.0209 - val_loss: 0.1897 - val_mse: 0.1897
Epoch 73/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0208 - mse:
0.0208 - val_loss: 0.1890 - val_mse: 0.1890
Epoch 74/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0206 - mse:
0.0206 - val_loss: 0.1915 - val_mse: 0.1915
Epoch 75/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0198 - mse:
0.0198 - val_loss: 0.1903 - val_mse: 0.1903
Epoch 76/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0196 - mse:
0.0196 - val_loss: 0.1904 - val_mse: 0.1904
Epoch 77/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0193 - mse:
0.0193 - val_loss: 0.1914 - val_mse: 0.1914
Epoch 78/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0194 - mse:
0.0194 - val_loss: 0.1909 - val_mse: 0.1909
Epoch 79/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0190 - mse:
0.0190 - val_loss: 0.1909 - val_mse: 0.1909
Epoch 80/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0187 - mse:
0.0187 - val_loss: 0.1926 - val_mse: 0.1926
Epoch 81/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0184 - mse:
0.0184 - val_loss: 0.1919 - val_mse: 0.1919
Epoch 82/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0188 - mse:
0.0188 - val_loss: 0.1945 - val_mse: 0.1945
Epoch 83/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0183 - mse:
0.0183 - val_loss: 0.1922 - val_mse: 0.1922
Epoch 84/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0174 - mse:
0.0174 - val_loss: 0.1937 - val_mse: 0.1937
Epoch 85/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0174 - mse:
0.0174 - val_loss: 0.1959 - val_mse: 0.1959
Epoch 86/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0176 - mse:
0.0176 - val_loss: 0.1963 - val_mse: 0.1963
Epoch 87/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0173 - mse:
0.0173 - val_loss: 0.1937 - val_mse: 0.1937
Epoch 88/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0165 - mse:
0.0165 - val_loss: 0.1927 - val_mse: 0.1927
Epoch 89/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0163 - mse:
0.0163 - val_loss: 0.1933 - val_mse: 0.1933
Epoch 90/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0162 - mse:
0.0162 - val_loss: 0.1937 - val_mse: 0.1937
Epoch 91/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0159 - mse:
0.0159 - val_loss: 0.1968 - val_mse: 0.1968
Epoch 92/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0156 - mse:
0.0156 - val_loss: 0.1926 - val_mse: 0.1926
Epoch 93/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0157 - mse:
0.0157 - val_loss: 0.1933 - val_mse: 0.1933
Epoch 94/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0153 - mse:
0.0153 - val_loss: 0.1927 - val_mse: 0.1927
Epoch 95/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0153 - mse:
0.0153 - val_loss: 0.1958 - val_mse: 0.1958
Epoch 96/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0151 - mse:
0.0151 - val_loss: 0.1946 - val_mse: 0.1946
Epoch 97/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0148 - mse:
0.0148 - val_loss: 0.1953 - val_mse: 0.1953
Epoch 98/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0145 - mse:
0.0145 - val_loss: 0.1970 - val_mse: 0.1970
Epoch 99/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0145 - mse:
0.0145 - val_loss: 0.1971 - val_mse: 0.1971
Epoch 100/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0144 - mse:
0.0144 - val_loss: 0.1944 - val_mse: 0.1944
Epoch 101/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0138 - mse:
0.0138 - val_loss: 0.1951 - val_mse: 0.1951
Epoch 102/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0138 - mse:
0.0138 - val_loss: 0.1965 - val_mse: 0.1965
Epoch 103/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0138 - mse:
0.0138 - val_loss: 0.1959 - val_mse: 0.1959
Epoch 104/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0135 - mse:
0.0135 - val_loss: 0.1971 - val_mse: 0.1971
Epoch 105/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0134 - mse:
0.0134 - val_loss: 0.1969 - val_mse: 0.1969
Epoch 106/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0131 - mse:
0.0131 - val_loss: 0.1967 - val_mse: 0.1967
Epoch 107/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0130 - mse:
0.0130 - val_loss: 0.1976 - val_mse: 0.1976
Epoch 108/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0131 - mse:
0.0131 - val_loss: 0.1995 - val_mse: 0.1995
Epoch 109/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0127 - mse:
0.0127 - val_loss: 0.1971 - val_mse: 0.1971
Epoch 110/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0126 - mse:
0.0126 - val_loss: 0.1973 - val_mse: 0.1973
Epoch 111/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0123 - mse:
0.0123 - val_loss: 0.1984 - val_mse: 0.1984
Epoch 112/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0123 - mse:
0.0123 - val_loss: 0.1983 - val_mse: 0.1983
Epoch 113/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0119 - mse:
0.0119 - val_loss: 0.1987 - val_mse: 0.1987
Epoch 114/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0120 - mse:
0.0120 - val_loss: 0.1973 - val_mse: 0.1973
Epoch 115/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0118 - mse:
0.0118 - val_loss: 0.2009 - val_mse: 0.2009
Epoch 116/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0116 - mse:
0.0116 - val_loss: 0.1988 - val_mse: 0.1988
Epoch 117/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0116 - mse:
0.0116 - val_loss: 0.2015 - val_mse: 0.2015
Epoch 118/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0117 - mse:
0.0117 - val_loss: 0.1994 - val_mse: 0.1994
Epoch 119/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0113 - mse:
0.0113 - val_loss: 0.2000 - val_mse: 0.2000
Epoch 120/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0112 - mse:
0.0112 - val_loss: 0.1976 - val_mse: 0.1976
Epoch 121/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0111 - mse:
0.0111 - val_loss: 0.2009 - val_mse: 0.2009
Epoch 122/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0107 - mse:
0.0107 - val_loss: 0.2010 - val_mse: 0.2010
Epoch 123/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0108 - mse:
0.0108 - val_loss: 0.2014 - val_mse: 0.2014
Epoch 124/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0106 - mse:
0.0106 - val_loss: 0.2005 - val_mse: 0.2005
Epoch 125/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0106 - mse:
0.0106 - val_loss: 0.1997 - val_mse: 0.1997
Epoch 126/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0106 - mse:
0.0106 - val_loss: 0.1994 - val_mse: 0.1994
Epoch 127/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0101 - mse:
0.0101 - val_loss: 0.2007 - val_mse: 0.2007
Epoch 128/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0102 - mse:
0.0102 - val_loss: 0.2044 - val_mse: 0.2044
Epoch 129/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0100 - mse:
0.0100 - val_loss: 0.1995 - val_mse: 0.1995
Epoch 130/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0098 - mse:
0.0098 - val_loss: 0.2025 - val_mse: 0.2025
Epoch 131/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0098 - mse:
0.0098 - val_loss: 0.2012 - val_mse: 0.2012
Epoch 132/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0098 - mse:
0.0098 - val_loss: 0.2010 - val_mse: 0.2010
Epoch 133/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0097 - mse:
0.0097 - val_loss: 0.2035 - val_mse: 0.2035
Epoch 134/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0096 - mse:
0.0096 - val_loss: 0.2014 - val_mse: 0.2014
Epoch 135/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0094 - mse:
0.0094 - val_loss: 0.2004 - val_mse: 0.2004
Epoch 136/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0093 - mse:
0.0093 - val_loss: 0.2004 - val_mse: 0.2004
Epoch 137/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0094 - mse:
0.0094 - val_loss: 0.2024 - val_mse: 0.2024
Epoch 138/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0091 - mse:
0.0091 - val_loss: 0.2027 - val_mse: 0.2027
Epoch 139/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0091 - mse:
0.0091 - val_loss: 0.2021 - val_mse: 0.2021
Epoch 140/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0090 - mse:
0.0090 - val_loss: 0.2006 - val_mse: 0.2006
Epoch 141/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0087 - mse:
0.0087 - val_loss: 0.2014 - val_mse: 0.2014
Epoch 142/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0087 - mse:
0.0087 - val_loss: 0.2015 - val_mse: 0.2015
Epoch 143/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.2030 - val_mse: 0.2030
Epoch 144/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.2031 - val_mse: 0.2031
Epoch 145/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0085 - mse:
0.0085 - val_loss: 0.2043 - val_mse: 0.2043
Epoch 146/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.2033 - val_mse: 0.2033
Epoch 147/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0083 - mse:
0.0083 - val_loss: 0.2013 - val_mse: 0.2013
Epoch 148/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0082 - mse:
0.0082 - val_loss: 0.2022 - val_mse: 0.2022
Epoch 149/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0081 - mse:
0.0081 - val_loss: 0.2026 - val_mse: 0.2026
Epoch 150/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0080 - mse:
0.0080 - val_loss: 0.2051 - val_mse: 0.2051
```

[14]:
```
<tensorflow.python.keras.callbacks.History at 0x7ff1992d4370>
```

Nicely done! After normalizing both the input and output, the model finally converged.

- Evaluate the model (`normalized_model`) on training data (`X_train` and `y_train_scaled`)

[15]:
```python
# Evaluate the model on training data
normalized_model.evaluate(X_train, y_train_scaled)
```

```
33/33 [==============================] - 0s 650us/step - loss: 0.0080 - mse:
```

```
0.0080
```

[15]:
```
[0.00796041265130043, 0.00796041265130043]
```

- Evaluate the model (`normalized_model`) on validate data (`X_val` and `y_val_scaled`)

[16]:
```python
# Evaluate the model on validate data
normalized_model.evaluate(X_val, y_val_scaled)
```

```
9/9 [==============================] - 0s 692us/step - loss: 0.2051 - mse:
0.2051
```

[16]:
```
[0.2051234394311905, 0.2051234394311905]
```

Since the output is normalized, the metric above is not interpretable. To remedy this:

- Generate predictions on validate data (`X_val`)
- Transform these predictions back to original scale using `ss_y`
- Now you can calculate the RMSE in the original units with `y_val` and `y_val_pred`

[21]:
```python
# Generate predictions on validate data
y_val_pred_scaled = normalized_model.predict(X_val)

# Transform the predictions back to original scale
y_val_pred = ss_y.inverse_transform(y_val_pred_scaled)

# RMSE of validate data
RMSE = mean_squared_error(y_val, y_val_pred, squared = False)
RMSE
```

[21]:
```
35590.91210505595
```

Great! Now that you have a converged model, you can also experiment with alternative optimizers and initialization strategies to see if you can find a better global minimum. (After all, the current models may have converged to a local minimum.)

1.7 Using Weight Initializers

In this section you will to use alternative initialization and optimization strategies. At the end, you'll then be asked to select the model which you believe performs the best.

1.8 He Initialization

In the cell below, sepcify the following in the first hidden layer:
- 100 units - `'relu'` activation - `input_shape` - `kernel_initializer='he_normal'`

[23]:
```python
np.random.seed(123)
he_model = Sequential()

# Add the first hidden layer
```

```python
he_model.add(layers.Dense(100, activation = "relu",
                          kernel_initializer = "he_normal",
                          input_shape = (X_train.shape[1],)))

# Add another hidden layer
he_model.add(layers.Dense(50, activation='relu'))

# Add an output layer
he_model.add(layers.Dense(1, activation='linear'))

# Compile the model
he_model.compile(optimizer='SGD',
                 loss='mse',
                 metrics=['mse'])

# Train the model
he_model.fit(X_train,
             y_train_scaled,
             batch_size=32,
             epochs=150,
             validation_data=(X_val, y_val_scaled))
```

