

# Untitled0

January 22, 2021

```
In [9]: from google.colab import files
        from math import sqrt
        import os
        import time
        import io
        from numpy import concatenate
        from matplotlib import pyplot
        from pandas import read_csv
        from pandas import DataFrame
        from pandas import concat
        import tensorflow as tf
        from sklearn.preprocessing import MinMaxScaler
        from sklearn.preprocessing import LabelEncoder
        from sklearn.metrics import mean_squared_error
        from tensorflow.keras import Sequential
        from tensorflow.keras.layers import Dense
        from tensorflow.keras.layers import LSTM
        uploaded = files.upload()

        # convert series to supervised learning
        def series_to_supervised(data, n_in=1, n_out=1, dropnan=True):
            n_vars = 1 if type(data) is list else data.shape[1]
            df = DataFrame(data)
            cols, names = list(), list()
            # input sequence (t-n, ... t-1)
            for i in range(n_in, 0, -1):
                cols.append(df.shift(i))
                names += [('var%d(t-%d)' % (j+1, i)) for j in range(n_vars)]
            # forecast sequence (t, t+1, ... t+n)
            for i in range(0, n_out):
                cols.append(df.shift(-i))
                if i == 0:
                    names += [('var%d(t)' % (j+1)) for j in range(n_vars)]
                else:
                    names += [('var%d(t+%d)' % (j+1, i)) for j in range(n_vars)]
            # put it all together
            agg = concat(cols, axis=1)
            agg.columns = names
```

```

    # drop rows with NaN values
    if dropnan:
        agg.dropna(inplace=True)
    return agg

```

<IPython.core.display.HTML object>

Saving Beijing\_PM25\_Data\_Set.csv to Beijing\_PM25\_Data\_Set (1).csv

```

In [10]: def get_device():
    if os.environ["CUDA_VISIBLE_DEVICES"] == "-1":
        return "CPU"
    else:
        return "GPU"

```

```

In [11]: def train_model(FILTERS=50, EPOCHS=50, BATCH=72, device="gpu"):
    if device == "gpu":
        %env CUDA_VISIBLE_DEVICES = 0
    else:
        %env CUDA_VISIBLE_DEVICES = -1

```

"""

*to execute call:*  
*python3 ./lab04.py*  
 """

#####

```

# #
# modify here: #
FILTERS=FILTERS #
EPOCHS=EPOCHS #
BATCH=BATCH #
# #

```

#####

*# load dataset*

```
dataset = read_csv(io.BytesIO(uploaded['Beijing_PM25_Data_Set.csv']), header=0, index_col=0)
```

```
values = dataset.values
```

*# integer encode direction*

```
encoder = LabelEncoder()
```

```
values[:,4] = encoder.fit_transform(values[:,4])
```

*# ensure all data is float*

```
values = values.astype('float32')
```

*# normalize features*

```
scaler = MinMaxScaler(feature_range=(0, 1))
```

```
scaled = scaler.fit_transform(values)
```

*# frame as supervised learning*

```
reframed = series_to_supervised(scaled, 1, 1)
```

```

# drop columns we don't want to predict
reframed.drop(reframed.columns[[9,10,11,12,13,14,15]], axis=1, inplace=True)
print(reframed.head())

# split into train and test sets
values = reframed.values
n_train_hours = 365 * 24
train = values[:n_train_hours, :]
test = values[n_train_hours:, :]
# split into input and outputs
train_X, train_y = train[:, :-1], train[:, -1]
test_X, test_y = test[:, :-1], test[:, -1]
# reshape input to be 3D [samples, timesteps, features]
train_X = train_X.reshape((train_X.shape[0], 1, train_X.shape[1]))
test_X = test_X.reshape((test_X.shape[0], 1, test_X.shape[1]))
print(train_X.shape, train_y.shape, test_X.shape, test_y.shape)

# design network
model = Sequential()
model.add(LSTM(FILTERS, input_shape=(train_X.shape[1], train_X.shape[2])))
model.add(Dense(1))
model.compile(loss='mae', optimizer='adam')
# fit network
%env CUDA_VISIBLE_DEVICES = 0
# os.environ["CUDA_VISIBLE_DEVICES"] == "0"
start = time.time()
history = model.fit(train_X, train_y, epochs=EPOCHS, batch_size=BATCH, validation_data=(test_X, test_y))
print('Training on ' + get_device() + ' took: {}'.format(time.time()-start) + ' seconds')
# plot history
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')
pyplot.legend()
pyplot.show()

# make a prediction
yhat = model.predict(test_X)
test_X = test_X.reshape((test_X.shape[0], test_X.shape[2]))
# invert scaling for forecast
inv_yhat = concatenate((yhat, test_X[:, 1:]), axis=1)
inv_yhat = scaler.inverse_transform(inv_yhat)
inv_yhat = inv_yhat[:,0]
# invert scaling for actual
test_y = test_y.reshape((len(test_y), 1))
inv_y = concatenate((test_y, test_X[:, 1:]), axis=1)
inv_y = scaler.inverse_transform(inv_y)
inv_y = inv_y[:,0]
# calculate RMSE
rmse = sqrt(mean_squared_error(inv_y, inv_yhat))

```

```
print('Test RMSE: %.3f' % rmse)
```

```
In [12]: train_model(256, 100, 72, 'gpu')
```

```
env: CUDA_VISIBLE_DEVICES=0
```

	var1(t-1)	var2(t-1)	var3(t-1)	...	var7(t-1)	var8(t-1)	var1(t)
1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893
2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

```
[5 rows x 9 columns]
```

```
(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)
```

```
env: CUDA_VISIBLE_DEVICES=0
```

```
Epoch 1/100
```

```
122/122 - 3s - loss: 0.0475 - val_loss: 0.0522
```

```
Epoch 2/100
```

```
122/122 - 1s - loss: 0.0214 - val_loss: 0.0334
```

```
Epoch 3/100
```

```
122/122 - 1s - loss: 0.0163 - val_loss: 0.0186
```

```
Epoch 4/100
```

```
122/122 - 1s - loss: 0.0160 - val_loss: 0.0183
```

```
Epoch 5/100
```

```
122/122 - 1s - loss: 0.0151 - val_loss: 0.0139
```

```
Epoch 6/100
```

```
122/122 - 1s - loss: 0.0154 - val_loss: 0.0155
```

```
Epoch 7/100
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```
122/122 - 1s - loss: 0.0156 - val_loss: 0.0145
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Epoch 8/100
```

```
122/122 - 1s - loss: 0.0155 - val_loss: 0.0140
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Epoch 9/100
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```
122/122 - 1s - loss: 0.0153 - val_loss: 0.0146
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Epoch 10/100
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```
122/122 - 1s - loss: 0.0152 - val_loss: 0.0141
```

```
Epoch 11/100
```

```
122/122 - 1s - loss: 0.0153 - val_loss: 0.0139
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```
Epoch 12/100
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```
122/122 - 1s - loss: 0.0153 - val_loss: 0.0140
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```
Epoch 13/100
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```
122/122 - 1s - loss: 0.0150 - val_loss: 0.0138
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```
Epoch 14/100
```

```
122/122 - 1s - loss: 0.0149 - val_loss: 0.0137
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Epoch 15/100
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```
122/122 - 1s - loss: 0.0153 - val_loss: 0.0139
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```
Epoch 16/100
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```
122/122 - 1s - loss: 0.0149 - val_loss: 0.0137
```

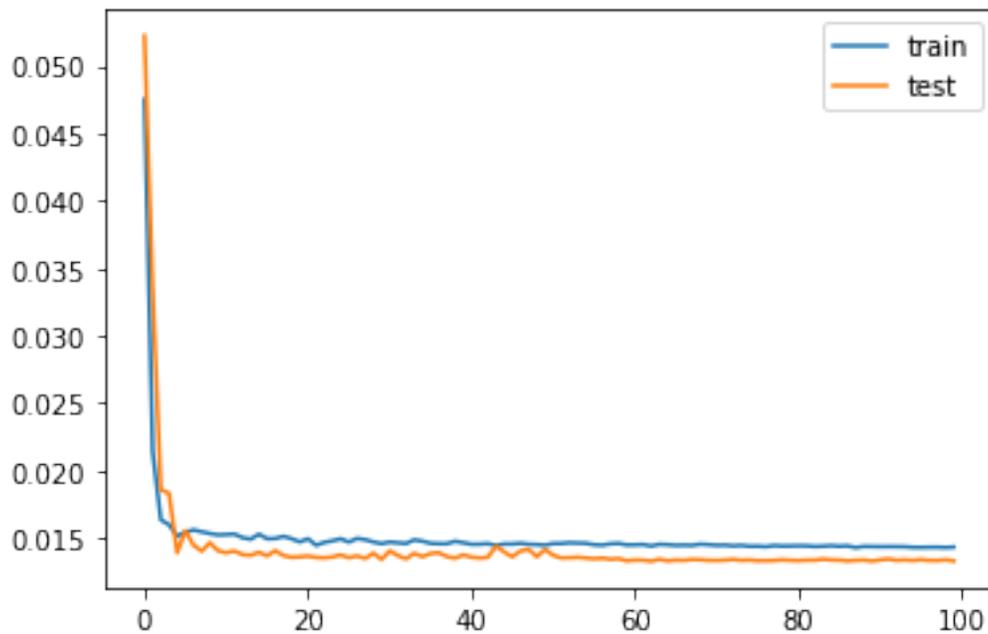
```
Epoch 17/100
```

122/122 - 1s - loss: 0.0150 - val\_loss: 0.0141  
Epoch 18/100  
122/122 - 1s - loss: 0.0151 - val\_loss: 0.0137  
Epoch 19/100  
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0136  
Epoch 20/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 21/100  
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0137  
Epoch 22/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0136  
Epoch 23/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 24/100  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0136  
Epoch 25/100  
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0137  
Epoch 26/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 27/100  
122/122 - 1s - loss: 0.0150 - val\_loss: 0.0137  
Epoch 28/100  
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0135  
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Epoch 31/100  
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Epoch 41/100