```
Epoch 1/150
33/33 [==============================] - 0s 4ms/step - loss: 0.5365 - mse:
0.5365 - val_loss: 0.1936 - val_mse: 0.1936
Epoch 2/150
33/33 [==============================] - 0s 2ms/step - loss: 0.2515 - mse:
0.2515 - val_loss: 0.1565 - val_mse: 0.1565
Epoch 3/150
33/33 [==============================] - 0s 1ms/step - loss: 0.2123 - mse:
0.2123 - val_loss: 0.1445 - val_mse: 0.1445
Epoch 4/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1921 - mse:
0.1921 - val_loss: 0.1493 - val_mse: 0.1493
Epoch 5/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1647 - mse:
0.1647 - val_loss: 0.1509 - val_mse: 0.1509
Epoch 6/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1447 - mse:
0.1447 - val_loss: 0.1479 - val_mse: 0.1479
Epoch 7/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1340 - mse:
0.1340 - val_loss: 0.1460 - val_mse: 0.1460
Epoch 8/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1224 - mse:
0.1224 - val_loss: 0.1541 - val_mse: 0.1541
Epoch 9/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.1122 - mse:
0.1122 - val_loss: 0.1553 - val_mse: 0.1553
Epoch 10/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1051 - mse:
0.1051 - val_loss: 0.1741 - val_mse: 0.1741
Epoch 11/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1025 - mse:
0.1025 - val_loss: 0.1724 - val_mse: 0.1724
Epoch 12/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0930 - mse:
0.0930 - val_loss: 0.1619 - val_mse: 0.1619
Epoch 13/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0879 - mse:
0.0879 - val_loss: 0.1741 - val_mse: 0.1741
Epoch 14/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0853 - mse:
0.0853 - val_loss: 0.1660 - val_mse: 0.1660
Epoch 15/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0802 - mse:
0.0802 - val_loss: 0.1717 - val_mse: 0.1717
Epoch 16/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0787 - mse:
0.0787 - val_loss: 0.1717 - val_mse: 0.1717
Epoch 17/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0748 - mse:
0.0748 - val_loss: 0.1723 - val_mse: 0.1723
Epoch 18/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0723 - mse:
0.0723 - val_loss: 0.1753 - val_mse: 0.1753
Epoch 19/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0712 - mse:
0.0712 - val_loss: 0.1743 - val_mse: 0.1743
Epoch 20/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0660 - mse:
0.0660 - val_loss: 0.1817 - val_mse: 0.1817
Epoch 21/150
33/33 [==============================] - 0s 3ms/step - loss: 0.0640 - mse:
0.0640 - val_loss: 0.1743 - val_mse: 0.1743
Epoch 22/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0618 - mse:
0.0618 - val_loss: 0.1763 - val_mse: 0.1763
Epoch 23/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0602 - mse:
0.0602 - val_loss: 0.1824 - val_mse: 0.1824
Epoch 24/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0591 - mse:
0.0591 - val_loss: 0.1792 - val_mse: 0.1792
Epoch 25/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0568 - mse:
0.0568 - val_loss: 0.1825 - val_mse: 0.1825
Epoch 26/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0556 - mse:
0.0556 - val_loss: 0.1788 - val_mse: 0.1788
Epoch 27/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0540 - mse:
0.0540 - val_loss: 0.1795 - val_mse: 0.1795
Epoch 28/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0525 - mse:
0.0525 - val_loss: 0.1799 - val_mse: 0.1799
Epoch 29/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0510 - mse:
0.0510 - val_loss: 0.1794 - val_mse: 0.1794
Epoch 30/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0500 - mse:
0.0500 - val_loss: 0.1801 - val_mse: 0.1801
Epoch 31/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0488 - mse:
0.0488 - val_loss: 0.1778 - val_mse: 0.1778
Epoch 32/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0472 - mse:
0.0472 - val_loss: 0.1789 - val_mse: 0.1789
Epoch 33/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0458 - mse:
0.0458 - val_loss: 0.1790 - val_mse: 0.1790
Epoch 34/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0451 - mse:
0.0451 - val_loss: 0.1799 - val_mse: 0.1799
Epoch 35/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0440 - mse:
0.0440 - val_loss: 0.1816 - val_mse: 0.1816
Epoch 36/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0421 - mse:
0.0421 - val_loss: 0.1833 - val_mse: 0.1833
Epoch 37/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0423 - mse:
0.0423 - val_loss: 0.1834 - val_mse: 0.1834
Epoch 38/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0405 - mse:
0.0405 - val_loss: 0.1874 - val_mse: 0.1874
Epoch 39/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0403 - mse:
0.0403 - val_loss: 0.1839 - val_mse: 0.1839
Epoch 40/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0397 - mse:
0.0397 - val_loss: 0.1826 - val_mse: 0.1826
Epoch 41/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0383 - mse:
0.0383 - val_loss: 0.1830 - val_mse: 0.1830
Epoch 42/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0370 - mse:
0.0370 - val_loss: 0.1850 - val_mse: 0.1850
Epoch 43/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0368 - mse:
0.0368 - val_loss: 0.1890 - val_mse: 0.1890
Epoch 44/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0368 - mse:
0.0368 - val_loss: 0.1857 - val_mse: 0.1857
Epoch 45/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0352 - mse:
0.0352 - val_loss: 0.1861 - val_mse: 0.1861
Epoch 46/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0343 - mse:
0.0343 - val_loss: 0.1862 - val_mse: 0.1862
Epoch 47/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0343 - mse:
0.0343 - val_loss: 0.1859 - val_mse: 0.1859
Epoch 48/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0335 - mse:
0.0335 - val_loss: 0.1866 - val_mse: 0.1866
Epoch 49/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0330 - mse:
0.0330 - val_loss: 0.1881 - val_mse: 0.1881
Epoch 50/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0324 - mse:
0.0324 - val_loss: 0.1900 - val_mse: 0.1900
Epoch 51/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0314 - mse:
0.0314 - val_loss: 0.1884 - val_mse: 0.1884
Epoch 52/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0312 - mse:
0.0312 - val_loss: 0.1863 - val_mse: 0.1863
Epoch 53/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0307 - mse:
0.0307 - val_loss: 0.1874 - val_mse: 0.1874
Epoch 54/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0299 - mse:
0.0299 - val_loss: 0.1878 - val_mse: 0.1878
Epoch 55/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0295 - mse:
0.0295 - val_loss: 0.1890 - val_mse: 0.1890
Epoch 56/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0290 - mse:
0.0290 - val_loss: 0.1896 - val_mse: 0.1896
Epoch 57/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0282 - mse:
0.0282 - val_loss: 0.1881 - val_mse: 0.1881
Epoch 58/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0287 - mse:
0.0287 - val_loss: 0.1873 - val_mse: 0.1873
Epoch 59/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0270 - mse:
0.0270 - val_loss: 0.1865 - val_mse: 0.1865
Epoch 60/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0272 - mse:
0.0272 - val_loss: 0.1852 - val_mse: 0.1852
Epoch 61/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0271 - mse:
0.0271 - val_loss: 0.1902 - val_mse: 0.1902
Epoch 62/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0262 - mse:
0.0262 - val_loss: 0.1881 - val_mse: 0.1881
Epoch 63/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0258 - mse:
0.0258 - val_loss: 0.1893 - val_mse: 0.1893
Epoch 64/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0252 - mse:
0.0252 - val_loss: 0.1906 - val_mse: 0.1906
Epoch 65/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0249 - mse:
0.0249 - val_loss: 0.1882 - val_mse: 0.1882
Epoch 66/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0243 - mse:
0.0243 - val_loss: 0.1898 - val_mse: 0.1898
Epoch 67/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0237 - mse:
0.0237 - val_loss: 0.1935 - val_mse: 0.1935
Epoch 68/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0237 - mse:
0.0237 - val_loss: 0.1885 - val_mse: 0.1885
Epoch 69/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0234 - mse:
0.0234 - val_loss: 0.1911 - val_mse: 0.1911
Epoch 70/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0230 - mse:
0.0230 - val_loss: 0.1897 - val_mse: 0.1897
Epoch 71/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0226 - mse:
0.0226 - val_loss: 0.1906 - val_mse: 0.1906
Epoch 72/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0218 - mse:
0.0218 - val_loss: 0.1906 - val_mse: 0.1906
Epoch 73/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0221 - mse:
0.0221 - val_loss: 0.1921 - val_mse: 0.1921
Epoch 74/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0218 - mse:
0.0218 - val_loss: 0.1906 - val_mse: 0.1906
Epoch 75/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0211 - mse:
0.0211 - val_loss: 0.1900 - val_mse: 0.1900
Epoch 76/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0214 - mse:
0.0214 - val_loss: 0.1956 - val_mse: 0.1956
Epoch 77/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0211 - mse:
0.0211 - val_loss: 0.1936 - val_mse: 0.1936
Epoch 78/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0203 - mse:
0.0203 - val_loss: 0.1927 - val_mse: 0.1927
Epoch 79/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0202 - mse:
0.0202 - val_loss: 0.1911 - val_mse: 0.1911
Epoch 80/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0201 - mse:
0.0201 - val_loss: 0.1926 - val_mse: 0.1926
Epoch 81/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0195 - mse:
0.0195 - val_loss: 0.1924 - val_mse: 0.1924
Epoch 82/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0192 - mse:
0.0192 - val_loss: 0.1915 - val_mse: 0.1915
Epoch 83/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0189 - mse:
0.0189 - val_loss: 0.1921 - val_mse: 0.1921
Epoch 84/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0186 - mse:
0.0186 - val_loss: 0.1951 - val_mse: 0.1951
Epoch 85/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0184 - mse:
0.0184 - val_loss: 0.1960 - val_mse: 0.1960
Epoch 86/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0182 - mse:
0.0182 - val_loss: 0.1928 - val_mse: 0.1928
Epoch 87/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0178 - mse:
0.0178 - val_loss: 0.2016 - val_mse: 0.2016
Epoch 88/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0178 - mse:
0.0178 - val_loss: 0.1939 - val_mse: 0.1939
Epoch 89/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0178 - mse:
0.0178 - val_loss: 0.1930 - val_mse: 0.1930
Epoch 90/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0172 - mse:
0.0172 - val_loss: 0.1920 - val_mse: 0.1920
Epoch 91/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0172 - mse:
0.0172 - val_loss: 0.1930 - val_mse: 0.1930
Epoch 92/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0168 - mse:
0.0168 - val_loss: 0.1923 - val_mse: 0.1923
Epoch 93/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0164 - mse:
0.0164 - val_loss: 0.1947 - val_mse: 0.1947
Epoch 94/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0161 - mse:
0.0161 - val_loss: 0.1953 - val_mse: 0.1953
Epoch 95/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0162 - mse:
0.0162 - val_loss: 0.1952 - val_mse: 0.1952
Epoch 96/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0158 - mse:
0.0158 - val_loss: 0.1952 - val_mse: 0.1952
Epoch 97/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0155 - mse:
0.0155 - val_loss: 0.1933 - val_mse: 0.1933
Epoch 98/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0157 - mse:
0.0157 - val_loss: 0.1931 - val_mse: 0.1931
Epoch 99/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0154 - mse:
0.0154 - val_loss: 0.1943 - val_mse: 0.1943
Epoch 100/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0151 - mse:
0.0151 - val_loss: 0.1949 - val_mse: 0.1949
Epoch 101/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0150 - mse:
0.0150 - val_loss: 0.1944 - val_mse: 0.1944
Epoch 102/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0147 - mse:
0.0147 - val_loss: 0.1947 - val_mse: 0.1947
Epoch 103/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0147 - mse:
0.0147 - val_loss: 0.1967 - val_mse: 0.1967
Epoch 104/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0145 - mse:
0.0145 - val_loss: 0.1951 - val_mse: 0.1951
Epoch 105/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0141 - mse:
0.0141 - val_loss: 0.1936 - val_mse: 0.1936
Epoch 106/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0141 - mse:
0.0141 - val_loss: 0.1933 - val_mse: 0.1933
Epoch 107/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0138 - mse:
0.0138 - val_loss: 0.1940 - val_mse: 0.1940
Epoch 108/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0139 - mse:
0.0139 - val_loss: 0.1944 - val_mse: 0.1944
Epoch 109/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0136 - mse:
0.0136 - val_loss: 0.1950 - val_mse: 0.1950
Epoch 110/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0133 - mse:
0.0133 - val_loss: 0.1967 - val_mse: 0.1967
Epoch 111/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0132 - mse:
0.0132 - val_loss: 0.1971 - val_mse: 0.1971
Epoch 112/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0132 - mse:
0.0132 - val_loss: 0.1945 - val_mse: 0.1945
Epoch 113/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0129 - mse:
0.0129 - val_loss: 0.1962 - val_mse: 0.1962
Epoch 114/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0127 - mse:
0.0127 - val_loss: 0.1959 - val_mse: 0.1959
Epoch 115/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0126 - mse:
0.0126 - val_loss: 0.1986 - val_mse: 0.1986
Epoch 116/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0125 - mse:
0.0125 - val_loss: 0.1964 - val_mse: 0.1964
Epoch 117/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0124 - mse:
0.0124 - val_loss: 0.1976 - val_mse: 0.1976
Epoch 118/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0120 - mse:
0.0120 - val_loss: 0.1950 - val_mse: 0.1950
Epoch 119/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0120 - mse:
0.0120 - val_loss: 0.1996 - val_mse: 0.1996
Epoch 120/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0122 - mse:
0.0122 - val_loss: 0.1960 - val_mse: 0.1960
Epoch 121/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0120 - mse:
0.0120 - val_loss: 0.1967 - val_mse: 0.1967
Epoch 122/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0117 - mse:
0.0117 - val_loss: 0.1968 - val_mse: 0.1968
Epoch 123/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0117 - mse:
0.0117 - val_loss: 0.1962 - val_mse: 0.1962
Epoch 124/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0114 - mse:
0.0114 - val_loss: 0.1982 - val_mse: 0.1982
Epoch 125/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0114 - mse:
0.0114 - val_loss: 0.1981 - val_mse: 0.1981
Epoch 126/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0113 - mse:
0.0113 - val_loss: 0.1972 - val_mse: 0.1972
Epoch 127/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0109 - mse:
0.0109 - val_loss: 0.1965 - val_mse: 0.1965
Epoch 128/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0109 - mse:
0.0109 - val_loss: 0.1969 - val_mse: 0.1969
Epoch 129/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0108 - mse:
0.0108 - val_loss: 0.1990 - val_mse: 0.1990
Epoch 130/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0108 - mse:
0.0108 - val_loss: 0.1977 - val_mse: 0.1977
Epoch 131/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0105 - mse:
0.0105 - val_loss: 0.1970 - val_mse: 0.1970
Epoch 132/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0105 - mse:
0.0105 - val_loss: 0.2005 - val_mse: 0.2005
Epoch 133/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0103 - mse:
0.0103 - val_loss: 0.1972 - val_mse: 0.1972
Epoch 134/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0102 - mse:
0.0102 - val_loss: 0.1984 - val_mse: 0.1984
Epoch 135/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0101 - mse:
0.0101 - val_loss: 0.1977 - val_mse: 0.1977
Epoch 136/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0100 - mse:
0.0100 - val_loss: 0.1977 - val_mse: 0.1977
Epoch 137/150
```

```
33/33 [==============================] - 0s 1ms/step - loss: 0.0099 - mse:
0.0099 - val_loss: 0.1968 - val_mse: 0.1968
Epoch 138/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0098 - mse:
0.0098 - val_loss: 0.1968 - val_mse: 0.1968
Epoch 139/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0097 - mse:
0.0097 - val_loss: 0.1977 - val_mse: 0.1977
Epoch 140/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0096 - mse:
0.0096 - val_loss: 0.1974 - val_mse: 0.1974
Epoch 141/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0095 - mse:
0.0095 - val_loss: 0.1988 - val_mse: 0.1988
Epoch 142/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0094 - mse:
0.0094 - val_loss: 0.1988 - val_mse: 0.1988
Epoch 143/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0091 - mse:
0.0091 - val_loss: 0.1973 - val_mse: 0.1973
Epoch 144/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0090 - mse:
0.0090 - val_loss: 0.1984 - val_mse: 0.1984
Epoch 145/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0090 - mse:
0.0090 - val_loss: 0.1986 - val_mse: 0.1986
Epoch 146/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0090 - mse:
0.0090 - val_loss: 0.1992 - val_mse: 0.1992
Epoch 147/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0087 - mse:
0.0087 - val_loss: 0.1988 - val_mse: 0.1988
Epoch 148/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0089 - mse:
0.0089 - val_loss: 0.1984 - val_mse: 0.1984
Epoch 149/150
33/33 [==============================] - 0s 3ms/step - loss: 0.0088 - mse:
0.0088 - val_loss: 0.1989 - val_mse: 0.1989
Epoch 150/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.1979 - val_mse: 0.1979
```

[23]:
```
<tensorflow.python.keras.callbacks.History at 0x7ff199e3c340>
```

Evaluate the model (`he_model`) on training data (`X_train` and `y_train_scaled`)

[24]:
```
# Evaluate the model on training data
he_model.evaluate(X_train, y_train_scaled)
```

```
33/33 [==============================] - 0s 657us/step - loss: 0.0082 - mse:
0.0082
```

[24]:
```
[0.008214985020458698, 0.008214985020458698]
```

Evaluate the model (`he_model`) on validate data (`X_val` and `y_val_scaled`)

[26]:
```
# Evaluate the model on validate data
he_model.evaluate(X_val, y_val_scaled)
```

```
9/9 [==============================] - 0s 783us/step - loss: 0.1979 - mse:
0.1979
```

[26]:
```
[0.19792889058589935, 0.19792889058589935]
```

1.9 Lecun Initialization

In the cell below, sepcify the following in the first hidden layer:
- 100 units - `'relu'` activation - `input_shape` - `kernel_initializer='lecun_normal'`

[27]:
```
np.random.seed(123)
lecun_model = Sequential()

# Add the first hidden layer
lecun_model.add(layers.Dense(100, activation = "relu",
                             kernel_initializer = "lecun_normal",
                             input_shape = (X_train.shape[1],)))

# Add another hidden layer
lecun_model.add(layers.Dense(50, activation='relu'))

# Add an output layer
lecun_model.add(layers.Dense(1, activation='linear'))

# Compile the model
lecun_model.compile(optimizer='SGD',
                    loss='mse',
                    metrics=['mse'])

# Train the model
lecun_model.fit(X_train,
                y_train_scaled,
                batch_size=32,
                epochs=150,
                validation_data=(X_val, y_val_scaled))
```

```
Epoch 1/150
33/33 [==============================] - 0s 4ms/step - loss: 0.4230 - mse:
```

```
0.4230 - val_loss: 0.1823 - val_mse: 0.1823
Epoch 2/150
33/33 [==============================] - 0s 2ms/step - loss: 0.2504 - mse:
0.2504 - val_loss: 0.1546 - val_mse: 0.1546
Epoch 3/150
33/33 [==============================] - 0s 2ms/step - loss: 0.1969 - mse:
0.1969 - val_loss: 0.1418 - val_mse: 0.1418
Epoch 4/150
33/33 [==============================] - 0s 2ms/step - loss: 0.1702 - mse:
0.1702 - val_loss: 0.1325 - val_mse: 0.1325
Epoch 5/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1491 - mse:
0.1491 - val_loss: 0.1198 - val_mse: 0.1198
Epoch 6/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1404 - mse:
0.1404 - val_loss: 0.1144 - val_mse: 0.1144
Epoch 7/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1252 - mse:
0.1252 - val_loss: 0.1125 - val_mse: 0.1125
Epoch 8/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1170 - mse:
0.1170 - val_loss: 0.1121 - val_mse: 0.1121
Epoch 9/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1084 - mse:
0.1084 - val_loss: 0.1119 - val_mse: 0.1119
Epoch 10/150
33/33 [==============================] - 0s 1ms/step - loss: 0.1019 - mse:
0.1019 - val_loss: 0.1088 - val_mse: 0.1088
Epoch 11/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0953 - mse:
0.0953 - val_loss: 0.1106 - val_mse: 0.1106
Epoch 12/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0912 - mse:
0.0912 - val_loss: 0.1087 - val_mse: 0.1087
Epoch 13/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0845 - mse:
0.0845 - val_loss: 0.1096 - val_mse: 0.1096
Epoch 14/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0800 - mse:
0.0800 - val_loss: 0.1230 - val_mse: 0.1230
Epoch 15/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0758 - mse:
0.0758 - val_loss: 0.1165 - val_mse: 0.1165
Epoch 16/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0715 - mse:
0.0715 - val_loss: 0.1129 - val_mse: 0.1129
Epoch 17/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0674 - mse:
```

```
0.0674 - val_loss: 0.1117 - val_mse: 0.1117
Epoch 18/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0647 - mse:
0.0647 - val_loss: 0.1093 - val_mse: 0.1093
Epoch 19/150
33/33 [==============================] - 0s 3ms/step - loss: 0.0624 - mse:
0.0624 - val_loss: 0.1112 - val_mse: 0.1112
Epoch 20/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0591 - mse:
0.0591 - val_loss: 0.1116 - val_mse: 0.1116
Epoch 21/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0573 - mse:
0.0573 - val_loss: 0.1176 - val_mse: 0.1176
Epoch 22/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0545 - mse:
0.0545 - val_loss: 0.1126 - val_mse: 0.1126
Epoch 23/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0533 - mse:
0.0533 - val_loss: 0.1141 - val_mse: 0.1141
Epoch 24/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0503 - mse:
0.0503 - val_loss: 0.1203 - val_mse: 0.1203
Epoch 25/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0494 - mse:
0.0494 - val_loss: 0.1193 - val_mse: 0.1193
Epoch 26/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0468 - mse:
0.0468 - val_loss: 0.1182 - val_mse: 0.1182
Epoch 27/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0462 - mse:
0.0462 - val_loss: 0.1181 - val_mse: 0.1181
Epoch 28/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0441 - mse:
0.0441 - val_loss: 0.1202 - val_mse: 0.1202
Epoch 29/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0428 - mse:
0.0428 - val_loss: 0.1242 - val_mse: 0.1242
Epoch 30/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0421 - mse:
0.0421 - val_loss: 0.1227 - val_mse: 0.1227
Epoch 31/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0400 - mse:
0.0400 - val_loss: 0.1227 - val_mse: 0.1227
Epoch 32/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0388 - mse:
0.0388 - val_loss: 0.1239 - val_mse: 0.1239
Epoch 33/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0391 - mse:
```