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Epoch 44/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0144  
Epoch 45/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0140  
Epoch 46/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0136  
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122/122 - 1s - loss: 0.0146 - val\_loss: 0.0140  
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122/122 - 1s - loss: 0.0145 - val\_loss: 0.0142  
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Epoch 50/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0142  
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Epoch 65/100

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122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 88/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 89/100

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122/122 - 1s - loss: 0.0144 - val_loss: 0.0134
Epoch 90/100
122/122 - 1s - loss: 0.0144 - val_loss: 0.0133
Epoch 91/100
122/122 - 1s - loss: 0.0144 - val_loss: 0.0134
Epoch 92/100
122/122 - 1s - loss: 0.0144 - val_loss: 0.0134
Epoch 93/100
122/122 - 1s - loss: 0.0144 - val_loss: 0.0133
Epoch 94/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0134
Epoch 95/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0133
Epoch 96/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0134
Epoch 97/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0133
Epoch 98/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0133
Epoch 99/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0134
Epoch 100/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0133
Training on GPU took: 107.73778653144836 seconds
```



Test RMSE: 26.244

In [13]: train\_model(256, 100, 72, 'cpu')

env: CUDA\_VISIBLE\_DEVICES=-1

	var1(t-1)	var2(t-1)	var3(t-1)	...	var7(t-1)	var8(t-1)	var1(t)
1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893
2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

[5 rows x 9 columns]

(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

env: CUDA\_VISIBLE\_DEVICES=0

Epoch 1/100

122/122 - 3s - loss: 0.0482 - val\_loss: 0.0495

Epoch 2/100

122/122 - 1s - loss: 0.0209 - val\_loss: 0.0279

Epoch 3/100

122/122 - 1s - loss: 0.0159 - val\_loss: 0.0155

Epoch 4/100

122/122 - 1s - loss: 0.0150 - val\_loss: 0.0143

Epoch 5/100

122/122 - 1s - loss: 0.0160 - val\_loss: 0.0143

Epoch 6/100

122/122 - 1s - loss: 0.0152 - val\_loss: 0.0157

Epoch 7/100

122/122 - 1s - loss: 0.0155 - val\_loss: 0.0159

Epoch 8/100

122/122 - 1s - loss: 0.0155 - val\_loss: 0.0148

Epoch 9/100

122/122 - 1s - loss: 0.0152 - val\_loss: 0.0139

Epoch 10/100

122/122 - 1s - loss: 0.0153 - val\_loss: 0.0149

Epoch 11/100

122/122 - 1s - loss: 0.0152 - val\_loss: 0.0139

Epoch 12/100

122/122 - 1s - loss: 0.0151 - val\_loss: 0.0138

Epoch 13/100

122/122 - 1s - loss: 0.0150 - val\_loss: 0.0137

Epoch 14/100

122/122 - 1s - loss: 0.0149 - val\_loss: 0.0135

Epoch 15/100

122/122 - 1s - loss: 0.0152 - val\_loss: 0.0136

Epoch 16/100

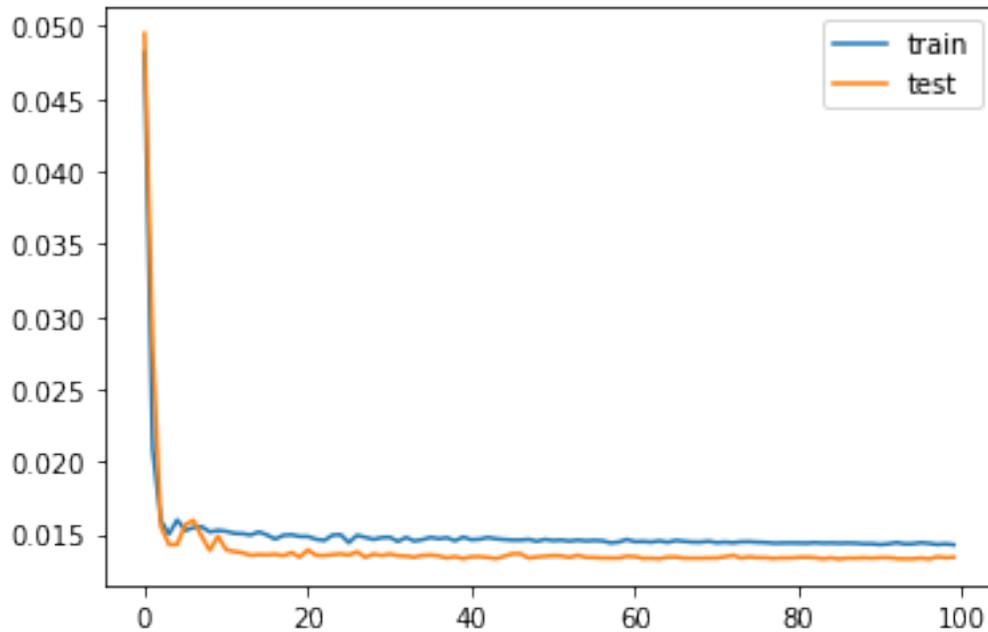
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0136

Epoch 17/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 18/100  
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122/122 - 1s - loss: 0.0148 - val\_loss: 0.0139  
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Epoch 23/100  
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Epoch 24/100  
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Epoch 25/100  
122/122 - 1s - loss: 0.0150 - val\_loss: 0.0136  
Epoch 26/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 27/100  
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0138  
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122/122 - 1s - loss: 0.0148 - val\_loss: 0.0136  
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122/122 - 1s - loss: 0.0148 - val\_loss: 0.0133

Epoch 41/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0135  
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122/122 - 1s - loss: 0.0146 - val\_loss: 0.0136  
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122/122 - 1s - loss: 0.0146 - val\_loss: 0.0137  
Epoch 48/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 49/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 50/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 51/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0135  
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122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
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122/122 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 55/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
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122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 57/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 58/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 59/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 60/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 61/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0135  
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122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 63/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 64/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133

Epoch 65/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 66/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 67/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 68/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 69/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 70/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 71/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 72/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 73/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 74/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 75/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 76/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 77/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 78/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 79/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 80/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 81/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 82/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 83/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 84/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 85/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 86/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 87/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 88/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133

Epoch 89/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 90/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 91/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 92/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 93/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 94/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 95/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 96/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 97/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 98/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 99/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 100/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Training on GPU took: 108.57767629623413 seconds



Test RMSE: 26.271

In [14]: train\_model(50, 50, 72, 'gpu')

env: CUDA\_VISIBLE\_DEVICES=0

	var1(t-1)	var2(t-1)	var3(t-1)	...	var7(t-1)	var8(t-1)	var1(t)
1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893
2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

[5 rows x 9 columns]

(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

env: CUDA\_VISIBLE\_DEVICES=0

Epoch 1/50

122/122 - 3s - loss: 0.0589 - val\_loss: 0.0574

Epoch 2/50

122/122 - 1s - loss: 0.0400 - val\_loss: 0.0608

Epoch 3/50

122/122 - 1s - loss: 0.0241 - val\_loss: 0.0523

Epoch 4/50

122/122 - 1s - loss: 0.0177 - val\_loss: 0.0436

Epoch 5/50

122/122 - 1s - loss: 0.0160 - val\_loss: 0.0288

Epoch 6/50

122/122 - 1s - loss: 0.0151 - val\_loss: 0.0202

Epoch 7/50

122/122 - 1s - loss: 0.0151 - val\_loss: 0.0197

Epoch 8/50

122/122 - 1s - loss: 0.0150 - val\_loss: 0.0184

Epoch 9/50

122/122 - 1s - loss: 0.0148 - val\_loss: 0.0173

Epoch 10/50

122/122 - 1s - loss: 0.0148 - val\_loss: 0.0162

Epoch 11/50

122/122 - 1s - loss: 0.0146 - val\_loss: 0.0153

Epoch 12/50

122/122 - 1s - loss: 0.0146 - val\_loss: 0.0148

Epoch 13/50

122/122 - 1s - loss: 0.0145 - val\_loss: 0.0146

Epoch 14/50

122/122 - 1s - loss: 0.0145 - val\_loss: 0.0145

Epoch 15/50

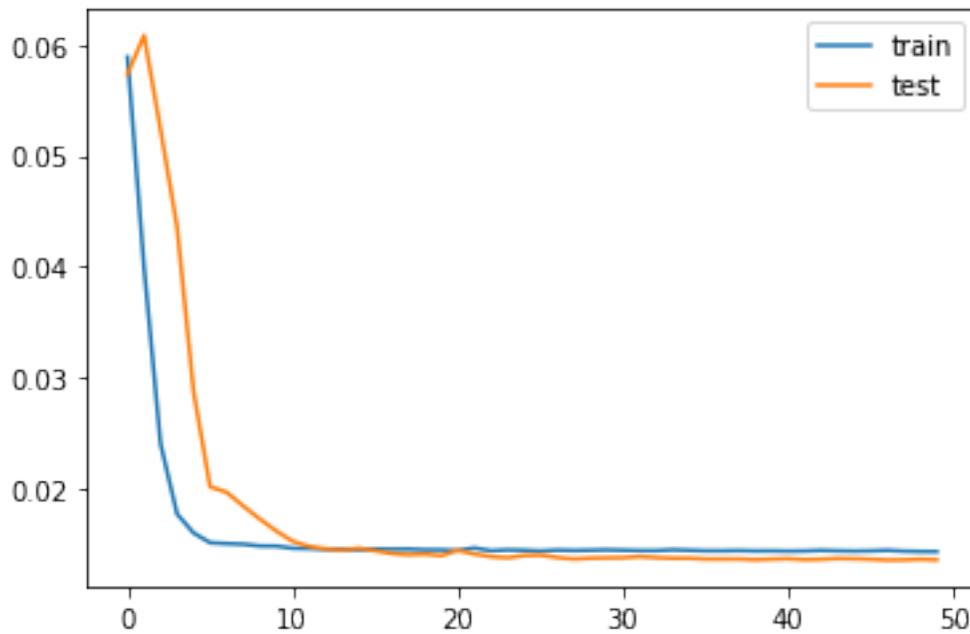
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0146

Epoch 16/50

122/122 - 1s - loss: 0.0146 - val\_loss: 0.0144

Epoch 17/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0142  
Epoch 18/50  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0141  
Epoch 19/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0141  
Epoch 20/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0140  
Epoch 21/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0144  
Epoch 22/50  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0141  
Epoch 23/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0139  
Epoch 24/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0138  
Epoch 25/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0140  
Epoch 26/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0140  
Epoch 27/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0138  
Epoch 28/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0137  
Epoch 29/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0137  
Epoch 30/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0138  
Epoch 31/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0138  
Epoch 32/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0139  
Epoch 33/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0138  
Epoch 34/50  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0137  
Epoch 35/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0137  
Epoch 36/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0137  
Epoch 37/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0137  
Epoch 38/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0137  
Epoch 39/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 40/50  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0137