```
0.0391 - val_loss: 0.1239 - val_mse: 0.1239
Epoch 34/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0382 - mse:
0.0382 - val_loss: 0.1240 - val_mse: 0.1240
Epoch 35/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0368 - mse:
0.0368 - val_loss: 0.1255 - val_mse: 0.1255
Epoch 36/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0366 - mse:
0.0366 - val_loss: 0.1258 - val_mse: 0.1258
Epoch 37/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0352 - mse:
0.0352 - val_loss: 0.1281 - val_mse: 0.1281
Epoch 38/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0350 - mse:
0.0350 - val_loss: 0.1283 - val_mse: 0.1283
Epoch 39/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0339 - mse:
0.0339 - val_loss: 0.1263 - val_mse: 0.1263
Epoch 40/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0328 - mse:
0.0328 - val_loss: 0.1274 - val_mse: 0.1274
Epoch 41/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0322 - mse:
0.0322 - val_loss: 0.1304 - val_mse: 0.1304
Epoch 42/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0317 - mse:
0.0317 - val_loss: 0.1313 - val_mse: 0.1313
Epoch 43/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0312 - mse:
0.0312 - val_loss: 0.1316 - val_mse: 0.1316
Epoch 44/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0305 - mse:
0.0305 - val_loss: 0.1337 - val_mse: 0.1337
Epoch 45/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0298 - mse:
0.0298 - val_loss: 0.1308 - val_mse: 0.1308
Epoch 46/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0298 - mse:
0.0298 - val_loss: 0.1324 - val_mse: 0.1324
Epoch 47/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0288 - mse:
0.0288 - val_loss: 0.1314 - val_mse: 0.1314
Epoch 48/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0278 - mse:
0.0278 - val_loss: 0.1333 - val_mse: 0.1333
Epoch 49/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0280 - mse:
```

```
0.0280 - val_loss: 0.1349 - val_mse: 0.1349
Epoch 50/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0273 - mse:
0.0273 - val_loss: 0.1344 - val_mse: 0.1344
Epoch 51/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0264 - mse:
0.0264 - val_loss: 0.1345 - val_mse: 0.1345
Epoch 52/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0266 - mse:
0.0266 - val_loss: 0.1358 - val_mse: 0.1358
Epoch 53/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0256 - mse:
0.0256 - val_loss: 0.1358 - val_mse: 0.1358
Epoch 54/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0259 - mse:
0.0259 - val_loss: 0.1358 - val_mse: 0.1358
Epoch 55/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0247 - mse:
0.0247 - val_loss: 0.1378 - val_mse: 0.1378
Epoch 56/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0250 - mse:
0.0250 - val_loss: 0.1370 - val_mse: 0.1370
Epoch 57/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0238 - mse:
0.0238 - val_loss: 0.1374 - val_mse: 0.1374
Epoch 58/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0238 - mse:
0.0238 - val_loss: 0.1391 - val_mse: 0.1391
Epoch 59/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0239 - mse:
0.0239 - val_loss: 0.1363 - val_mse: 0.1363
Epoch 60/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0228 - mse:
0.0228 - val_loss: 0.1386 - val_mse: 0.1386
Epoch 61/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0229 - mse:
0.0229 - val_loss: 0.1398 - val_mse: 0.1398
Epoch 62/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0224 - mse:
0.0224 - val_loss: 0.1413 - val_mse: 0.1413
Epoch 63/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0221 - mse:
0.0221 - val_loss: 0.1407 - val_mse: 0.1407
Epoch 64/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0216 - mse:
0.0216 - val_loss: 0.1425 - val_mse: 0.1425
Epoch 65/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0213 - mse:
```

```
0.0213 - val_loss: 0.1436 - val_mse: 0.1436
Epoch 66/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0217 - mse:
0.0217 - val_loss: 0.1429 - val_mse: 0.1429
Epoch 67/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0207 - mse:
0.0207 - val_loss: 0.1427 - val_mse: 0.1427
Epoch 68/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0206 - mse:
0.0206 - val_loss: 0.1427 - val_mse: 0.1427
Epoch 69/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0200 - mse:
0.0200 - val_loss: 0.1457 - val_mse: 0.1457
Epoch 70/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0197 - mse:
0.0197 - val_loss: 0.1476 - val_mse: 0.1476
Epoch 71/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0201 - mse:
0.0201 - val_loss: 0.1454 - val_mse: 0.1454
Epoch 72/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0195 - mse:
0.0195 - val_loss: 0.1432 - val_mse: 0.1432
Epoch 73/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0193 - mse:
0.0193 - val_loss: 0.1445 - val_mse: 0.1445
Epoch 74/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0191 - mse:
0.0191 - val_loss: 0.1453 - val_mse: 0.1453
Epoch 75/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0188 - mse:
0.0188 - val_loss: 0.1464 - val_mse: 0.1464
Epoch 76/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0188 - mse:
0.0188 - val_loss: 0.1447 - val_mse: 0.1447
Epoch 77/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0181 - mse:
0.0181 - val_loss: 0.1468 - val_mse: 0.1468
Epoch 78/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0179 - mse:
0.0179 - val_loss: 0.1468 - val_mse: 0.1468
Epoch 79/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0176 - mse:
0.0176 - val_loss: 0.1456 - val_mse: 0.1456
Epoch 80/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0175 - mse:
0.0175 - val_loss: 0.1463 - val_mse: 0.1463
Epoch 81/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0171 - mse:
```

```
0.0171 - val_loss: 0.1447 - val_mse: 0.1447
Epoch 82/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0174 - mse:
0.0174 - val_loss: 0.1457 - val_mse: 0.1457
Epoch 83/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0167 - mse:
0.0167 - val_loss: 0.1474 - val_mse: 0.1474
Epoch 84/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0164 - mse:
0.0164 - val_loss: 0.1458 - val_mse: 0.1458
Epoch 85/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0163 - mse:
0.0163 - val_loss: 0.1476 - val_mse: 0.1476
Epoch 86/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0161 - mse:
0.0161 - val_loss: 0.1473 - val_mse: 0.1473
Epoch 87/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0161 - mse:
0.0161 - val_loss: 0.1467 - val_mse: 0.1467
Epoch 88/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0154 - mse:
0.0154 - val_loss: 0.1450 - val_mse: 0.1450
Epoch 89/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0156 - mse:
0.0156 - val_loss: 0.1453 - val_mse: 0.1453
Epoch 90/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0152 - mse:
0.0152 - val_loss: 0.1472 - val_mse: 0.1472
Epoch 91/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0151 - mse:
0.0151 - val_loss: 0.1467 - val_mse: 0.1467
Epoch 92/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0155 - mse:
0.0155 - val_loss: 0.1480 - val_mse: 0.1480
Epoch 93/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0150 - mse:
0.0150 - val_loss: 0.1459 - val_mse: 0.1459
Epoch 94/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0146 - mse:
0.0146 - val_loss: 0.1478 - val_mse: 0.1478
Epoch 95/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0144 - mse:
0.0144 - val_loss: 0.1503 - val_mse: 0.1503
Epoch 96/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0143 - mse:
0.0143 - val_loss: 0.1475 - val_mse: 0.1475
Epoch 97/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0140 - mse:
```

```
0.0140 - val_loss: 0.1478 - val_mse: 0.1478
Epoch 98/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0142 - mse:
0.0142 - val_loss: 0.1489 - val_mse: 0.1489
Epoch 99/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0138 - mse:
0.0138 - val_loss: 0.1502 - val_mse: 0.1502
Epoch 100/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0138 - mse:
0.0138 - val_loss: 0.1502 - val_mse: 0.1502
Epoch 101/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0136 - mse:
0.0136 - val_loss: 0.1491 - val_mse: 0.1491
Epoch 102/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0133 - mse:
0.0133 - val_loss: 0.1495 - val_mse: 0.1495
Epoch 103/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0133 - mse:
0.0133 - val_loss: 0.1478 - val_mse: 0.1478
Epoch 104/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0132 - mse:
0.0132 - val_loss: 0.1486 - val_mse: 0.1486
Epoch 105/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0131 - mse:
0.0131 - val_loss: 0.1488 - val_mse: 0.1488
Epoch 106/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0129 - mse:
0.0129 - val_loss: 0.1492 - val_mse: 0.1492
Epoch 107/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0128 - mse:
0.0128 - val_loss: 0.1480 - val_mse: 0.1480
Epoch 108/150
33/33 [==============================] - 0s 3ms/step - loss: 0.0126 - mse:
0.0126 - val_loss: 0.1481 - val_mse: 0.1481
Epoch 109/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0125 - mse:
0.0125 - val_loss: 0.1511 - val_mse: 0.1511
Epoch 110/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0122 - mse:
0.0122 - val_loss: 0.1497 - val_mse: 0.1497
Epoch 111/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0121 - mse:
0.0121 - val_loss: 0.1489 - val_mse: 0.1489
Epoch 112/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0120 - mse:
0.0120 - val_loss: 0.1475 - val_mse: 0.1475
Epoch 113/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0119 - mse:
```

```
0.0119 - val_loss: 0.1478 - val_mse: 0.1478
Epoch 114/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0120 - mse:
0.0120 - val_loss: 0.1500 - val_mse: 0.1500
Epoch 115/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0119 - mse:
0.0119 - val_loss: 0.1497 - val_mse: 0.1497
Epoch 116/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0116 - mse:
0.0116 - val_loss: 0.1489 - val_mse: 0.1489
Epoch 117/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0116 - mse:
0.0116 - val_loss: 0.1491 - val_mse: 0.1491
Epoch 118/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0114 - mse:
0.0114 - val_loss: 0.1498 - val_mse: 0.1498
Epoch 119/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0113 - mse:
0.0113 - val_loss: 0.1509 - val_mse: 0.1509
Epoch 120/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0114 - mse:
0.0114 - val_loss: 0.1508 - val_mse: 0.1508
Epoch 121/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0110 - mse:
0.0110 - val_loss: 0.1502 - val_mse: 0.1502
Epoch 122/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0109 - mse:
0.0109 - val_loss: 0.1505 - val_mse: 0.1505
Epoch 123/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0109 - mse:
0.0109 - val_loss: 0.1517 - val_mse: 0.1517
Epoch 124/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0107 - mse:
0.0107 - val_loss: 0.1521 - val_mse: 0.1521
Epoch 125/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0106 - mse:
0.0106 - val_loss: 0.1508 - val_mse: 0.1508
Epoch 126/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0106 - mse:
0.0106 - val_loss: 0.1509 - val_mse: 0.1509
Epoch 127/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0105 - mse:
0.0105 - val_loss: 0.1513 - val_mse: 0.1513
Epoch 128/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0103 - mse:
0.0103 - val_loss: 0.1503 - val_mse: 0.1503
Epoch 129/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0102 - mse:
```

```
0.0102 - val_loss: 0.1521 - val_mse: 0.1521
Epoch 130/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0100 - mse:
0.0100 - val_loss: 0.1527 - val_mse: 0.1527
Epoch 131/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0101 - mse:
0.0101 - val_loss: 0.1510 - val_mse: 0.1510
Epoch 132/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0100 - mse:
0.0100 - val_loss: 0.1526 - val_mse: 0.1526
Epoch 133/150
33/33 [==============================] - 0s 3ms/step - loss: 0.0096 - mse:
0.0096 - val_loss: 0.1523 - val_mse: 0.1523
Epoch 134/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0097 - mse:
0.0097 - val_loss: 0.1526 - val_mse: 0.1526
Epoch 135/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0095 - mse:
0.0095 - val_loss: 0.1519 - val_mse: 0.1519
Epoch 136/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0094 - mse:
0.0094 - val_loss: 0.1543 - val_mse: 0.1543
Epoch 137/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0096 - mse:
0.0096 - val_loss: 0.1523 - val_mse: 0.1523
Epoch 138/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0092 - mse:
0.0092 - val_loss: 0.1509 - val_mse: 0.1509
Epoch 139/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0093 - mse:
0.0093 - val_loss: 0.1510 - val_mse: 0.1510
Epoch 140/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0091 - mse:
0.0091 - val_loss: 0.1501 - val_mse: 0.1501
Epoch 141/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0091 - mse:
0.0091 - val_loss: 0.1529 - val_mse: 0.1529
Epoch 142/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0090 - mse:
0.0090 - val_loss: 0.1520 - val_mse: 0.1520
Epoch 143/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0088 - mse:
0.0088 - val_loss: 0.1537 - val_mse: 0.1537
Epoch 144/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0092 - mse:
0.0092 - val_loss: 0.1519 - val_mse: 0.1519
Epoch 145/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0087 - mse:
```

```
0.0087 - val_loss: 0.1525 - val_mse: 0.1525
Epoch 146/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0086 - mse:
0.0086 - val_loss: 0.1518 - val_mse: 0.1518
Epoch 147/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0086 - mse:
0.0086 - val_loss: 0.1521 - val_mse: 0.1521
Epoch 148/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0085 - mse:
0.0085 - val_loss: 0.1525 - val_mse: 0.1525
Epoch 149/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.1542 - val_mse: 0.1542
Epoch 150/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0083 - mse:
0.0083 - val_loss: 0.1532 - val_mse: 0.1532
```

[27]:
```
<tensorflow.python.keras.callbacks.History at 0x7ff19a0f8520>
```

Evaluate the model (`lecun_model`) on training data (`X_train` and `y_train_scaled`)

[28]:
```
# Evaluate the model on training data
lecun_model.evaluate(X_train, y_train_scaled)
```

```
33/33 [==============================] - 0s 674us/step - loss: 0.0088 - mse:
0.0088
```

[28]:
```
[0.008768126368522644, 0.008768126368522644]
```

Evaluate the model (`lecun_model`) on validate data (`X_val` and `y_val_scaled`)

[29]:
```
# Evaluate the model on validate data
lecun_model.evaluate(X_val, y_val_scaled)
```

```
9/9 [==============================] - 0s 712us/step - loss: 0.1532 - mse:
0.1532
```

[29]:
```
[0.15321286022663116, 0.15321286022663116]
```

Not much of a difference, but a useful note to consider when tuning your network. Next, let's investigate the impact of various optimization algorithms.

1.10 RMSprop

Compile the `rmsprop_model` with:

- `'rmsprop'` as the optimizer
- track `'mse'` as the loss and metric

[31]:
```
np.random.seed(123)
rmsprop_model = Sequential()
rmsprop_model.add(layers.Dense(100, activation='relu',␣
↪input_shape=(n_features,)))
rmsprop_model.add(layers.Dense(50, activation='relu'))
rmsprop_model.add(layers.Dense(1, activation='linear'))

# Compile the model
rmsprop_model.compile(optimizer = "rmsprop", loss = "mse", metrics = ["mse"])

# Train the model
rmsprop_model.fit(X_train,
                  y_train_scaled,
                  batch_size=32,
                  epochs=150,
                  validation_data=(X_val, y_val_scaled))
```

```
Epoch 1/150
33/33 [==============================] - 0s 4ms/step - loss: 0.3343 - mse:
0.3343 - val_loss: 0.1196 - val_mse: 0.1196
Epoch 2/150
33/33 [==============================] - 0s 2ms/step - loss: 0.1779 - mse:
0.1779 - val_loss: 0.1412 - val_mse: 0.1412
Epoch 3/150
33/33 [==============================] - 0s 2ms/step - loss: 0.1327 - mse:
0.1327 - val_loss: 0.1018 - val_mse: 0.1018
Epoch 4/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0962 - mse:
0.0962 - val_loss: 0.1278 - val_mse: 0.1278
Epoch 5/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0937 - mse:
0.0937 - val_loss: 0.1127 - val_mse: 0.1127
Epoch 6/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0647 - mse:
0.0647 - val_loss: 0.1218 - val_mse: 0.1218
Epoch 7/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0557 - mse:
0.0557 - val_loss: 0.1334 - val_mse: 0.1334
Epoch 8/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0474 - mse:
0.0474 - val_loss: 0.1399 - val_mse: 0.1399
Epoch 9/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0505 - mse:
0.0505 - val_loss: 0.1213 - val_mse: 0.1213
Epoch 10/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0385 - mse:
0.0385 - val_loss: 0.1551 - val_mse: 0.1551
```

```
Epoch 11/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0347 - mse:
0.0347 - val_loss: 0.2104 - val_mse: 0.2104
Epoch 12/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0277 - mse:
0.0277 - val_loss: 0.1731 - val_mse: 0.1731
Epoch 13/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0264 - mse:
0.0264 - val_loss: 0.1319 - val_mse: 0.1319
Epoch 14/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0302 - mse:
0.0302 - val_loss: 0.1414 - val_mse: 0.1414
Epoch 15/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0248 - mse:
0.0248 - val_loss: 0.1347 - val_mse: 0.1347
Epoch 16/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0218 - mse:
0.0218 - val_loss: 0.1345 - val_mse: 0.1345
Epoch 17/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0242 - mse:
0.0242 - val_loss: 0.1596 - val_mse: 0.1596
Epoch 18/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0233 - mse:
0.0233 - val_loss: 0.1419 - val_mse: 0.1419
Epoch 19/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0195 - mse:
0.0195 - val_loss: 0.1324 - val_mse: 0.1324
Epoch 20/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0190 - mse:
0.0190 - val_loss: 0.1351 - val_mse: 0.1351
Epoch 21/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0191 - mse:
0.0191 - val_loss: 0.1495 - val_mse: 0.1495
Epoch 22/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0174 - mse:
0.0174 - val_loss: 0.1304 - val_mse: 0.1304
Epoch 23/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0162 - mse:
0.0162 - val_loss: 0.1439 - val_mse: 0.1439
Epoch 24/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0175 - mse:
0.0175 - val_loss: 0.1517 - val_mse: 0.1517
Epoch 25/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0175 - mse:
0.0175 - val_loss: 0.1282 - val_mse: 0.1282
Epoch 26/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0163 - mse:
0.0163 - val_loss: 0.1767 - val_mse: 0.1767
```

```
Epoch 27/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0137 - mse:
0.0137 - val_loss: 0.1349 - val_mse: 0.1349
Epoch 28/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0169 - mse:
0.0169 - val_loss: 0.1483 - val_mse: 0.1483
Epoch 29/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0158 - mse:
0.0158 - val_loss: 0.1464 - val_mse: 0.1464
Epoch 30/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0146 - mse:
0.0146 - val_loss: 0.1350 - val_mse: 0.1350
Epoch 31/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0152 - mse:
0.0152 - val_loss: 0.1256 - val_mse: 0.1256
Epoch 32/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0136 - mse:
0.0136 - val_loss: 0.1460 - val_mse: 0.1460
Epoch 33/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0139 - mse:
0.0139 - val_loss: 0.1372 - val_mse: 0.1372
Epoch 34/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0139 - mse:
0.0139 - val_loss: 0.1655 - val_mse: 0.1655
Epoch 35/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0113 - mse:
0.0113 - val_loss: 0.1265 - val_mse: 0.1265
Epoch 36/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0104 - mse:
0.0104 - val_loss: 0.1391 - val_mse: 0.1391
Epoch 37/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0144 - mse:
0.0144 - val_loss: 0.1722 - val_mse: 0.1722
Epoch 38/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0117 - mse:
0.0117 - val_loss: 0.1361 - val_mse: 0.1361
Epoch 39/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0099 - mse:
0.0099 - val_loss: 0.1364 - val_mse: 0.1364
Epoch 40/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0107 - mse:
0.0107 - val_loss: 0.1400 - val_mse: 0.1400
Epoch 41/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0112 - mse:
0.0112 - val_loss: 0.1418 - val_mse: 0.1418
Epoch 42/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0119 - mse:
0.0119 - val_loss: 0.1364 - val_mse: 0.1364
```

```
Epoch 43/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0122 - mse:
0.0122 - val_loss: 0.1482 - val_mse: 0.1482
Epoch 44/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0104 - mse:
0.0104 - val_loss: 0.1263 - val_mse: 0.1263
Epoch 45/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0123 - mse:
0.0123 - val_loss: 0.1467 - val_mse: 0.1467
Epoch 46/150
33/33 [==============================] - 0s 3ms/step - loss: 0.0095 - mse:
0.0095 - val_loss: 0.1260 - val_mse: 0.1260
Epoch 47/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0085 - mse:
0.0085 - val_loss: 0.1306 - val_mse: 0.1306
Epoch 48/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0125 - mse:
0.0125 - val_loss: 0.1373 - val_mse: 0.1373
Epoch 49/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0112 - mse:
0.0112 - val_loss: 0.1266 - val_mse: 0.1266
Epoch 50/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0089 - mse:
0.0089 - val_loss: 0.1239 - val_mse: 0.1239
Epoch 51/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0104 - mse:
0.0104 - val_loss: 0.1464 - val_mse: 0.1464
Epoch 52/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0088 - mse:
0.0088 - val_loss: 0.1307 - val_mse: 0.1307
Epoch 53/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.1604 - val_mse: 0.1604
Epoch 54/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0124 - mse:
0.0124 - val_loss: 0.1404 - val_mse: 0.1404
Epoch 55/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0094 - mse:
0.0094 - val_loss: 0.1420 - val_mse: 0.1420
Epoch 56/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0088 - mse:
0.0088 - val_loss: 0.1282 - val_mse: 0.1282
Epoch 57/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0082 - mse:
0.0082 - val_loss: 0.1341 - val_mse: 0.1341
Epoch 58/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0085 - mse:
0.0085 - val_loss: 0.1340 - val_mse: 0.1340
```