```
Epoch 41/50
122/122 - 1s - loss: 0.0144 - val_loss: 0.0137
Epoch 42/50
122/122 - 1s - loss: 0.0144 - val_loss: 0.0136
Epoch 43/50
122/122 - 1s - loss: 0.0144 - val_loss: 0.0136
Epoch 44/50
122/122 - 1s - loss: 0.0144 - val_loss: 0.0137
Epoch 45/50
122/122 - 1s - loss: 0.0144 - val_loss: 0.0137
Epoch 46/50
122/122 - 1s - loss: 0.0144 - val_loss: 0.0136
Epoch 47/50
122/122 - 1s - loss: 0.0144 - val_loss: 0.0136
Epoch 48/50
122/122 - 1s - loss: 0.0144 - val_loss: 0.0136
Epoch 49/50
122/122 - 1s - loss: 0.0143 - val_loss: 0.0136
Epoch 50/50
122/122 - 1s - loss: 0.0143 - val_loss: 0.0136
Training on GPU took: 55.18148684501648 seconds
```



Test RMSE: 26.566

```
In [15]: train_model(128, 100, 72, 'gpu')
```

env: CUDA\_VISIBLE\_DEVICES=0

	var1(t-1)	var2(t-1)	var3(t-1)	...	var7(t-1)	var8(t-1)	var1(t)
1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893
2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

[5 rows x 9 columns]

(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

env: CUDA\_VISIBLE\_DEVICES=0

Epoch 1/100

122/122 - 3s - loss: 0.0591 - val\_loss: 0.0612

Epoch 2/100

122/122 - 1s - loss: 0.0324 - val\_loss: 0.0462

Epoch 3/100

122/122 - 1s - loss: 0.0187 - val\_loss: 0.0283

Epoch 4/100

122/122 - 1s - loss: 0.0156 - val\_loss: 0.0164

Epoch 5/100

122/122 - 1s - loss: 0.0151 - val\_loss: 0.0143

Epoch 6/100

122/122 - 1s - loss: 0.0150 - val\_loss: 0.0145

Epoch 7/100

122/122 - 1s - loss: 0.0149 - val\_loss: 0.0141

Epoch 8/100

122/122 - 1s - loss: 0.0150 - val\_loss: 0.0144

Epoch 9/100

122/122 - 1s - loss: 0.0149 - val\_loss: 0.0145

Epoch 10/100

122/122 - 1s - loss: 0.0149 - val\_loss: 0.0145

Epoch 11/100

122/122 - 1s - loss: 0.0149 - val\_loss: 0.0157

Epoch 12/100

122/122 - 1s - loss: 0.0148 - val\_loss: 0.0140

Epoch 13/100

122/122 - 1s - loss: 0.0149 - val\_loss: 0.0142

Epoch 14/100

122/122 - 1s - loss: 0.0149 - val\_loss: 0.0137

Epoch 15/100

122/122 - 1s - loss: 0.0148 - val\_loss: 0.0135

Epoch 16/100

122/122 - 1s - loss: 0.0148 - val\_loss: 0.0136

Epoch 17/100

122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135

Epoch 18/100

122/122 - 1s - loss: 0.0146 - val\_loss: 0.0136

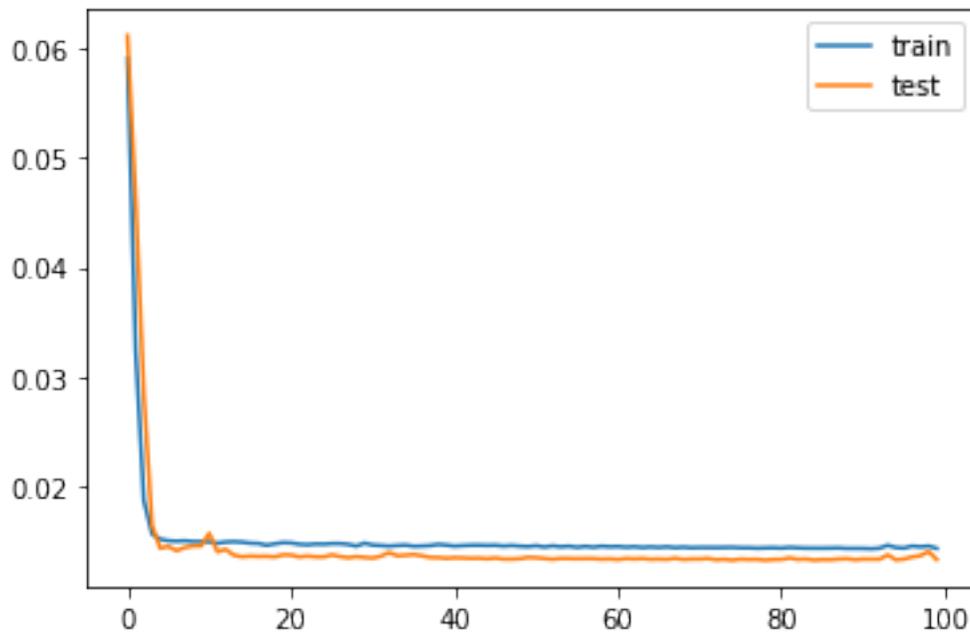
Epoch 19/100

122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 20/100  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0137  
Epoch 21/100  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0137  
Epoch 22/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 23/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0136  
Epoch 24/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 25/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 26/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 27/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 28/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 29/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 30/100  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0134  
Epoch 31/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 32/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0136  
Epoch 33/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0139  
Epoch 34/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0136  
Epoch 35/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0136  
Epoch 36/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0137  
Epoch 37/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0136  
Epoch 38/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 39/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 40/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 41/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 42/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 43/100

122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 44/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 45/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 46/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 47/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 48/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 49/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 50/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 51/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 52/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 53/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 54/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 55/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 56/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 57/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 58/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 59/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 60/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 61/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 62/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 63/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 64/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 65/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 66/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 67/100

122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 68/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 69/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 70/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 71/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 72/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 73/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0132  
Epoch 74/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0133  
Epoch 75/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0132  
Epoch 76/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 77/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 78/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 79/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0132  
Epoch 80/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 81/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 82/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 83/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 84/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 85/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0132  
Epoch 86/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 87/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0132  
Epoch 88/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 89/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0133  
Epoch 90/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0132  
Epoch 91/100

```
122/122 - 1s - loss: 0.0143 - val_loss: 0.0133
Epoch 92/100
122/122 - 1s - loss: 0.0142 - val_loss: 0.0133
Epoch 93/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0133
Epoch 94/100
122/122 - 1s - loss: 0.0146 - val_loss: 0.0137
Epoch 95/100
122/122 - 1s - loss: 0.0144 - val_loss: 0.0132
Epoch 96/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0133
Epoch 97/100
122/122 - 1s - loss: 0.0145 - val_loss: 0.0135
Epoch 98/100
122/122 - 1s - loss: 0.0144 - val_loss: 0.0136
Epoch 99/100
122/122 - 1s - loss: 0.0145 - val_loss: 0.0140
Epoch 100/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0133
Training on GPU took: 109.80831694602966 seconds
```



Test RMSE: 26.281

```
In [16]: train_model(64, 100, 72, 'gpu')
```

env: CUDA\_VISIBLE\_DEVICES=0

	var1(t-1)	var2(t-1)	var3(t-1)	...	var7(t-1)	var8(t-1)	var1(t)
1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893
2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

[5 rows x 9 columns]

(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

env: CUDA\_VISIBLE\_DEVICES=0

Epoch 1/100

122/122 - 3s - loss: 0.0573 - val\_loss: 0.0617

Epoch 2/100

122/122 - 1s - loss: 0.0376 - val\_loss: 0.0646

Epoch 3/100

122/122 - 1s - loss: 0.0233 - val\_loss: 0.0553

Epoch 4/100

122/122 - 1s - loss: 0.0188 - val\_loss: 0.0507

Epoch 5/100

122/122 - 1s - loss: 0.0169 - val\_loss: 0.0371

Epoch 6/100

122/122 - 1s - loss: 0.0155 - val\_loss: 0.0249

Epoch 7/100

122/122 - 1s - loss: 0.0152 - val\_loss: 0.0215

Epoch 8/100

122/122 - 1s - loss: 0.0150 - val\_loss: 0.0191

Epoch 9/100

122/122 - 1s - loss: 0.0148 - val\_loss: 0.0180

Epoch 10/100

122/122 - 1s - loss: 0.0148 - val\_loss: 0.0167

Epoch 11/100

122/122 - 1s - loss: 0.0148 - val\_loss: 0.0161

Epoch 12/100

122/122 - 1s - loss: 0.0147 - val\_loss: 0.0159

Epoch 13/100

122/122 - 1s - loss: 0.0147 - val\_loss: 0.0148

Epoch 14/100

122/122 - 1s - loss: 0.0146 - val\_loss: 0.0150

Epoch 15/100

122/122 - 1s - loss: 0.0147 - val\_loss: 0.0147

Epoch 16/100

122/122 - 1s - loss: 0.0147 - val\_loss: 0.0144

Epoch 17/100

122/122 - 1s - loss: 0.0146 - val\_loss: 0.0144

Epoch 18/100

122/122 - 1s - loss: 0.0146 - val\_loss: 0.0144

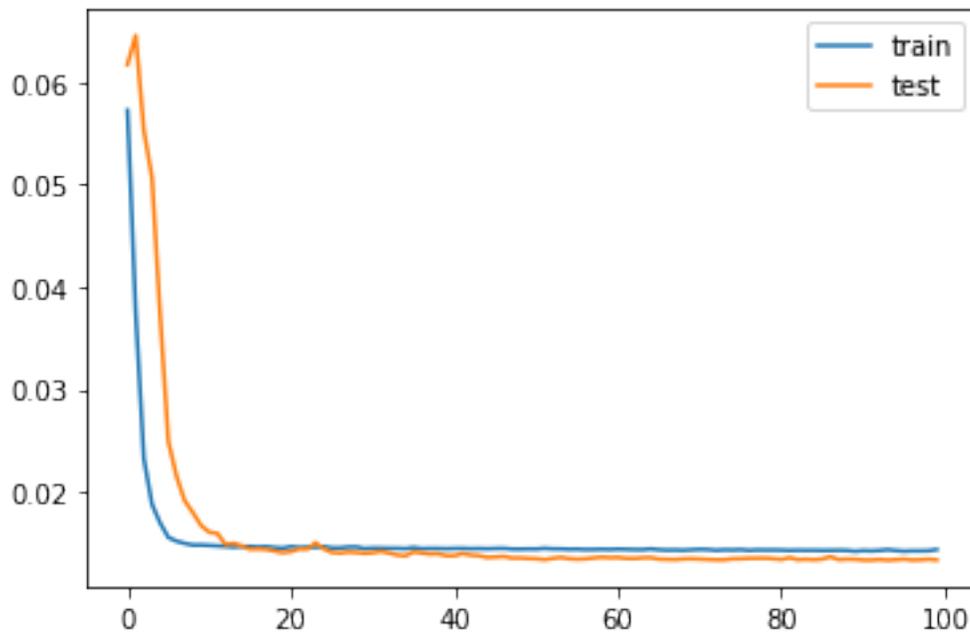
Epoch 19/100

122/122 - 1s - loss: 0.0146 - val\_loss: 0.0142  
Epoch 20/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0141  
Epoch 21/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0142  
Epoch 22/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0144  
Epoch 23/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0144  
Epoch 24/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0150  
Epoch 25/100  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0144  
Epoch 26/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0141  
Epoch 27/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0140  
Epoch 28/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0141  
Epoch 29/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0141  
Epoch 30/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0140  
Epoch 31/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0141  
Epoch 32/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0142  
Epoch 33/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0140  
Epoch 34/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0138  
Epoch 35/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0137  
Epoch 36/100  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0141  
Epoch 37/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0140  
Epoch 38/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0139  
Epoch 39/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0140  
Epoch 40/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0138  
Epoch 41/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0138  
Epoch 42/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0140  
Epoch 43/100

122/122 - 1s - loss: 0.0144 - val\_loss: 0.0138  
Epoch 44/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0138  
Epoch 45/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 46/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0136  
Epoch 47/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0137  
Epoch 48/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 49/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 50/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 51/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 52/100  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 53/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 54/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 55/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 56/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 57/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 58/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 59/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 60/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 61/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 62/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 63/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 64/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 65/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 66/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 67/100

122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 68/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 69/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 70/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0135  
Epoch 71/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 72/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 73/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 74/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 75/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0135  
Epoch 76/100  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 77/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0135  
Epoch 78/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0135  
Epoch 79/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0135  
Epoch 80/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0135  
Epoch 81/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 82/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0136  
Epoch 83/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 84/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 85/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 86/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 87/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0137  
Epoch 88/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 89/100  
122/122 - 1s - loss: 0.0143 - val\_loss: 0.0134  
Epoch 90/100  
122/122 - 1s - loss: 0.0142 - val\_loss: 0.0134  
Epoch 91/100

```
122/122 - 1s - loss: 0.0143 - val_loss: 0.0133
Epoch 92/100
122/122 - 1s - loss: 0.0142 - val_loss: 0.0133
Epoch 93/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0134
Epoch 94/100
122/122 - 1s - loss: 0.0144 - val_loss: 0.0133
Epoch 95/100
122/122 - 1s - loss: 0.0143 - val_loss: 0.0134
Epoch 96/100
122/122 - 1s - loss: 0.0142 - val_loss: 0.0134
Epoch 97/100
122/122 - 1s - loss: 0.0142 - val_loss: 0.0133
Epoch 98/100
122/122 - 1s - loss: 0.0142 - val_loss: 0.0134
Epoch 99/100
122/122 - 1s - loss: 0.0142 - val_loss: 0.0134
Epoch 100/100
122/122 - 1s - loss: 0.0144 - val_loss: 0.0133
Training on GPU took: 108.70553207397461 seconds
```



Test RMSE: 26.387

```
In [17]: train_model(256, 75, 72, 'gpu')
```

```

env: CUDA_VISIBLE_DEVICES=0
  var1(t-1)  var2(t-1)  var3(t-1)  ...  var7(t-1)  var8(t-1)  var1(t)
1  0.129779  0.352941  0.245902  ...  0.000000  0.0  0.148893
2  0.148893  0.367647  0.245902  ...  0.000000  0.0  0.159960
3  0.159960  0.426471  0.229508  ...  0.000000  0.0  0.182093
4  0.182093  0.485294  0.229508  ...  0.037037  0.0  0.138833
5  0.138833  0.485294  0.229508  ...  0.074074  0.0  0.109658

```

```

[5 rows x 9 columns]
(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

```

```

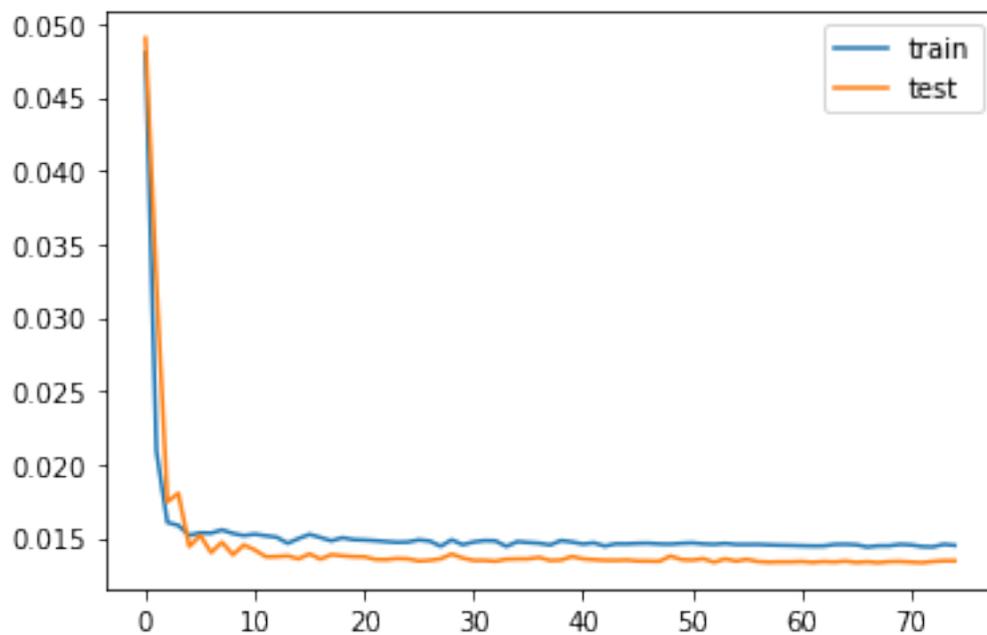
env: CUDA_VISIBLE_DEVICES=0
Epoch 1/75
122/122 - 3s - loss: 0.0480 - val_loss: 0.0491
Epoch 2/75
122/122 - 1s - loss: 0.0209 - val_loss: 0.0324
Epoch 3/75
122/122 - 1s - loss: 0.0161 - val_loss: 0.0175
Epoch 4/75
122/122 - 1s - loss: 0.0159 - val_loss: 0.0180
Epoch 5/75
122/122 - 1s - loss: 0.0152 - val_loss: 0.0144
Epoch 6/75
122/122 - 1s - loss: 0.0153 - val_loss: 0.0152
Epoch 7/75
122/122 - 1s - loss: 0.0153 - val_loss: 0.0140
Epoch 8/75
122/122 - 1s - loss: 0.0155 - val_loss: 0.0147
Epoch 9/75
122/122 - 1s - loss: 0.0153 - val_loss: 0.0139
Epoch 10/75
122/122 - 1s - loss: 0.0152 - val_loss: 0.0145
Epoch 11/75
122/122 - 1s - loss: 0.0153 - val_loss: 0.0142
Epoch 12/75
122/122 - 1s - loss: 0.0152 - val_loss: 0.0137
Epoch 13/75
122/122 - 1s - loss: 0.0151 - val_loss: 0.0137
Epoch 14/75
122/122 - 1s - loss: 0.0146 - val_loss: 0.0138
Epoch 15/75
122/122 - 1s - loss: 0.0150 - val_loss: 0.0136
Epoch 16/75
122/122 - 1s - loss: 0.0152 - val_loss: 0.0139
Epoch 17/75
122/122 - 1s - loss: 0.0150 - val_loss: 0.0136
Epoch 18/75
122/122 - 1s - loss: 0.0148 - val_loss: 0.0139
Epoch 19/75

```

122/122 - 1s - loss: 0.0150 - val\_loss: 0.0138  
Epoch 20/75  
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0137  
Epoch 21/75  
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0137  
Epoch 22/75  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0135  
Epoch 23/75  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0135  
Epoch 24/75  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 25/75  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 26/75  
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0134  
Epoch 27/75  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0135  
Epoch 28/75  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 29/75  
122/122 - 1s - loss: 0.0149 - val\_loss: 0.0139  
Epoch 30/75  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0136  
Epoch 31/75  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 32/75  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0135  
Epoch 33/75  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0134  
Epoch 34/75  
122/122 - 1s - loss: 0.0144 - val\_loss: 0.0136  
Epoch 35/75  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 36/75  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 37/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0137  
Epoch 38/75  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 39/75  
122/122 - 1s - loss: 0.0148 - val\_loss: 0.0135  
Epoch 40/75  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 41/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0136  
Epoch 42/75  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 43/75

122/122 - 1s - loss: 0.0144 - val\_loss: 0.0135  
Epoch 44/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 45/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 46/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 47/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 48/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 49/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0138  
Epoch 50/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 51/75  
122/122 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 52/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0136  
Epoch 53/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0133  
Epoch 54/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0136  
Epoch 55/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 56/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 57/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 58/75  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 59/75  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 60/75  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 61/75  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 62/75  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 63/75  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 64/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 65/75  
122/122 - 1s - loss: 0.0146 - val\_loss: 0.0134  
Epoch 66/75  
122/122 - 1s - loss: 0.0145 - val\_loss: 0.0133  
Epoch 67/75