```
Epoch 59/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0087 - mse:
0.0087 - val_loss: 0.1250 - val_mse: 0.1250
Epoch 60/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0082 - mse:
0.0082 - val_loss: 0.1394 - val_mse: 0.1394
Epoch 61/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0100 - mse:
0.0100 - val_loss: 0.1387 - val_mse: 0.1387
Epoch 62/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0083 - mse:
0.0083 - val_loss: 0.1237 - val_mse: 0.1237
Epoch 63/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0073 - mse:
0.0073 - val_loss: 0.1586 - val_mse: 0.1586
Epoch 64/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0093 - mse:
0.0093 - val_loss: 0.1461 - val_mse: 0.1461
Epoch 65/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.1382 - val_mse: 0.1382
Epoch 66/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.1389 - val_mse: 0.1389
Epoch 67/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0081 - mse:
0.0081 - val_loss: 0.1282 - val_mse: 0.1282
Epoch 68/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0070 - mse:
0.0070 - val_loss: 0.1298 - val_mse: 0.1298
Epoch 69/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0075 - mse:
0.0075 - val_loss: 0.1314 - val_mse: 0.1314
Epoch 70/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0072 - mse:
0.0072 - val_loss: 0.1417 - val_mse: 0.1417
Epoch 71/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0095 - mse:
0.0095 - val_loss: 0.1320 - val_mse: 0.1320
Epoch 72/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0076 - mse:
0.0076 - val_loss: 0.1428 - val_mse: 0.1428
Epoch 73/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0071 - mse:
0.0071 - val_loss: 0.1361 - val_mse: 0.1361
Epoch 74/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0085 - mse:
0.0085 - val_loss: 0.1619 - val_mse: 0.1619
```

```
Epoch 75/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0073 - mse:
0.0073 - val_loss: 0.1248 - val_mse: 0.1248
Epoch 76/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0079 - mse:
0.0079 - val_loss: 0.1305 - val_mse: 0.1305
Epoch 77/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0070 - mse:
0.0070 - val_loss: 0.1410 - val_mse: 0.1410
Epoch 78/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0079 - mse:
0.0079 - val_loss: 0.1348 - val_mse: 0.1348
Epoch 79/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0057 - mse:
0.0057 - val_loss: 0.1297 - val_mse: 0.1297
Epoch 80/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0090 - mse:
0.0090 - val_loss: 0.1252 - val_mse: 0.1252
Epoch 81/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0073 - mse:
0.0073 - val_loss: 0.1266 - val_mse: 0.1266
Epoch 82/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0057 - mse:
0.0057 - val_loss: 0.1264 - val_mse: 0.1264
Epoch 83/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0064 - mse:
0.0064 - val_loss: 0.1157 - val_mse: 0.1157
Epoch 84/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0069 - mse:
0.0069 - val_loss: 0.1348 - val_mse: 0.1348
Epoch 85/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0070 - mse:
0.0070 - val_loss: 0.1165 - val_mse: 0.1165
Epoch 86/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0065 - mse:
0.0065 - val_loss: 0.1181 - val_mse: 0.1181
Epoch 87/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0055 - mse:
0.0055 - val_loss: 0.1391 - val_mse: 0.1391
Epoch 88/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0073 - mse:
0.0073 - val_loss: 0.1302 - val_mse: 0.1302
Epoch 89/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0069 - mse:
0.0069 - val_loss: 0.1301 - val_mse: 0.1301
Epoch 90/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.1220 - val_mse: 0.1220
```

```
Epoch 91/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0053 - mse:
0.0053 - val_loss: 0.1245 - val_mse: 0.1245
Epoch 92/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0063 - mse:
0.0063 - val_loss: 0.1281 - val_mse: 0.1281
Epoch 93/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0066 - mse:
0.0066 - val_loss: 0.1244 - val_mse: 0.1244
Epoch 94/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0058 - mse:
0.0058 - val_loss: 0.1300 - val_mse: 0.1300
Epoch 95/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0087 - mse:
0.0087 - val_loss: 0.1212 - val_mse: 0.1212
Epoch 96/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0047 - mse:
0.0047 - val_loss: 0.1369 - val_mse: 0.1369
Epoch 97/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0046 - mse:
0.0046 - val_loss: 0.1255 - val_mse: 0.1255
Epoch 98/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0061 - mse:
0.0061 - val_loss: 0.1356 - val_mse: 0.1356
Epoch 99/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0071 - mse:
0.0071 - val_loss: 0.1167 - val_mse: 0.1167
Epoch 100/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0054 - mse:
0.0054 - val_loss: 0.1288 - val_mse: 0.1288
Epoch 101/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0054 - mse:
0.0054 - val_loss: 0.1203 - val_mse: 0.1203
Epoch 102/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0057 - mse:
0.0057 - val_loss: 0.1222 - val_mse: 0.1222
Epoch 103/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0053 - mse:
0.0053 - val_loss: 0.1163 - val_mse: 0.1163
Epoch 104/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0059 - mse:
0.0059 - val_loss: 0.1177 - val_mse: 0.1177
Epoch 105/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0055 - mse:
0.0055 - val_loss: 0.1258 - val_mse: 0.1258
Epoch 106/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0058 - mse:
0.0058 - val_loss: 0.1269 - val_mse: 0.1269
```

```
Epoch 107/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0054 - mse:
0.0054 - val_loss: 0.1271 - val_mse: 0.1271
Epoch 108/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0055 - mse:
0.0055 - val_loss: 0.1181 - val_mse: 0.1181
Epoch 109/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0052 - mse:
0.0052 - val_loss: 0.1229 - val_mse: 0.1229
Epoch 110/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0045 - mse:
0.0045 - val_loss: 0.1138 - val_mse: 0.1138
Epoch 111/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0073 - mse:
0.0073 - val_loss: 0.1262 - val_mse: 0.1262
Epoch 112/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0043 - mse:
0.0043 - val_loss: 0.1288 - val_mse: 0.1288
Epoch 113/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0067 - mse:
0.0067 - val_loss: 0.1198 - val_mse: 0.1198
Epoch 114/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0048 - mse:
0.0048 - val_loss: 0.1183 - val_mse: 0.1183
Epoch 115/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0077 - mse:
0.0077 - val_loss: 0.1171 - val_mse: 0.1171
Epoch 116/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0037 - mse:
0.0037 - val_loss: 0.1275 - val_mse: 0.1275
Epoch 117/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0050 - mse:
0.0050 - val_loss: 0.1145 - val_mse: 0.1145
Epoch 118/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0049 - mse:
0.0049 - val_loss: 0.1286 - val_mse: 0.1286
Epoch 119/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0053 - mse:
0.0053 - val_loss: 0.1130 - val_mse: 0.1130
Epoch 120/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0049 - mse:
0.0049 - val_loss: 0.1215 - val_mse: 0.1215
Epoch 121/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0047 - mse:
0.0047 - val_loss: 0.1246 - val_mse: 0.1246
Epoch 122/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0054 - mse:
0.0054 - val_loss: 0.1119 - val_mse: 0.1119
```

```
Epoch 123/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0041 - mse:
0.0041 - val_loss: 0.1084 - val_mse: 0.1084
Epoch 124/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0045 - mse:
0.0045 - val_loss: 0.1186 - val_mse: 0.1186
Epoch 125/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0049 - mse:
0.0049 - val_loss: 0.1176 - val_mse: 0.1176
Epoch 126/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0054 - mse:
0.0054 - val_loss: 0.1162 - val_mse: 0.1162
Epoch 127/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0057 - mse:
0.0057 - val_loss: 0.1269 - val_mse: 0.1269
Epoch 128/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0039 - mse:
0.0039 - val_loss: 0.1079 - val_mse: 0.1079
Epoch 129/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0048 - mse:
0.0048 - val_loss: 0.1122 - val_mse: 0.1122
Epoch 130/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0054 - mse:
0.0054 - val_loss: 0.1075 - val_mse: 0.1075
Epoch 131/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0063 - mse:
0.0063 - val_loss: 0.1139 - val_mse: 0.1139
Epoch 132/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0039 - mse:
0.0039 - val_loss: 0.1132 - val_mse: 0.1132
Epoch 133/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0035 - mse:
0.0035 - val_loss: 0.1160 - val_mse: 0.1160
Epoch 134/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0049 - mse:
0.0049 - val_loss: 0.1212 - val_mse: 0.1212
Epoch 135/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0036 - mse:
0.0036 - val_loss: 0.1103 - val_mse: 0.1103
Epoch 136/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0051 - mse:
0.0051 - val_loss: 0.1207 - val_mse: 0.1207
Epoch 137/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0043 - mse:
0.0043 - val_loss: 0.1091 - val_mse: 0.1091
Epoch 138/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0041 - mse:
0.0041 - val_loss: 0.1102 - val_mse: 0.1102
```

```
Epoch 139/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0049 - mse:
0.0049 - val_loss: 0.1213 - val_mse: 0.1213
Epoch 140/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0043 - mse:
0.0043 - val_loss: 0.1093 - val_mse: 0.1093
Epoch 141/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0039 - mse:
0.0039 - val_loss: 0.1148 - val_mse: 0.1148
Epoch 142/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0051 - mse:
0.0051 - val_loss: 0.1135 - val_mse: 0.1135
Epoch 143/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0041 - mse:
0.0041 - val_loss: 0.1191 - val_mse: 0.1191
Epoch 144/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0039 - mse:
0.0039 - val_loss: 0.1180 - val_mse: 0.1180
Epoch 145/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0074 - mse:
0.0074 - val_loss: 0.1125 - val_mse: 0.1125
Epoch 146/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0037 - mse:
0.0037 - val_loss: 0.1136 - val_mse: 0.1136
Epoch 147/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0032 - mse:
0.0032 - val_loss: 0.1325 - val_mse: 0.1325
Epoch 148/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0052 - mse:
0.0052 - val_loss: 0.1047 - val_mse: 0.1047
Epoch 149/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0048 - mse:
0.0048 - val_loss: 0.1191 - val_mse: 0.1191
Epoch 150/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0050 - mse:
0.0050 - val_loss: 0.1118 - val_mse: 0.1118
```

[31]:
```
<tensorflow.python.keras.callbacks.History at 0x7ff19a28c670>
```

Evaluate the model (`rmsprop_model`) on training data (`X_train` and `y_train_scaled`)

[32]:
```python
# Evaluate the model on training data
rmsprop_model.evaluate(X_train, y_train_scaled)
```

```
33/33 [==============================] - 0s 677us/step - loss: 0.0028 - mse:
0.0028
```

[32]:
```
[0.0027529627550393343, 0.0027529627550393343]
```

Evaluate the model (`rmsprop_model`) on training data (`X_train` and `y_train_scaled`)

[33]:
```
# Evaluate the model on validate data
rmsprop_model.evaluate(X_val, y_val_scaled)
```

```
9/9 [==============================] - 0s 747us/step - loss: 0.1118 - mse:
0.1118
```

[33]:
```
[0.11178913712501526, 0.11178913712501526]
```

1.11 Adam

Compile the `adam_model` with:

- `'Adam'` as the optimizer
- track `'mse'` as the loss and metric

[34]:
```
np.random.seed(123)
adam_model = Sequential()
adam_model.add(layers.Dense(100, activation='relu', input_shape=(n_features,)))
adam_model.add(layers.Dense(50, activation='relu'))
adam_model.add(layers.Dense(1, activation='linear'))

# Compile the model
adam_model.compile(optimizer = "Adam", loss = "mse", metrics = ["mse"])

# Train the model
adam_model.fit(X_train,
               y_train_scaled,
               batch_size=32,
               epochs=150,
               validation_data=(X_val, y_val_scaled))
```

```
Epoch 1/150
33/33 [==============================] - 0s 4ms/step - loss: 0.3832 - mse:
0.3832 - val_loss: 0.1305 - val_mse: 0.1305
Epoch 2/150
33/33 [==============================] - 0s 2ms/step - loss: 0.1599 - mse:
0.1599 - val_loss: 0.1216 - val_mse: 0.1216
Epoch 3/150
33/33 [==============================] - 0s 2ms/step - loss: 0.1067 - mse:
0.1067 - val_loss: 0.1150 - val_mse: 0.1150
Epoch 4/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0821 - mse:
0.0821 - val_loss: 0.1234 - val_mse: 0.1234
Epoch 5/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0588 - mse:
0.0588 - val_loss: 0.1167 - val_mse: 0.1167
Epoch 6/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0474 - mse:
0.0474 - val_loss: 0.1210 - val_mse: 0.1210
Epoch 7/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0359 - mse:
0.0359 - val_loss: 0.1388 - val_mse: 0.1388
Epoch 8/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0294 - mse:
0.0294 - val_loss: 0.1219 - val_mse: 0.1219
Epoch 9/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0241 - mse:
0.0241 - val_loss: 0.1597 - val_mse: 0.1597
Epoch 10/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0225 - mse:
0.0225 - val_loss: 0.1243 - val_mse: 0.1243
Epoch 11/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0199 - mse:
0.0199 - val_loss: 0.1658 - val_mse: 0.1658
Epoch 12/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0171 - mse:
0.0171 - val_loss: 0.1260 - val_mse: 0.1260
Epoch 13/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0152 - mse:
0.0152 - val_loss: 0.1383 - val_mse: 0.1383
Epoch 14/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0153 - mse:
0.0153 - val_loss: 0.1314 - val_mse: 0.1314
Epoch 15/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0113 - mse:
0.0113 - val_loss: 0.1364 - val_mse: 0.1364
Epoch 16/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0097 - mse:
0.0097 - val_loss: 0.1342 - val_mse: 0.1342
Epoch 17/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0092 - mse:
0.0092 - val_loss: 0.1308 - val_mse: 0.1308
Epoch 18/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0130 - mse:
0.0130 - val_loss: 0.1319 - val_mse: 0.1319
Epoch 19/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0126 - mse:
0.0126 - val_loss: 0.1516 - val_mse: 0.1516
Epoch 20/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0119 - mse:
0.0119 - val_loss: 0.1307 - val_mse: 0.1307
Epoch 21/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0259 - mse:
0.0259 - val_loss: 0.1378 - val_mse: 0.1378
Epoch 22/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0199 - mse:
0.0199 - val_loss: 0.1272 - val_mse: 0.1272
Epoch 23/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0210 - mse:
0.0210 - val_loss: 0.1419 - val_mse: 0.1419
Epoch 24/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0150 - mse:
0.0150 - val_loss: 0.1296 - val_mse: 0.1296
Epoch 25/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0084 - mse:
0.0084 - val_loss: 0.1235 - val_mse: 0.1235
Epoch 26/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0058 - mse:
0.0058 - val_loss: 0.1275 - val_mse: 0.1275
Epoch 27/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0047 - mse:
0.0047 - val_loss: 0.1306 - val_mse: 0.1306
Epoch 28/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0032 - mse:
0.0032 - val_loss: 0.1272 - val_mse: 0.1272
Epoch 29/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0027 - mse:
0.0027 - val_loss: 0.1305 - val_mse: 0.1305
Epoch 30/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0026 - mse:
0.0026 - val_loss: 0.1224 - val_mse: 0.1224
Epoch 31/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0028 - mse:
0.0028 - val_loss: 0.1345 - val_mse: 0.1345
Epoch 32/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0034 - mse:
0.0034 - val_loss: 0.1258 - val_mse: 0.1258
Epoch 33/150
33/33 [==============================] - 0s 3ms/step - loss: 0.0033 - mse:
0.0033 - val_loss: 0.1291 - val_mse: 0.1291
Epoch 34/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0051 - mse:
0.0051 - val_loss: 0.1312 - val_mse: 0.1312
Epoch 35/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0053 - mse:
0.0053 - val_loss: 0.1334 - val_mse: 0.1334
Epoch 36/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0054 - mse:
0.0054 - val_loss: 0.1314 - val_mse: 0.1314
Epoch 37/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0085 - mse:
0.0085 - val_loss: 0.1416 - val_mse: 0.1416
Epoch 38/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0112 - mse:
0.0112 - val_loss: 0.1186 - val_mse: 0.1186
Epoch 39/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0085 - mse:
0.0085 - val_loss: 0.1336 - val_mse: 0.1336
Epoch 40/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0066 - mse:
0.0066 - val_loss: 0.1332 - val_mse: 0.1332
Epoch 41/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0073 - mse:
0.0073 - val_loss: 0.1276 - val_mse: 0.1276
Epoch 42/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0093 - mse:
0.0093 - val_loss: 0.1311 - val_mse: 0.1311
Epoch 43/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0067 - mse:
0.0067 - val_loss: 0.1206 - val_mse: 0.1206
Epoch 44/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0036 - mse:
0.0036 - val_loss: 0.1227 - val_mse: 0.1227
Epoch 45/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0020 - mse:
0.0020 - val_loss: 0.1223 - val_mse: 0.1223
Epoch 46/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0017 - mse:
0.0017 - val_loss: 0.1231 - val_mse: 0.1231
Epoch 47/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0016 - mse:
0.0016 - val_loss: 0.1248 - val_mse: 0.1248
Epoch 48/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0019 - mse:
0.0019 - val_loss: 0.1232 - val_mse: 0.1232
Epoch 49/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0045 - mse:
0.0045 - val_loss: 0.1207 - val_mse: 0.1207
Epoch 50/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0060 - mse:
0.0060 - val_loss: 0.1233 - val_mse: 0.1233
Epoch 51/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0099 - mse:
0.0099 - val_loss: 0.1229 - val_mse: 0.1229
Epoch 52/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0089 - mse:
0.0089 - val_loss: 0.1139 - val_mse: 0.1139
Epoch 53/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0060 - mse:
0.0060 - val_loss: 0.1216 - val_mse: 0.1216
Epoch 54/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0047 - mse:
0.0047 - val_loss: 0.1104 - val_mse: 0.1104
Epoch 55/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0028 - mse:
0.0028 - val_loss: 0.1235 - val_mse: 0.1235
Epoch 56/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0018 - mse:
0.0018 - val_loss: 0.1141 - val_mse: 0.1141
Epoch 57/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0011 - mse:
0.0011 - val_loss: 0.1147 - val_mse: 0.1147
Epoch 58/150
33/33 [==============================] - 0s 2ms/step - loss: 7.9010e-04 - mse:
7.9010e-04 - val_loss: 0.1166 - val_mse: 0.1166
Epoch 59/150
33/33 [==============================] - 0s 2ms/step - loss: 6.0425e-04 - mse:
6.0425e-04 - val_loss: 0.1163 - val_mse: 0.1163
Epoch 60/150
33/33 [==============================] - 0s 2ms/step - loss: 4.5378e-04 - mse:
4.5378e-04 - val_loss: 0.1172 - val_mse: 0.1172
Epoch 61/150
33/33 [==============================] - 0s 2ms/step - loss: 3.7978e-04 - mse:
3.7978e-04 - val_loss: 0.1146 - val_mse: 0.1146
Epoch 62/150
33/33 [==============================] - 0s 2ms/step - loss: 2.8653e-04 - mse:
2.8653e-04 - val_loss: 0.1152 - val_mse: 0.1152
Epoch 63/150
33/33 [==============================] - 0s 2ms/step - loss: 2.8772e-04 - mse:
2.8772e-04 - val_loss: 0.1169 - val_mse: 0.1169
Epoch 64/150
33/33 [==============================] - 0s 2ms/step - loss: 3.1232e-04 - mse:
3.1232e-04 - val_loss: 0.1156 - val_mse: 0.1156
Epoch 65/150
33/33 [==============================] - 0s 2ms/step - loss: 3.2732e-04 - mse:
3.2732e-04 - val_loss: 0.1165 - val_mse: 0.1165
Epoch 66/150
33/33 [==============================] - 0s 2ms/step - loss: 3.2007e-04 - mse:
3.2007e-04 - val_loss: 0.1137 - val_mse: 0.1137
Epoch 67/150
33/33 [==============================] - 0s 2ms/step - loss: 3.2825e-04 - mse:
3.2825e-04 - val_loss: 0.1170 - val_mse: 0.1170
Epoch 68/150
33/33 [==============================] - 0s 2ms/step - loss: 3.3012e-04 - mse:
3.3012e-04 - val_loss: 0.1143 - val_mse: 0.1143
Epoch 69/150
33/33 [==============================] - 0s 2ms/step - loss: 3.9314e-04 - mse:
3.9314e-04 - val_loss: 0.1177 - val_mse: 0.1177
Epoch 70/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 5.7634e-04 - mse:
5.7634e-04 - val_loss: 0.1135 - val_mse: 0.1135
Epoch 71/150
33/33 [==============================] - 0s 1ms/step - loss: 6.8785e-04 - mse:
6.8785e-04 - val_loss: 0.1205 - val_mse: 0.1205
Epoch 72/150
33/33 [==============================] - 0s 2ms/step - loss: 8.2294e-04 - mse:
8.2294e-04 - val_loss: 0.1108 - val_mse: 0.1108
Epoch 73/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0012 - mse:
0.0012 - val_loss: 0.1213 - val_mse: 0.1213
Epoch 74/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0021 - mse:
0.0021 - val_loss: 0.1079 - val_mse: 0.1079
Epoch 75/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0037 - mse:
0.0037 - val_loss: 0.1256 - val_mse: 0.1256
Epoch 76/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0044 - mse:
0.0044 - val_loss: 0.1119 - val_mse: 0.1119
Epoch 77/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0056 - mse:
0.0056 - val_loss: 0.1274 - val_mse: 0.1274
Epoch 78/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0060 - mse:
0.0060 - val_loss: 0.1034 - val_mse: 0.1034
Epoch 79/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0063 - mse:
0.0063 - val_loss: 0.1263 - val_mse: 0.1263
Epoch 80/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0072 - mse:
0.0072 - val_loss: 0.0983 - val_mse: 0.0983
Epoch 81/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0052 - mse:
0.0052 - val_loss: 0.1187 - val_mse: 0.1187
Epoch 82/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0048 - mse:
0.0048 - val_loss: 0.1079 - val_mse: 0.1079
Epoch 83/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0074 - mse:
0.0074 - val_loss: 0.1198 - val_mse: 0.1198
Epoch 84/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0135 - mse:
0.0135 - val_loss: 0.0979 - val_mse: 0.0979
Epoch 85/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0114 - mse:
0.0114 - val_loss: 0.1219 - val_mse: 0.1219
Epoch 86/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0066 - mse:
0.0066 - val_loss: 0.1040 - val_mse: 0.1040
Epoch 87/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0041 - mse:
0.0041 - val_loss: 0.1116 - val_mse: 0.1116
Epoch 88/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0033 - mse:
0.0033 - val_loss: 0.1093 - val_mse: 0.1093
Epoch 89/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0029 - mse:
0.0029 - val_loss: 0.1047 - val_mse: 0.1047
Epoch 90/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0033 - mse:
0.0033 - val_loss: 0.1115 - val_mse: 0.1115
Epoch 91/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0024 - mse:
0.0024 - val_loss: 0.1063 - val_mse: 0.1063
Epoch 92/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0016 - mse:
0.0016 - val_loss: 0.1121 - val_mse: 0.1121
Epoch 93/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0012 - mse:
0.0012 - val_loss: 0.1050 - val_mse: 0.1050
Epoch 94/150
33/33 [==============================] - 0s 2ms/step - loss: 7.6140e-04 - mse:
7.6140e-04 - val_loss: 0.1084 - val_mse: 0.1084
Epoch 95/150
33/33 [==============================] - 0s 2ms/step - loss: 7.7036e-04 - mse:
7.7036e-04 - val_loss: 0.1060 - val_mse: 0.1060
Epoch 96/150
33/33 [==============================] - 0s 2ms/step - loss: 7.4114e-04 - mse:
7.4114e-04 - val_loss: 0.1061 - val_mse: 0.1061
Epoch 97/150
33/33 [==============================] - 0s 2ms/step - loss: 9.8494e-04 - mse:
9.8494e-04 - val_loss: 0.1098 - val_mse: 0.1098
Epoch 98/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0013 - mse:
0.0013 - val_loss: 0.1079 - val_mse: 0.1079
Epoch 99/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0021 - mse:
0.0021 - val_loss: 0.1100 - val_mse: 0.1100
Epoch 100/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0032 - mse:
0.0032 - val_loss: 0.1073 - val_mse: 0.1073
Epoch 101/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0050 - mse:
0.0050 - val_loss: 0.1103 - val_mse: 0.1103
Epoch 102/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0078 - mse:
0.0078 - val_loss: 0.1141 - val_mse: 0.1141
Epoch 103/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0165 - mse:
0.0165 - val_loss: 0.1025 - val_mse: 0.1025
Epoch 104/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0152 - mse:
0.0152 - val_loss: 0.1220 - val_mse: 0.1220
Epoch 105/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0192 - mse:
0.0192 - val_loss: 0.1149 - val_mse: 0.1149
Epoch 106/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0163 - mse:
0.0163 - val_loss: 0.1074 - val_mse: 0.1074
Epoch 107/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0107 - mse:
0.0107 - val_loss: 0.1114 - val_mse: 0.1114
Epoch 108/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0104 - mse:
0.0104 - val_loss: 0.1239 - val_mse: 0.1239
Epoch 109/150
33/33 [==============================] - 0s 1ms/step - loss: 0.0148 - mse:
0.0148 - val_loss: 0.0951 - val_mse: 0.0951
Epoch 110/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0073 - mse:
0.0073 - val_loss: 0.1019 - val_mse: 0.1019
Epoch 111/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0030 - mse:
0.0030 - val_loss: 0.1002 - val_mse: 0.1002
Epoch 112/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0019 - mse:
0.0019 - val_loss: 0.1003 - val_mse: 0.1003
Epoch 113/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0013 - mse:
0.0013 - val_loss: 0.1003 - val_mse: 0.1003
Epoch 114/150
33/33 [==============================] - 0s 2ms/step - loss: 8.0570e-04 - mse:
8.0570e-04 - val_loss: 0.1006 - val_mse: 0.1006
Epoch 115/150
33/33 [==============================] - 0s 2ms/step - loss: 5.6472e-04 - mse:
5.6472e-04 - val_loss: 0.0999 - val_mse: 0.0999
Epoch 116/150
33/33 [==============================] - 0s 2ms/step - loss: 3.9107e-04 - mse:
3.9107e-04 - val_loss: 0.0991 - val_mse: 0.0991
Epoch 117/150
33/33 [==============================] - 0s 2ms/step - loss: 2.9013e-04 - mse:
2.9013e-04 - val_loss: 0.1003 - val_mse: 0.1003
Epoch 118/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 2.0509e-04 - mse:
2.0509e-04 - val_loss: 0.0988 - val_mse: 0.0988
Epoch 119/150
33/33 [==============================] - 0s 2ms/step - loss: 1.9364e-04 - mse:
1.9364e-04 - val_loss: 0.0992 - val_mse: 0.0992
Epoch 120/150
33/33 [==============================] - 0s 2ms/step - loss: 1.2910e-04 - mse:
1.2910e-04 - val_loss: 0.0990 - val_mse: 0.0990
Epoch 121/150
33/33 [==============================] - 0s 2ms/step - loss: 1.2374e-04 - mse:
1.2374e-04 - val_loss: 0.1002 - val_mse: 0.1002
Epoch 122/150
33/33 [==============================] - 0s 2ms/step - loss: 1.0726e-04 - mse:
1.0726e-04 - val_loss: 0.0998 - val_mse: 0.0998
Epoch 123/150
33/33 [==============================] - 0s 2ms/step - loss: 8.0730e-05 - mse:
8.0730e-05 - val_loss: 0.1002 - val_mse: 0.1002
Epoch 124/150
33/33 [==============================] - 0s 1ms/step - loss: 6.6349e-05 - mse:
6.6349e-05 - val_loss: 0.0993 - val_mse: 0.0993
Epoch 125/150
33/33 [==============================] - 0s 2ms/step - loss: 7.1356e-05 - mse:
7.1356e-05 - val_loss: 0.1000 - val_mse: 0.1000
Epoch 126/150
33/33 [==============================] - 0s 2ms/step - loss: 6.5658e-05 - mse:
6.5658e-05 - val_loss: 0.0988 - val_mse: 0.0988
Epoch 127/150
33/33 [==============================] - 0s 1ms/step - loss: 5.9304e-05 - mse:
5.9304e-05 - val_loss: 0.1002 - val_mse: 0.1002
Epoch 128/150
33/33 [==============================] - 0s 1ms/step - loss: 5.9500e-05 - mse:
5.9500e-05 - val_loss: 0.0991 - val_mse: 0.0991
Epoch 129/150
33/33 [==============================] - 0s 2ms/step - loss: 5.9513e-05 - mse:
5.9513e-05 - val_loss: 0.1000 - val_mse: 0.1000
Epoch 130/150
33/33 [==============================] - 0s 2ms/step - loss: 6.1346e-05 - mse:
6.1346e-05 - val_loss: 0.0992 - val_mse: 0.0992
Epoch 131/150
33/33 [==============================] - 0s 2ms/step - loss: 6.5084e-05 - mse:
6.5084e-05 - val_loss: 0.1001 - val_mse: 0.1001
Epoch 132/150
33/33 [==============================] - 0s 2ms/step - loss: 7.8508e-05 - mse:
7.8508e-05 - val_loss: 0.0998 - val_mse: 0.0998
Epoch 133/150
33/33 [==============================] - 0s 1ms/step - loss: 1.0812e-04 - mse:
1.0812e-04 - val_loss: 0.1005 - val_mse: 0.1005
Epoch 134/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 1.7396e-04 - mse:
1.7396e-04 - val_loss: 0.0992 - val_mse: 0.0992
Epoch 135/150
33/33 [==============================] - 0s 2ms/step - loss: 2.6164e-04 - mse:
2.6164e-04 - val_loss: 0.1006 - val_mse: 0.1006
Epoch 136/150
33/33 [==============================] - 0s 1ms/step - loss: 3.7319e-04 - mse:
3.7319e-04 - val_loss: 0.0990 - val_mse: 0.0990
Epoch 137/150
33/33 [==============================] - 0s 2ms/step - loss: 6.0664e-04 - mse:
6.0664e-04 - val_loss: 0.1027 - val_mse: 0.1027
Epoch 138/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0011 - mse:
0.0011 - val_loss: 0.0983 - val_mse: 0.0983
Epoch 139/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0023 - mse:
0.0023 - val_loss: 0.1027 - val_mse: 0.1027
Epoch 140/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0036 - mse:
0.0036 - val_loss: 0.1037 - val_mse: 0.1037
Epoch 141/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0039 - mse:
0.0039 - val_loss: 0.0958 - val_mse: 0.0958
Epoch 142/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0034 - mse:
0.0034 - val_loss: 0.0989 - val_mse: 0.0989
Epoch 143/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0033 - mse:
0.0033 - val_loss: 0.1068 - val_mse: 0.1068
Epoch 144/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0047 - mse:
0.0047 - val_loss: 0.0979 - val_mse: 0.0979
Epoch 145/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0055 - mse:
0.0055 - val_loss: 0.1090 - val_mse: 0.1090
Epoch 146/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0051 - mse:
0.0051 - val_loss: 0.0900 - val_mse: 0.0900
Epoch 147/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0052 - mse:
0.0052 - val_loss: 0.1188 - val_mse: 0.1188
Epoch 148/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0054 - mse:
0.0054 - val_loss: 0.0923 - val_mse: 0.0923
Epoch 149/150
33/33 [==============================] - 0s 2ms/step - loss: 0.0058 - mse:
0.0058 - val_loss: 0.1114 - val_mse: 0.1114
Epoch 150/150
```