```
122/122 - 1s - loss: 0.0144 - val_loss: 0.0134
Epoch 68/75
122/122 - 1s - loss: 0.0145 - val_loss: 0.0133
Epoch 69/75
122/122 - 1s - loss: 0.0145 - val_loss: 0.0134
Epoch 70/75
122/122 - 1s - loss: 0.0146 - val_loss: 0.0134
Epoch 71/75
122/122 - 1s - loss: 0.0145 - val_loss: 0.0134
Epoch 72/75
122/122 - 1s - loss: 0.0144 - val_loss: 0.0133
Epoch 73/75
122/122 - 1s - loss: 0.0144 - val_loss: 0.0134
Epoch 74/75
122/122 - 1s - loss: 0.0146 - val_loss: 0.0134
Epoch 75/75
122/122 - 1s - loss: 0.0145 - val_loss: 0.0134
Training on GPU took: 82.06787896156311 seconds
```



Test RMSE: 26.307

```
In [18]: train_model(256, 100, 96, 'gpu')
```

```
env: CUDA_VISIBLE_DEVICES=0
```

```
var1(t-1) var2(t-1) var3(t-1) ... var7(t-1) var8(t-1) var1(t)
```

1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893
2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

[5 rows x 9 columns]

(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

env: CUDA\_VISIBLE\_DEVICES=0

Epoch 1/100

92/92 - 2s - loss: 0.0489 - val\_loss: 0.0575

Epoch 2/100

92/92 - 1s - loss: 0.0243 - val\_loss: 0.0464

Epoch 3/100

92/92 - 1s - loss: 0.0179 - val\_loss: 0.0335

Epoch 4/100

92/92 - 1s - loss: 0.0162 - val\_loss: 0.0206

Epoch 5/100

92/92 - 1s - loss: 0.0152 - val\_loss: 0.0176

Epoch 6/100

92/92 - 1s - loss: 0.0150 - val\_loss: 0.0156

Epoch 7/100

92/92 - 1s - loss: 0.0151 - val\_loss: 0.0157

Epoch 8/100

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0141

Epoch 9/100

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0148

Epoch 10/100

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0143

Epoch 11/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0144

Epoch 12/100

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0140

Epoch 13/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0139

Epoch 14/100

92/92 - 1s - loss: 0.0150 - val\_loss: 0.0139

Epoch 15/100

92/92 - 1s - loss: 0.0147 - val\_loss: 0.0143

Epoch 16/100

92/92 - 1s - loss: 0.0147 - val\_loss: 0.0141

Epoch 17/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0137

Epoch 18/100

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0143

Epoch 19/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0140

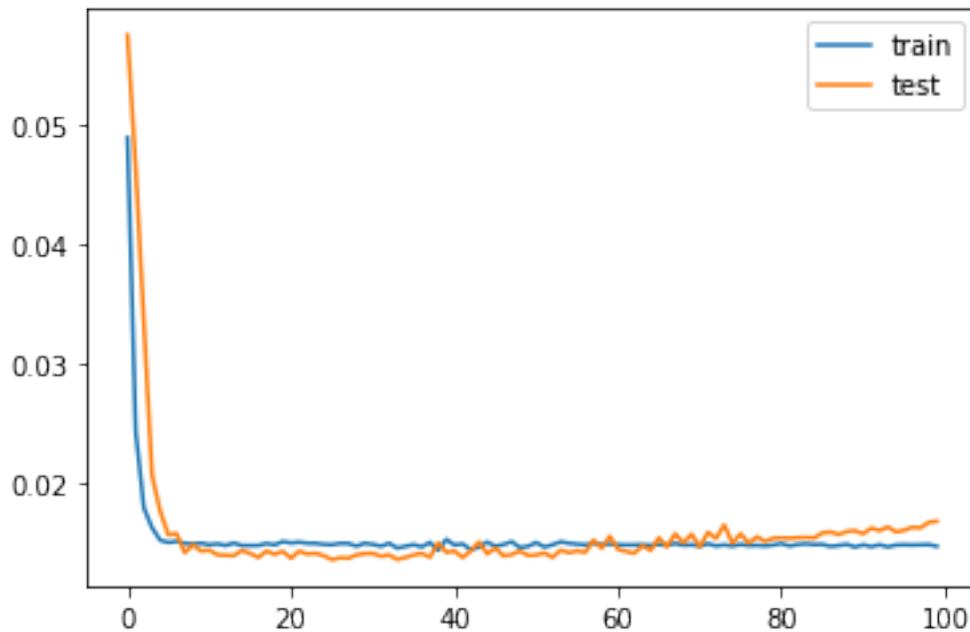
Epoch 20/100

92/92 - 1s - loss: 0.0151 - val\_loss: 0.0143  
Epoch 21/100  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0137  
Epoch 22/100  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0143  
Epoch 23/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0140  
Epoch 24/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0141  
Epoch 25/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0139  
Epoch 26/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0136  
Epoch 27/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0137  
Epoch 28/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0137  
Epoch 29/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0140  
Epoch 30/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0141  
Epoch 31/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0141  
Epoch 32/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0139  
Epoch 33/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0140  
Epoch 34/100  
92/92 - 1s - loss: 0.0145 - val\_loss: 0.0136  
Epoch 35/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 36/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0140  
Epoch 37/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0141  
Epoch 38/100  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0138  
Epoch 39/100  
92/92 - 1s - loss: 0.0143 - val\_loss: 0.0150  
Epoch 40/100  
92/92 - 1s - loss: 0.0153 - val\_loss: 0.0142  
Epoch 41/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0143  
Epoch 42/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0137  
Epoch 43/100  
92/92 - 1s - loss: 0.0144 - val\_loss: 0.0143  
Epoch 44/100

92/92 - 1s - loss: 0.0146 - val\_loss: 0.0150  
Epoch 45/100  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0140  
Epoch 46/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0145  
Epoch 47/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0139  
Epoch 48/100  
92/92 - 1s - loss: 0.0151 - val\_loss: 0.0140  
Epoch 49/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0143  
Epoch 50/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0139  
Epoch 51/100  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0139  
Epoch 52/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0141  
Epoch 53/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0138  
Epoch 54/100  
92/92 - 1s - loss: 0.0151 - val\_loss: 0.0144  
Epoch 55/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0141  
Epoch 56/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0143  
Epoch 57/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0142  
Epoch 58/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0152  
Epoch 59/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0145  
Epoch 60/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0155  
Epoch 61/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0144  
Epoch 62/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0142  
Epoch 63/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0141  
Epoch 64/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0147  
Epoch 65/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0143  
Epoch 66/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0154  
Epoch 67/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0146  
Epoch 68/100

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0157  
Epoch 69/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0150  
Epoch 70/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0157  
Epoch 71/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0146  
Epoch 72/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0158  
Epoch 73/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0153  
Epoch 74/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0165  
Epoch 75/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0149  
Epoch 76/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0157  
Epoch 77/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0149  
Epoch 78/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0155  
Epoch 79/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0151  
Epoch 80/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0154  
Epoch 81/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0154  
Epoch 82/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0153  
Epoch 83/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0154  
Epoch 84/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0154  
Epoch 85/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0154  
Epoch 86/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0158  
Epoch 87/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0159  
Epoch 88/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0157  
Epoch 89/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0159  
Epoch 90/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0160  
Epoch 91/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0157  
Epoch 92/100

```
92/92 - 1s - loss: 0.0146 - val_loss: 0.0162
Epoch 93/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0160
Epoch 94/100
92/92 - 1s - loss: 0.0146 - val_loss: 0.0163
Epoch 95/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0159
Epoch 96/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0160
Epoch 97/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0163
Epoch 98/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0162
Epoch 99/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0167
Epoch 100/100
92/92 - 1s - loss: 0.0147 - val_loss: 0.0168
Training on GPU took: 83.43401598930359 seconds
```



Test RMSE: 30.245

```
In [19]: train_model(256, 100, 144, 'gpu')
```

```
env: CUDA_VISIBLE_DEVICES=0
```

```
var1(t-1) var2(t-1) var3(t-1) ... var7(t-1) var8(t-1) var1(t)
```

1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893
2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

[5 rows x 9 columns]

(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

env: CUDA\_VISIBLE\_DEVICES=0

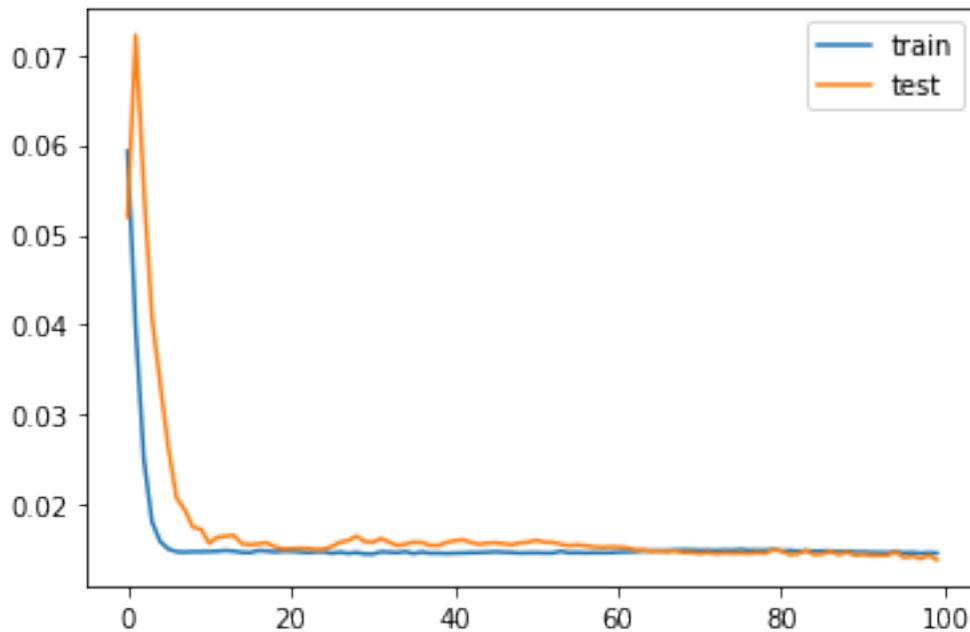
Epoch 1/100  
61/61 - 2s - loss: 0.0593 - val\_loss: 0.0520  
Epoch 2/100  
61/61 - 1s - loss: 0.0397 - val\_loss: 0.0722  
Epoch 3/100  
61/61 - 1s - loss: 0.0251 - val\_loss: 0.0551  
Epoch 4/100  
61/61 - 1s - loss: 0.0181 - val\_loss: 0.0408  
Epoch 5/100  
61/61 - 1s - loss: 0.0159 - val\_loss: 0.0335  
Epoch 6/100  
61/61 - 1s - loss: 0.0151 - val\_loss: 0.0263  
Epoch 7/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0208  
Epoch 8/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0195  
Epoch 9/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0175  
Epoch 10/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0173  
Epoch 11/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0157  
Epoch 12/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0164  
Epoch 13/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0165  
Epoch 14/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0166  
Epoch 15/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0157  
Epoch 16/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0156  
Epoch 17/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0157  
Epoch 18/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0158  
Epoch 19/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0153  
Epoch 20/100

61/61 - 1s - loss: 0.0149 - val\_loss: 0.0151  
Epoch 21/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0151  
Epoch 22/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0152  
Epoch 23/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0152  
Epoch 24/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0150  
Epoch 25/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0151  
Epoch 26/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0154  
Epoch 27/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0158  
Epoch 28/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0160  
Epoch 29/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0165  
Epoch 30/100  
61/61 - 1s - loss: 0.0145 - val\_loss: 0.0159  
Epoch 31/100  
61/61 - 1s - loss: 0.0145 - val\_loss: 0.0158  
Epoch 32/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0163  
Epoch 33/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0159  
Epoch 34/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0155  
Epoch 35/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0156  
Epoch 36/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0159  
Epoch 37/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0158  
Epoch 38/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0155  
Epoch 39/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0155  
Epoch 40/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0158  
Epoch 41/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0160  
Epoch 42/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0161  
Epoch 43/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0158  
Epoch 44/100

61/61 - 1s - loss: 0.0147 - val\_loss: 0.0156  
Epoch 45/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0157  
Epoch 46/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0158  
Epoch 47/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0157  
Epoch 48/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0156  
Epoch 49/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0158  
Epoch 50/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0158  
Epoch 51/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0161  
Epoch 52/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0159  
Epoch 53/100  
61/61 - 1s - loss: 0.0146 - val\_loss: 0.0158  
Epoch 54/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0156  
Epoch 55/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0155  
Epoch 56/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0156  
Epoch 57/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0155  
Epoch 58/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0154  
Epoch 59/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0153  
Epoch 60/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0153  
Epoch 61/100  
61/61 - 1s - loss: 0.0147 - val\_loss: 0.0153  
Epoch 62/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0152  
Epoch 63/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0150  
Epoch 64/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0150  
Epoch 65/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0148  
Epoch 66/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0149  
Epoch 67/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0148  
Epoch 68/100

61/61 - 1s - loss: 0.0150 - val\_loss: 0.0149  
Epoch 69/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0147  
Epoch 70/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0147  
Epoch 71/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0146  
Epoch 72/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0147  
Epoch 73/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0146  
Epoch 74/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0147  
Epoch 75/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0146  
Epoch 76/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0147  
Epoch 77/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0146  
Epoch 78/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0147  
Epoch 79/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0146  
Epoch 80/100  
61/61 - 1s - loss: 0.0150 - val\_loss: 0.0150  
Epoch 81/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0149  
Epoch 82/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0145  
Epoch 83/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0145  
Epoch 84/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0150  
Epoch 85/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0145  
Epoch 86/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0145  
Epoch 87/100  
61/61 - 1s - loss: 0.0149 - val\_loss: 0.0148  
Epoch 88/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0145  
Epoch 89/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0148  
Epoch 90/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0144  
Epoch 91/100  
61/61 - 1s - loss: 0.0148 - val\_loss: 0.0145  
Epoch 92/100

```
61/61 - 1s - loss: 0.0147 - val_loss: 0.0144
Epoch 93/100
61/61 - 1s - loss: 0.0147 - val_loss: 0.0144
Epoch 94/100
61/61 - 1s - loss: 0.0147 - val_loss: 0.0144
Epoch 95/100
61/61 - 1s - loss: 0.0148 - val_loss: 0.0148
Epoch 96/100
61/61 - 1s - loss: 0.0147 - val_loss: 0.0141
Epoch 97/100
61/61 - 1s - loss: 0.0147 - val_loss: 0.0143
Epoch 98/100
61/61 - 1s - loss: 0.0146 - val_loss: 0.0140
Epoch 99/100
61/61 - 1s - loss: 0.0147 - val_loss: 0.0144
Epoch 100/100
61/61 - 1s - loss: 0.0146 - val_loss: 0.0139
Training on GPU took: 58.46469855308533 seconds
```



Test RMSE: 27.068

```
In [20]: train_model(256, 75, 96, 'gpu')
```

```
env: CUDA_VISIBLE_DEVICES=0
```

```
var1(t-1) var2(t-1) var3(t-1) ... var7(t-1) var8(t-1) var1(t)
```

1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893
2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

[5 rows x 9 columns]

(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

env: CUDA\_VISIBLE\_DEVICES=0

Epoch 1/75

92/92 - 2s - loss: 0.0509 - val\_loss: 0.0504

Epoch 2/75

92/92 - 1s - loss: 0.0239 - val\_loss: 0.0415

Epoch 3/75

92/92 - 1s - loss: 0.0163 - val\_loss: 0.0211

Epoch 4/75

92/92 - 1s - loss: 0.0152 - val\_loss: 0.0180

Epoch 5/75

92/92 - 1s - loss: 0.0153 - val\_loss: 0.0149

Epoch 6/75

92/92 - 1s - loss: 0.0151 - val\_loss: 0.0145

Epoch 7/75

92/92 - 1s - loss: 0.0146 - val\_loss: 0.0148

Epoch 8/75

92/92 - 1s - loss: 0.0151 - val\_loss: 0.0139

Epoch 9/75

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0139

Epoch 10/75

92/92 - 1s - loss: 0.0147 - val\_loss: 0.0142

Epoch 11/75

92/92 - 1s - loss: 0.0150 - val\_loss: 0.0137

Epoch 12/75

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0136

Epoch 13/75

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0137

Epoch 14/75

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0134

Epoch 15/75

92/92 - 1s - loss: 0.0146 - val\_loss: 0.0136

Epoch 16/75

92/92 - 1s - loss: 0.0147 - val\_loss: 0.0138

Epoch 17/75

92/92 - 1s - loss: 0.0147 - val\_loss: 0.0141

Epoch 18/75

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0138

Epoch 19/75

92/92 - 1s - loss: 0.0150 - val\_loss: 0.0136

Epoch 20/75

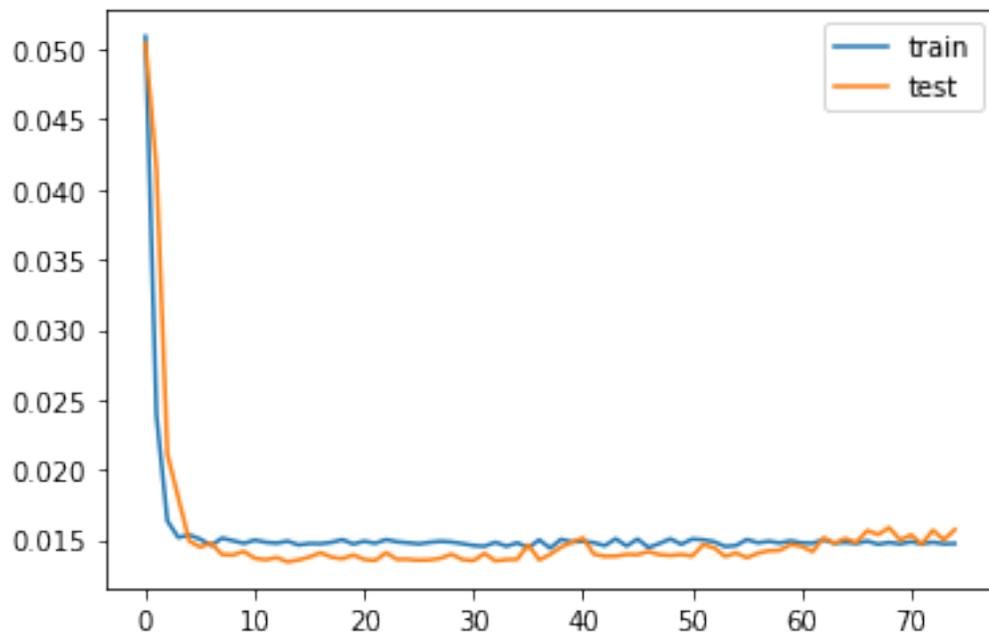
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0139  
Epoch 21/75  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0136  
Epoch 22/75  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 23/75  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0141  
Epoch 24/75  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0136  
Epoch 25/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0136  
Epoch 26/75  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0135  
Epoch 27/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0136  
Epoch 28/75  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0137  
Epoch 29/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0140  
Epoch 30/75  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 31/75  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 32/75  
92/92 - 1s - loss: 0.0145 - val\_loss: 0.0140  
Epoch 33/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0135  
Epoch 34/75  
92/92 - 1s - loss: 0.0145 - val\_loss: 0.0136  
Epoch 35/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0136  
Epoch 36/75  
92/92 - 1s - loss: 0.0144 - val\_loss: 0.0146  
Epoch 37/75  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0136  
Epoch 38/75  
92/92 - 1s - loss: 0.0144 - val\_loss: 0.0140  
Epoch 39/75  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0145  
Epoch 40/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0148  
Epoch 41/75  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0151  
Epoch 42/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0140  
Epoch 43/75  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0138  
Epoch 44/75

92/92 - 1s - loss: 0.0151 - val\_loss: 0.0138  
Epoch 45/75  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0140  
Epoch 46/75  
92/92 - 1s - loss: 0.0151 - val\_loss: 0.0139  
Epoch 47/75  
92/92 - 1s - loss: 0.0144 - val\_loss: 0.0142  
Epoch 48/75  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0139  
Epoch 49/75  
92/92 - 1s - loss: 0.0151 - val\_loss: 0.0139  
Epoch 50/75  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0140  
Epoch 51/75  
92/92 - 1s - loss: 0.0151 - val\_loss: 0.0138  
Epoch 52/75  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0147  
Epoch 53/75  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0144  
Epoch 54/75  
92/92 - 1s - loss: 0.0145 - val\_loss: 0.0138  
Epoch 55/75  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0141  
Epoch 56/75  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0137  
Epoch 57/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0140  
Epoch 58/75  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0142  
Epoch 59/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0142  
Epoch 60/75  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0147  
Epoch 61/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0145  
Epoch 62/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0142  
Epoch 63/75  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0151  
Epoch 64/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0148  
Epoch 65/75  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0151  
Epoch 66/75  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0148  
Epoch 67/75  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0157  
Epoch 68/75