```
33/33 [==============================] - 0s 2ms/step - loss: 0.0036 - mse:
0.0036 - val_loss: 0.0999 - val_mse: 0.0999
```

[34]:
```
<tensorflow.python.keras.callbacks.History at 0x7ff19b7330a0>
```

Evaluate the model (`adam_model`) on training data (`X_train` and `y_train_scaled`)

[35]:
```python
# Evaluate the model on training data
adam_model.evaluate(X_train, y_train_scaled)
```

```
33/33 [==============================] - 0s 657us/step - loss: 0.0033 - mse:
0.0033
```

[35]:
```
[0.003275700379163027, 0.003275700379163027]
```

Evaluate the model (`adam_model`) on training data (`X_val` and `y_val_scaled`)

[36]:
```python
# Evaluate the model on validate data
adam_model.evaluate(X_val, y_val_scaled)
```

```
9/9 [==============================] - 0s 677us/step - loss: 0.0999 - mse:
0.0999
```

[36]:
```
[0.09989020228385925, 0.09989020228385925]
```

1.12 Select a Final Model

Now, select the model with the best performance based on the training and validation sets. Evaluate this top model using the test set!

[41]:
```python
# Evaluate the best model on test data
# They used rmsprop_model but for me adam_model looks better

print(adam_model.evaluate(X_test, y_test_scaled))
print()
print(rmsprop_model.evaluate(X_test, y_test_scaled))
```

```
5/5 [==============================] - 0s 744us/step - loss: 0.1548 - mse:
0.1548
[0.15477198362350464, 0.15477198362350464]

5/5 [==============================] - 0s 741us/step - loss: 0.1665 - mse:
0.1665
[0.16654819250106812, 0.16654819250106812]
```

As earlier, this metric is hard to interpret because the output is scaled.

- Generate predictions on test data (`X_test`)
- Transform these predictions back to original scale using `ss_y`
- Now you can calculate the RMSE in the original units with `y_test` and `y_test_pred`

[46]:
```python
# Generate predictions on test data
y_test_pred_scaled = adam_model.predict(X_test)

# Transform the predictions back to original scale
y_test_pred = ss_y.inverse_transform(y_test_pred_scaled)

# MSE of test data
RMSE_final = mean_squared_error(y_test, y_test_pred, squared = False)
RMSE_final
```

[46]: 30915.59986780489

1.13 Summary

In this lab, you worked to ensure your model converged properly by normalizing both the input and output. Additionally, you also investigated the impact of varying initialization and optimization routines.