```

92/92 - 1s - loss: 0.0147 - val_loss: 0.0154
Epoch 69/75
92/92 - 1s - loss: 0.0148 - val_loss: 0.0159
Epoch 70/75
92/92 - 1s - loss: 0.0147 - val_loss: 0.0150
Epoch 71/75
92/92 - 1s - loss: 0.0149 - val_loss: 0.0154
Epoch 72/75
92/92 - 1s - loss: 0.0147 - val_loss: 0.0147
Epoch 73/75
92/92 - 1s - loss: 0.0148 - val_loss: 0.0157
Epoch 74/75
92/92 - 1s - loss: 0.0147 - val_loss: 0.0150
Epoch 75/75
92/92 - 1s - loss: 0.0147 - val_loss: 0.0157
Training on GPU took: 63.26408505439758 seconds

```



Test RMSE: 28.812

```
In [21]: train_model(100, 100, 128, 'gpu')
```

```
env: CUDA_VISIBLE_DEVICES=0
```

	var1(t-1)	var2(t-1)	var3(t-1)	...	var7(t-1)	var8(t-1)	var1(t)
1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893

2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

[5 rows x 9 columns]

(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

env: CUDA\_VISIBLE\_DEVICES=0

Epoch 1/100  
69/69 - 3s - loss: 0.0557 - val\_loss: 0.0562  
Epoch 2/100  
69/69 - 1s - loss: 0.0400 - val\_loss: 0.0739  
Epoch 3/100  
69/69 - 1s - loss: 0.0269 - val\_loss: 0.0709  
Epoch 4/100  
69/69 - 1s - loss: 0.0203 - val\_loss: 0.0582  
Epoch 5/100  
69/69 - 1s - loss: 0.0176 - val\_loss: 0.0462  
Epoch 6/100  
69/69 - 1s - loss: 0.0163 - val\_loss: 0.0405  
Epoch 7/100  
69/69 - 1s - loss: 0.0155 - val\_loss: 0.0335  
Epoch 8/100  
69/69 - 1s - loss: 0.0151 - val\_loss: 0.0277  
Epoch 9/100  
69/69 - 1s - loss: 0.0149 - val\_loss: 0.0229  
Epoch 10/100  
69/69 - 1s - loss: 0.0148 - val\_loss: 0.0223  
Epoch 11/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0194  
Epoch 12/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0189  
Epoch 13/100  
69/69 - 1s - loss: 0.0148 - val\_loss: 0.0197  
Epoch 14/100  
69/69 - 1s - loss: 0.0144 - val\_loss: 0.0162  
Epoch 15/100  
69/69 - 1s - loss: 0.0148 - val\_loss: 0.0177  
Epoch 16/100  
69/69 - 1s - loss: 0.0144 - val\_loss: 0.0159  
Epoch 17/100  
69/69 - 1s - loss: 0.0148 - val\_loss: 0.0169  
Epoch 18/100  
69/69 - 1s - loss: 0.0144 - val\_loss: 0.0162  
Epoch 19/100  
69/69 - 1s - loss: 0.0148 - val\_loss: 0.0182  
Epoch 20/100  
69/69 - 1s - loss: 0.0149 - val\_loss: 0.0177

Epoch 21/100  
69/69 - 1s - loss: 0.0149 - val\_loss: 0.0181  
Epoch 22/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0178  
Epoch 23/100  
69/69 - 1s - loss: 0.0144 - val\_loss: 0.0172  
Epoch 24/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0163  
Epoch 25/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0153  
Epoch 26/100  
69/69 - 1s - loss: 0.0148 - val\_loss: 0.0157  
Epoch 27/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0157  
Epoch 28/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0162  
Epoch 29/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0170  
Epoch 30/100  
69/69 - 1s - loss: 0.0149 - val\_loss: 0.0165  
Epoch 31/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0158  
Epoch 32/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0158  
Epoch 33/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0160  
Epoch 34/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0157  
Epoch 35/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0157  
Epoch 36/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0160  
Epoch 37/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0156  
Epoch 38/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0152  
Epoch 39/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0153  
Epoch 40/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0152  
Epoch 41/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0147  
Epoch 42/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0148  
Epoch 43/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0146  
Epoch 44/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0146

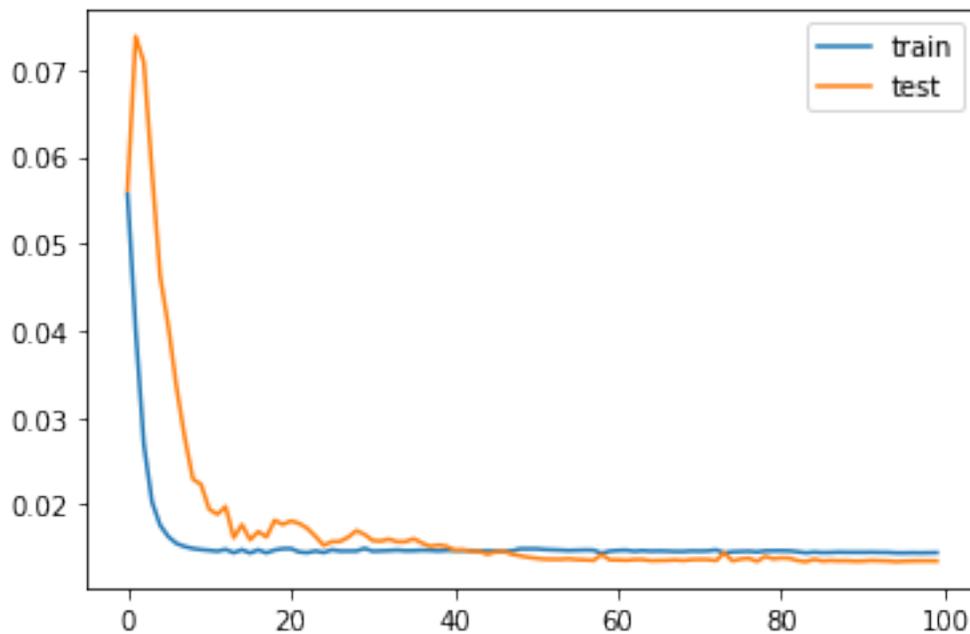
Epoch 45/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0143  
Epoch 46/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0145  
Epoch 47/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0146  
Epoch 48/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0143  
Epoch 49/100  
69/69 - 1s - loss: 0.0149 - val\_loss: 0.0141  
Epoch 50/100  
69/69 - 1s - loss: 0.0149 - val\_loss: 0.0139  
Epoch 51/100  
69/69 - 1s - loss: 0.0149 - val\_loss: 0.0138  
Epoch 52/100  
69/69 - 1s - loss: 0.0148 - val\_loss: 0.0137  
Epoch 53/100  
69/69 - 1s - loss: 0.0148 - val\_loss: 0.0137  
Epoch 54/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 55/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 56/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 57/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 58/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 59/100  
69/69 - 1s - loss: 0.0144 - val\_loss: 0.0142  
Epoch 60/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0136  
Epoch 61/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 62/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0136  
Epoch 63/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0136  
Epoch 64/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 65/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 66/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 67/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0136  
Epoch 68/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0136

Epoch 69/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0135  
Epoch 70/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0136  
Epoch 71/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0137  
Epoch 72/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 73/100  
69/69 - 1s - loss: 0.0148 - val\_loss: 0.0135  
Epoch 74/100  
69/69 - 1s - loss: 0.0144 - val\_loss: 0.0144  
Epoch 75/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 76/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0137  
Epoch 77/100  
69/69 - 1s - loss: 0.0146 - val\_loss: 0.0138  
Epoch 78/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0134  
Epoch 79/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0140  
Epoch 80/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 81/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0138  
Epoch 82/100  
69/69 - 1s - loss: 0.0147 - val\_loss: 0.0138  
Epoch 83/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 84/100  
69/69 - 1s - loss: 0.0144 - val\_loss: 0.0134  
Epoch 85/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0137  
Epoch 86/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 87/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 88/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 89/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 90/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 91/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0135  
Epoch 92/100  
69/69 - 1s - loss: 0.0145 - val\_loss: 0.0135

```

Epoch 93/100
69/69 - 1s - loss: 0.0145 - val_loss: 0.0135
Epoch 94/100
69/69 - 1s - loss: 0.0145 - val_loss: 0.0135
Epoch 95/100
69/69 - 1s - loss: 0.0144 - val_loss: 0.0134
Epoch 96/100
69/69 - 1s - loss: 0.0144 - val_loss: 0.0135
Epoch 97/100
69/69 - 1s - loss: 0.0144 - val_loss: 0.0135
Epoch 98/100
69/69 - 1s - loss: 0.0144 - val_loss: 0.0135
Epoch 99/100
69/69 - 1s - loss: 0.0144 - val_loss: 0.0135
Epoch 100/100
69/69 - 1s - loss: 0.0144 - val_loss: 0.0135
Training on GPU took: 65.33863520622253 seconds

```



Test RMSE: 26.671

```
In [22]: train_model(150, 100, 96, 'gpu')
```

```
env: CUDA_VISIBLE_DEVICES=0
```

```
var1(t-1) var2(t-1) var3(t-1) ... var7(t-1) var8(t-1) var1(t)
```

1	0.129779	0.352941	0.245902	...	0.000000	0.0	0.148893
2	0.148893	0.367647	0.245902	...	0.000000	0.0	0.159960
3	0.159960	0.426471	0.229508	...	0.000000	0.0	0.182093
4	0.182093	0.485294	0.229508	...	0.037037	0.0	0.138833
5	0.138833	0.485294	0.229508	...	0.074074	0.0	0.109658

[5 rows x 9 columns]

(8760, 1, 8) (8760,) (35039, 1, 8) (35039,)

env: CUDA\_VISIBLE\_DEVICES=0

Epoch 1/100

92/92 - 2s - loss: 0.0547 - val\_loss: 0.0614

Epoch 2/100

92/92 - 1s - loss: 0.0300 - val\_loss: 0.0513

Epoch 3/100

92/92 - 1s - loss: 0.0184 - val\_loss: 0.0413

Epoch 4/100

92/92 - 1s - loss: 0.0161 - val\_loss: 0.0242

Epoch 5/100

92/92 - 1s - loss: 0.0152 - val\_loss: 0.0194

Epoch 6/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0177

Epoch 7/100

92/92 - 1s - loss: 0.0151 - val\_loss: 0.0147

Epoch 8/100

92/92 - 1s - loss: 0.0150 - val\_loss: 0.0141

Epoch 9/100

92/92 - 1s - loss: 0.0150 - val\_loss: 0.0142

Epoch 10/100

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0144

Epoch 11/100

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0144

Epoch 12/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0145

Epoch 13/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0143

Epoch 14/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0142

Epoch 15/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0138

Epoch 16/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0137

Epoch 17/100

92/92 - 1s - loss: 0.0149 - val\_loss: 0.0139

Epoch 18/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0137

Epoch 19/100

92/92 - 1s - loss: 0.0146 - val\_loss: 0.0137

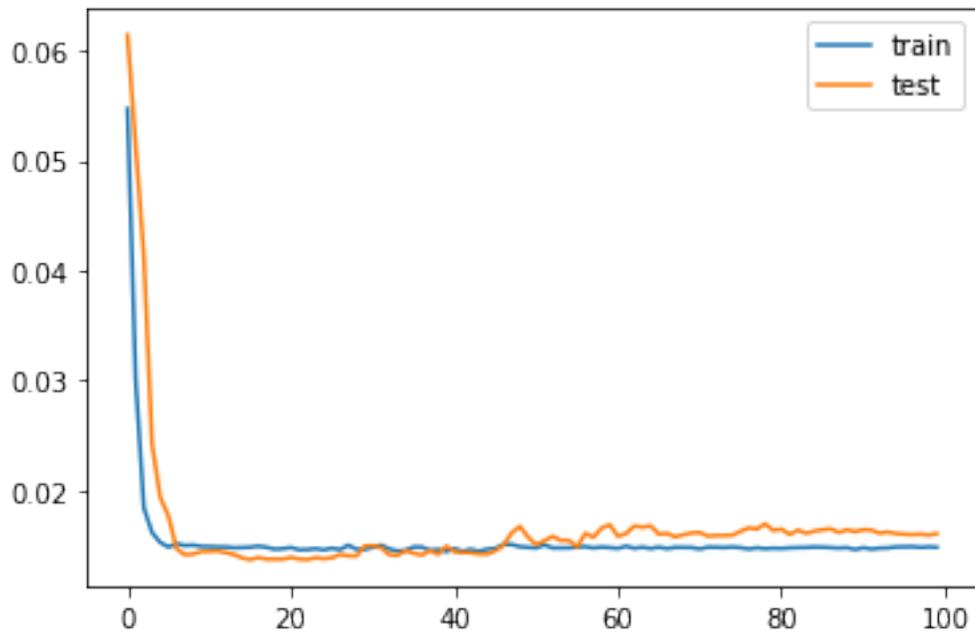
Epoch 20/100

92/92 - 1s - loss: 0.0147 - val\_loss: 0.0137  
Epoch 21/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0139  
Epoch 22/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0137  
Epoch 23/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0137  
Epoch 24/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0139  
Epoch 25/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0138  
Epoch 26/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0139  
Epoch 27/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0142  
Epoch 28/100  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0140  
Epoch 29/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0140  
Epoch 30/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0149  
Epoch 31/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0150  
Epoch 32/100  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0148  
Epoch 33/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0141  
Epoch 34/100  
92/92 - 1s - loss: 0.0145 - val\_loss: 0.0141  
Epoch 35/100  
92/92 - 1s - loss: 0.0145 - val\_loss: 0.0145  
Epoch 36/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0143  
Epoch 37/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0141  
Epoch 38/100  
92/92 - 1s - loss: 0.0145 - val\_loss: 0.0145  
Epoch 39/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0142  
Epoch 40/100  
92/92 - 1s - loss: 0.0144 - val\_loss: 0.0149  
Epoch 41/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0144  
Epoch 42/100  
92/92 - 1s - loss: 0.0144 - val\_loss: 0.0143  
Epoch 43/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0143  
Epoch 44/100

92/92 - 1s - loss: 0.0144 - val\_loss: 0.0142  
Epoch 45/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0142  
Epoch 46/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0145  
Epoch 47/100  
92/92 - 1s - loss: 0.0151 - val\_loss: 0.0150  
Epoch 48/100  
92/92 - 1s - loss: 0.0151 - val\_loss: 0.0161  
Epoch 49/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0167  
Epoch 50/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0157  
Epoch 51/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0151  
Epoch 52/100  
92/92 - 1s - loss: 0.0150 - val\_loss: 0.0154  
Epoch 53/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0158  
Epoch 54/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0154  
Epoch 55/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0154  
Epoch 56/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0148  
Epoch 57/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0161  
Epoch 58/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0157  
Epoch 59/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0166  
Epoch 60/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0169  
Epoch 61/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0158  
Epoch 62/100  
92/92 - 1s - loss: 0.0149 - val\_loss: 0.0161  
Epoch 63/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0167  
Epoch 64/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0166  
Epoch 65/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0168  
Epoch 66/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0160  
Epoch 67/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0161  
Epoch 68/100

92/92 - 1s - loss: 0.0148 - val\_loss: 0.0158  
Epoch 69/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0160  
Epoch 70/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0161  
Epoch 71/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0162  
Epoch 72/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0158  
Epoch 73/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0159  
Epoch 74/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0159  
Epoch 75/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0159  
Epoch 76/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0163  
Epoch 77/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0166  
Epoch 78/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0165  
Epoch 79/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0169  
Epoch 80/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0163  
Epoch 81/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0165  
Epoch 82/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0160  
Epoch 83/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0164  
Epoch 84/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0161  
Epoch 85/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0163  
Epoch 86/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0164  
Epoch 87/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0165  
Epoch 88/100  
92/92 - 1s - loss: 0.0147 - val\_loss: 0.0162  
Epoch 89/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0164  
Epoch 90/100  
92/92 - 1s - loss: 0.0146 - val\_loss: 0.0162  
Epoch 91/100  
92/92 - 1s - loss: 0.0148 - val\_loss: 0.0164  
Epoch 92/100

```
92/92 - 1s - loss: 0.0146 - val_loss: 0.0164
Epoch 93/100
92/92 - 1s - loss: 0.0147 - val_loss: 0.0161
Epoch 94/100
92/92 - 1s - loss: 0.0147 - val_loss: 0.0162
Epoch 95/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0161
Epoch 96/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0160
Epoch 97/100
92/92 - 1s - loss: 0.0149 - val_loss: 0.0160
Epoch 98/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0160
Epoch 99/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0159
Epoch 100/100
92/92 - 1s - loss: 0.0148 - val_loss: 0.0161
Training on GPU took: 83.32967782020569 seconds
```



Test RMSE: 29.532

In [ ]: