

# Introduction to Deep Learning Regression Models

A typical problem with linear regression models is how to specify the list of predictor variables (or features) to include when the list of possible predictors is very large (in the hundreds or thousands). It is usually impossible to test all possible models. This gets even worse when we consider possible interactions between different predictors. For problems such as these, Deep Learning models are an attractive option. Deep Learning is an area of machine learning where we seek a predictor  $F$  of output  $Y$  given (usually) high dimensional inputs  $X$ ,

$$Y = F(X),$$

where  $F$  is constructed via a nested series of functions called *layers*.  $Y$  can be continuous, discrete or mixed. When  $Y$  is continuous we call the resulting model a regression model. In the following we focus on this case.

The number and type of layers of  $F$  is called the *architecture* of the model. To train the model (i.e., find  $F$ ), we specify a loss function that measures the degree of success in learning and an algorithm/optimizer that guides the learning process. Deep Learning models can be trained in R using the package **Keras**. This package provides an easy to use interface to Google's *TensorFlow* engine (and others).

In order to understand the idea of layers, consider the following simple DL model where we assume we have  $K$  inputs  $X$ :

$$\begin{aligned} Y &= w_2' f^1 + b_2, \\ f^1 &= \text{ReLU}(w_1 X + b_1), \end{aligned}$$

and ReLU is the rectified linear unit function (vector function):

$$\text{ReLU}(z) = (\max\{0, z_1\}, \dots, \max\{0, z_L\}),$$

where  $L$  is the dimension of the argument  $z$ . The ReLU function is an example of an *activation* function. It is crucial that it is a non-linear function - if it wasn't we would just end up with a linear model in the end (to see this just substitute  $f^1 = w_1 X + b_1$  into the top layer).

This is a shallow learner - there is only one hidden layer and the output layer. In practice, DL models can have many hidden layers. The parameters of this model are  $w_2, b_2, w_1, b_1$ . The number of parameters of the model depends on the *width* of each layer. For example, if first layer (the hidden layer) has a width of 16, then the number of parameters in this layer is  $16 * K + 16$  (why? because  $w_1$  is then a  $16 \times K$  array and  $b_1$  is a  $16 \times 1$  vector). The number of parameters in the second layer - which here is the final layer - also called the *output layer* - is driven by the architecture of the first layer. The number of parameters in the output layer would here be  $16 + 1 = 17$  (why? since the output from the first layer -  $f^1$  - is 16 dimensional). So if we have  $K = 100$  inputs, then this model would have

$$16 * 100 + 16 + 16 + 1 = 1633 \text{ parameters.}$$

This large number of parameters make DL models extremely prone to overfitting in the training sample and is the main reason why we never judge them on the performance in the training sample. The standard procedure is to split the full sample into three: training, validation and test. We use the training and validation data to fine tune the architecture of the model and then judge performance on the test data.

We can specify the architecture of this model in **Keras** as

```
library(keras)
K=100
model <- keras_model_sequential() %>%
  layer_dense(units = 16, activation = "relu", input_shape = c(K)) %>%
  layer_dense(units = 1)
```

We can check our parameter calculation by looking at the structure of the model

```
model
```

```
## Model
## Model: "sequential"
## _____
## Layer (type)                Output Shape          Param #
## =====
## dense (Dense)                (None, 16)            1616
## _____
## dense_1 (Dense)              (None, 1)             17
## =====
## Total params: 1,633
## Trainable params: 1,633
## Non-trainable params: 0
## _____
```

## Case Study: Pricing a Tractor

Let's develop a deep learning model to predict prices in the tractor example we used for the linear model. We start by reading in the data and make the same grouping of the age variable we used for the linear model.



```

## get libraries
library(tidyverse)
library(keras)
library(recipes) # for setting up data for keras

## read data
train <- bind_rows(read_csv('data/auction_tractor_train.csv'),
                  read_csv('data/auction_tractor_validation.csv')) %>%
  mutate(MachineAgeCat = cut(MachineAge,
                             breaks=c(0,2,4,6,10,15,100),
                             include.lowest=T,
                             labels = c('<= 2', '3-4', '5-6', '7-10', '11-15', '>15')),
         saleyear = factor(saleyear))

test <- read_csv('data/auction_tractor_test.csv') %>%
  mutate(MachineAgeCat = cut(MachineAge,
                             breaks=c(0,2,4,6,10,15,100),
                             include.lowest=T,
                             labels = c('<= 2', '3-4', '5-6', '7-10', '11-15', '>15')),
         saleyear = factor(saleyear))

```

The first thing to do is to set up the data in the right way. To use the *keras* library we first need to “one-hot” code all factors used as inputs. This simply means turning each factor into a set of dummy columns. As an example, take the input *fiSecondaryDesc* (these are different models of tractors). The possible values for this input is

```
table(train$fiSecondaryDesc)
```

```

##
##      C      D      E      H      K      M      N      R
## 1447 1839  155 2638   79 1254  722 1826

```

So there are 8 different values for this input. Since there are 9960 observations in the training data, the one-hot coded version of *fiSecondaryDesc* will be a 9960 x 8 array of ones and zeros. Each row will be all zeros except for one element being one (corresponding to that tractor’s model).

For example, if the first five observations of this input was “C”, “C”, “H”, “E”, “M”, then the one-hot coded version would be

<b>fiSecondaryDesc</b>	<b>XC</b>	<b>XD</b>	<b>XE</b>	<b>XH</b>	<b>XK</b>	<b>XM</b>	<b>XN</b>	<b>XR</b>
C	1	0	0	0	0	0	0	0
C	1	0	0	0	0	0	0	0
H	0	0	0	1	0	0	0	0
E	0	0	1	0	0	0	0	0
M	0	0	0	0	0	1	0	0

We can use the *recipes* library to generate one-hot coded versions of all the factors in one go. In the current model we will only use factors as input so this represents all the inputs we will use:

```

dataTransRec <- recipe(SalePrice ~ state+saleyear+salemonth+fiSecondaryDesc+MachineAgeCat+
                      Ripper+Hydraulics+Transmission+Travel_Controls+Blade_Type+Enclosure, data = train) %>%
step_dummy(state,saleyear,salemonth,fiSecondaryDesc,MachineAgeCat,Ripper,Hydraulics,Transmission,Travel_Controls,Blade_Type,Enclosure,one_hot = T) %>%
prep(data = train)

trainTransF <- bake(dataTransRec, new_data = train)
testTransF <- bake(dataTransRec, new_data = test)

```

This “recipe” instructs R to turn all factor inputs into one-hot coded versions. We then “bake” the recipe on the training and test data, i.e., create the one-hot coded versions.

Now we can set up the feature array for training and test, along with the targets we are trying to predict:

```

Xtrain <- trainTransF %>% select(-SalePrice)
Xtest <- testTransF %>% select(-SalePrice)

dimX <- dim(Xtrain)[2]

Ytrain <- trainTransF %>% select(SalePrice)
Ytest <- testTransF %>% select(SalePrice)

```

Ok - now down to business! Let’s try out a 3 layer model, i.e., two hidden layers and an output layer. We choose the first layer to have a width of 8 and the second one of 8 (the output layer has to have a width of one by definition).

```

model <- keras_model_sequential() %>%
  layer_dense(units=8,activation = "relu", input_shape = dimX) %>%
  layer_dense(units=8,activation = "relu") %>%
  layer_dense(units=1)

```

Next we compile the model which means setting up the optimization algorithm and the loss function that that algorithm attempts to minimize. In this case we are choosing *Adam*. This one of several popular algorithms for training deep learning models known as stochastic gradient descent algorithms. We will not go into the details of these algorithms here. For a technical overview see here (<https://www.deeplearningbook.org/contents/optimization.html>).

```

model %>%
  compile(
    optimizer=optimizer_adam(lr=0.04),
    loss="mse",
    metrics=c("mae")
  )

```

In this case we are choosing a learning rate of 0.04 (this controls how fast the algorithm learns, i.e., how much the parameters are adjusted at each step). We use a mean squared error loss which is standard for regression problems. We will also monitor the mean absolute error.

Now we are ready to train the model. We use a validation split of 20% to monitor when learning should stop (to avoid overfitting). The option *batch\_size* refers to how many data points are used to evaluate the gradient of the loss function at each step of the algorithm - in this case we use 32. That means that we can run through all the

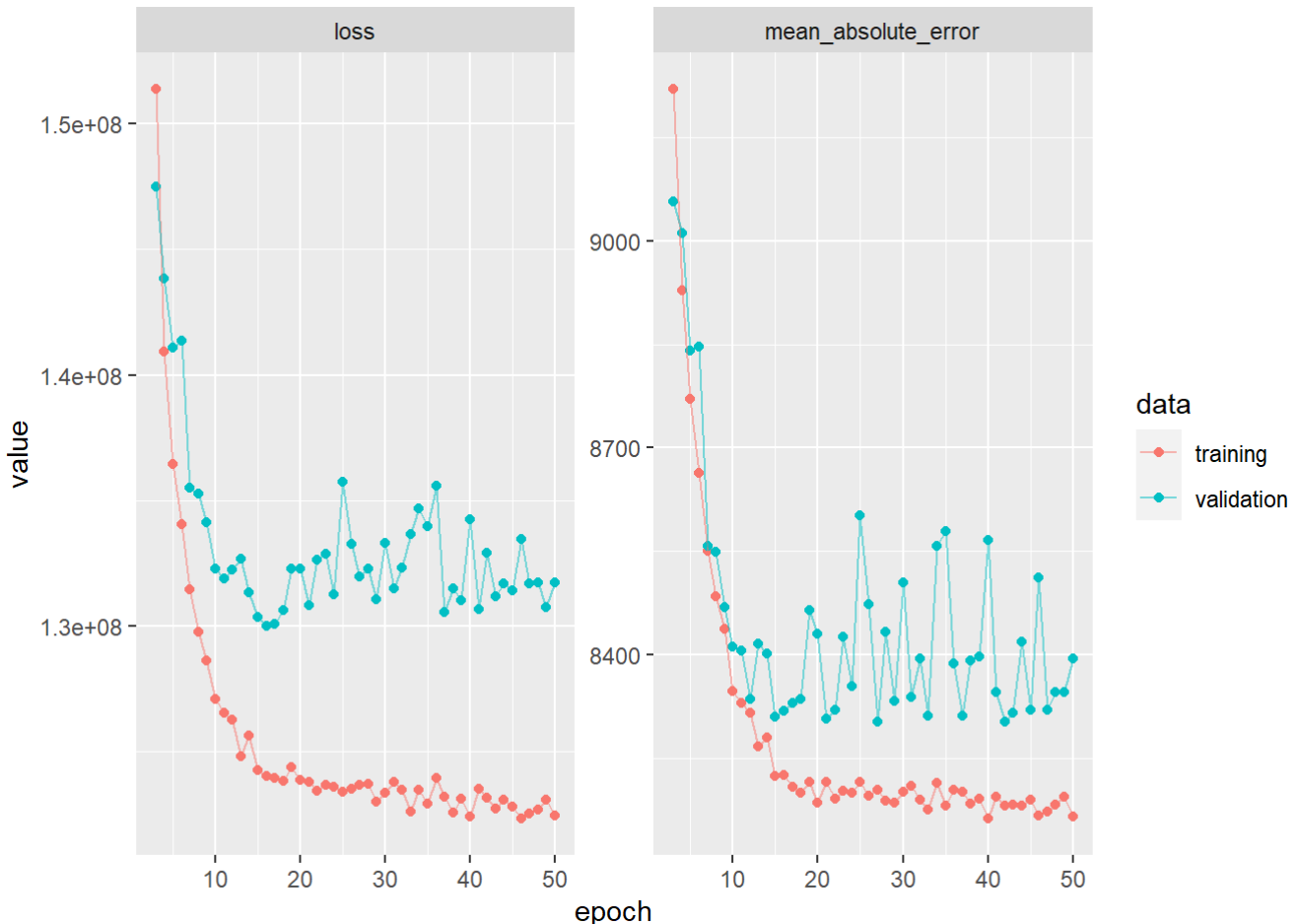
data in a total of sample size/32 steps. One run-through of the data is called an *epoch*. Here we choose to run the algorithm for a total of 50 epochs.

```
## fit
historyT <- model %>% fit(
  as.matrix(Xtrain),
  Ytrain$SalePrice,
  epochs = 50,
  batch_size = 32,
  validation_split = 0.2
)
```

Having trained the model we can plot the learning performance of the model as a function of length of learning (epochs):

```
plotDF <- as.data.frame(historyT)

plotDF %>%
  filter(epoch > 2) %>%
  ggplot(aes(x=epoch,y=value,group=data,color=data)) +
  geom_point() + geom_line(alpha=0.5) +
  facet_wrap(~metric,scales='free')
```



What we see here is that while the model continues to improve on the training data (overfitting), there is not much improvement after around 22 epochs when looking at the validation data. So we will stop learning at this point. We now re-train the model on the full training data using 22 epochs:

```

theEpoch <- 22

model <- keras_model_sequential() %>%
  layer_dense(units=8,activation = "relu", input_shape = dimX) %>%
  layer_dense(units=8,activation = "relu") %>%
  layer_dense(units=1)

model %>%
  compile(
    optimizer=optimizer_adam(lr=0.04),
    loss="mse",
    metrics=c("mae")
  )

historyT <- model %>% fit(
  as.matrix(Xtrain),
  Ytrain$SalePrice,
  epochs = theEpoch,
  batch_size = 32
  )

```

Finally we can now predict the prices in the test data:

```

## predictions
dlDF <- data.frame(predDL=predict(model,as.matrix(Xtest)),
                  salesPrice = Ytest$SalePrice)

dlDF %>%
  summarize(MAE = mean(abs(salesPrice-predDL)),
            MSE = mean((salesPrice-predDL)**2),
            RMSE = sqrt(MSE))

```

```

##           MAE           MSE           RMSE
## 1 8275.638 123400507 11108.58

```

The average absolute error is 8275. If you fit a linear model using the same features as used here, you will get an average error over \$9000.

## Python Version

We can use Keras/Tensorflow just as easily in Python. Let's start by reading the data and make the required data transformations:

```

import pandas as pd
import numpy as np
from sklearn.preprocessing import OneHotEncoder
from keras.models import Sequential
from keras.layers import Dense
import matplotlib.pyplot as plt
from keras.optimizers import adam
from sklearn.metrics import mean_absolute_error

## get data
train = pd.read_csv('data/auction_tractor_train.csv')
validation = pd.read_csv('data/auction_tractor_validation.csv')
test = pd.read_csv('data/auction_tractor_test.csv')

test['saleyear'] = test['saleyear'].astype('category')
test['MachineAgeCat'] = pd.cut(test["MachineAge"],
                               bins=[0,2,4,6,10,15,100])

allDF = pd.concat([train, validation])
allDF['MachineAgeCat'] = pd.cut(allDF["MachineAge"],
                               bins=[0,2,4,6,10,15,100])
allDF['saleyear'] = allDF['saleyear'].astype('category')

```

```
## Using TensorFlow backend.
```

Next we define the feature matrices for training and test and convert to one-hot coding using the `get_dummies` function in pandas:

```

## features
Xtrain = allDF[['saleyear', 'state', 'salemonth', 'fiSecondaryDesc', 'Ripper', 'Transmission', 'Hydraulics', 'Travel_Controls', 'Blade_Type', 'Enclosure', 'MachineAgeCat']].copy()
Xtest = test[['saleyear', 'state', 'salemonth', 'fiSecondaryDesc', 'Ripper', 'Transmission', 'Hydraulics', 'Travel_Controls', 'Blade_Type', 'Enclosure', 'MachineAgeCat']].copy()

Xtrain_enc = pd.get_dummies(data=Xtrain)
Xtest_enc = pd.get_dummies(data=Xtest)

## targets
yTrain = allDF['SalePrice']
yTest = test['SalePrice']

```

Next we build the model architecture and train using a 20% validation split:

```
model = Sequential()
model.add(Dense(8, input_dim=Xtrain_enc.shape[1], activation='relu'))
model.add(Dense(8, activation='relu'))
model.add(Dense(1))

# compile the keras model
opt = adam(lr=0.04)
model.compile(loss='mse', optimizer=opt, metrics=['mae'])

# fit the keras model on the dataset
history = model.fit(Xtrain_enc, yTrain, epochs=50, batch_size=32, validation_split=0.2)
```



```

## Train on 7968 samples, validate on 1992 samples
## Epoch 1/50
##
## 32/7968 [.....] - ETA: 32s - loss: 5416301568.0000
- mae: 67037.6172
## 1440/7968 [====>.....] - ETA: 0s - loss: 3839098402.1333
- mae: 54534.1016
## 2880/7968 [=====>.....] - ETA: 0s - loss: 3421241729.4222
- mae: 50413.5273
## 4160/7968 [=====>.....] - ETA: 0s - loss: 2773760974.2769
- mae: 43406.0078
## 5568/7968 [=====>.....] - ETA: 0s - loss: 2233369877.1494
- mae: 37744.1172
## 6976/7968 [=====>.....] - ETA: 0s - loss: 1882004780.5505
- mae: 33753.2070
## 7968/7968 [=====>.....] - 1s 65us/step - loss: 1697706701.
0442 - mae: 31523.8867 - val_loss: 377009951.4859 - val_mae: 15397.3018
## Epoch 2/50
##
## 32/7968 [.....] - ETA: 0s - loss: 339497216.0000 -
mae: 15122.1602
## 1120/7968 [====>.....] - ETA: 0s - loss: 344115562.5143 -
mae: 14620.8096
## 2368/7968 [=====>.....] - ETA: 0s - loss: 338049555.2432 -
mae: 14357.6660
## 3776/7968 [=====>.....] - ETA: 0s - loss: 314969451.2542 -
mae: 13753.4805
## 5184/7968 [=====>.....] - ETA: 0s - loss: 299366147.3086 -
mae: 13324.4941
## 6592/7968 [=====>.....] - ETA: 0s - loss: 284495016.5825 -
mae: 12899.7510
## 7968/7968 [=====>.....] - 0s 45us/step - loss: 271855386.6
667 - mae: 12532.6230 - val_loss: 203264372.3695 - val_mae: 10635.1270
## Epoch 3/50
##
## 32/7968 [.....] - ETA: 0s - loss: 117046256.0000 -
mae: 8542.9395
## 1280/7968 [====>.....] - ETA: 0s - loss: 198276478.8000 -
mae: 10493.0801
## 2656/7968 [=====>.....] - ETA: 0s - loss: 195128758.9398 -
mae: 10468.4922
## 4064/7968 [=====>.....] - ETA: 0s - loss: 184758747.7165 -
mae: 10130.3896
## 5440/7968 [=====>.....] - ETA: 0s - loss: 180112316.4706 -
mae: 10021.0254
## 6848/7968 [=====>.....] - ETA: 0s - loss: 176845936.2243 -
mae: 9948.2568
## 7968/7968 [=====>.....] - 0s 45us/step - loss: 174794601.9
277 - mae: 9881.6182 - val_loss: 157740102.2329 - val_mae: 9374.2939
## Epoch 4/50
##
## 32/7968 [.....] - ETA: 0s - loss: 130416960.0000 -
mae: 9186.4932
## 1376/7968 [====>.....] - ETA: 0s - loss: 153335267.5349 -
mae: 9289.7441
## 2656/7968 [=====>.....] - ETA: 0s - loss: 154400387.3735 -
mae: 9219.8213

```

```
## 4000/7968 [=====>.....] - ETA: 0s - loss: 154661127.7440 -  
mae: 9259.4268  
## 5408/7968 [=====>.....] - ETA: 0s - loss: 153031200.8047 -  
mae: 9245.1055  
## 6784/7968 [=====>.....] - ETA: 0s - loss: 149350820.3396 -  
mae: 9149.5215  
## 7968/7968 [=====] - 0s 44us/step - loss: 147713176.8  
835 - mae: 9113.3711 - val_loss: 147285140.1767 - val_mae: 9132.3799  
## Epoch 5/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 120505840.0000 -  
mae: 9054.2637  
## 1440/7968 [====>.....] - ETA: 0s - loss: 149403628.8000 -  
mae: 9211.8359  
## 2880/7968 [=====>.....] - ETA: 0s - loss: 144531613.1556 -  
mae: 9118.3809  
## 4256/7968 [=====>.....] - ETA: 0s - loss: 143342479.8496 -  
mae: 9071.3340  
## 5632/7968 [=====>.....] - ETA: 0s - loss: 141813106.3409 -  
mae: 9003.2412  
## 7040/7968 [=====>.....] - ETA: 0s - loss: 141077990.4182 -  
mae: 8963.2539  
## 7968/7968 [=====] - 0s 42us/step - loss: 141591639.0  
201 - mae: 8970.4414 - val_loss: 144636992.1285 - val_mae: 8992.2246  
## Epoch 6/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 130168448.0000 -  
mae: 9513.5693  
## 1376/7968 [====>.....] - ETA: 0s - loss: 133312265.4884 -  
mae: 8709.6494  
## 2848/7968 [=====>.....] - ETA: 0s - loss: 138279002.2022 -  
mae: 8800.5859  
## 4256/7968 [=====>.....] - ETA: 0s - loss: 142332811.6992 -  
mae: 8955.6787  
## 5664/7968 [=====>.....] - ETA: 0s - loss: 141929407.7966 -  
mae: 8967.6963  
## 7104/7968 [=====>.....] - ETA: 0s - loss: 138747290.1441 -  
mae: 8888.1699  
## 7968/7968 [=====] - 0s 42us/step - loss: 139534571.1  
647 - mae: 8899.9365 - val_loss: 144728460.3373 - val_mae: 9061.7539  
## Epoch 7/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 181784336.0000 -  
mae: 10864.9785  
## 1376/7968 [====>.....] - ETA: 0s - loss: 133469092.5581 -  
mae: 8776.5928  
## 2688/7968 [=====>.....] - ETA: 0s - loss: 138884777.6667 -  
mae: 8915.5137  
## 4032/7968 [=====>.....] - ETA: 0s - loss: 138879937.6825 -  
mae: 8894.6016  
## 5440/7968 [=====>.....] - ETA: 0s - loss: 138855061.3412 -  
mae: 8887.2510  
## 6880/7968 [=====>.....] - ETA: 0s - loss: 138962616.2791 -  
mae: 8872.6680  
## 7968/7968 [=====] - 0s 43us/step - loss: 138547342.1  
687 - mae: 8872.1045 - val_loss: 142211368.4819 - val_mae: 8920.1992  
## Epoch 8/50  
##
```

```

## 32/7968 [.....] - ETA: 0s - loss: 79794720.0000 -
mae: 6436.8340
## 1344/7968 [====>.....] - ETA: 0s - loss: 142701293.0476 -
mae: 8992.3975
## 2752/7968 [=====>.....] - ETA: 0s - loss: 143130210.0930 -
mae: 9060.8613
## 4192/7968 [=====>.....] - ETA: 0s - loss: 140963158.3206 -
mae: 8944.6875
## 5056/7968 [=====>.....] - ETA: 0s - loss: 139973827.6456 -
mae: 8906.9434
## 6208/7968 [=====>.....] - ETA: 0s - loss: 141334826.2680 -
mae: 8952.6895
## 7520/7968 [=====>..] - ETA: 0s - loss: 138153475.0128 -
mae: 8864.0391
## 7968/7968 [=====] - 0s 47us/step - loss: 138371709.2
691 - mae: 8876.5850 - val_loss: 143432496.0643 - val_mae: 8994.4424
## Epoch 9/50
##
## 32/7968 [.....] - ETA: 0s - loss: 157548960.0000 -
mae: 8816.2998
## 1376/7968 [====>.....] - ETA: 0s - loss: 142881367.4419 -
mae: 9024.6045
## 2784/7968 [=====>.....] - ETA: 0s - loss: 138121951.3103 -
mae: 8814.6426
## 4096/7968 [=====>.....] - ETA: 0s - loss: 138264729.6250 -
mae: 8836.2627
## 5472/7968 [=====>.....] - ETA: 0s - loss: 137209139.2749 -
mae: 8829.6270
## 6784/7968 [=====>.....] - ETA: 0s - loss: 138743746.1887 -
mae: 8887.6309
## 7968/7968 [=====] - 0s 43us/step - loss: 138298053.1
406 - mae: 8870.1533 - val_loss: 142324562.1847 - val_mae: 8918.6221
## Epoch 10/50
##
## 32/7968 [.....] - ETA: 0s - loss: 111525352.0000 -
mae: 7824.9531
## 1440/7968 [====>.....] - ETA: 0s - loss: 137340728.8889 -
mae: 8788.4521
## 2816/7968 [=====>.....] - ETA: 0s - loss: 144683803.9545 -
mae: 9075.1729
## 4256/7968 [=====>.....] - ETA: 0s - loss: 141695850.9173 -
mae: 8993.3174
## 5728/7968 [=====>.....] - ETA: 0s - loss: 141998725.2961 -
mae: 8973.8926
## 7136/7968 [=====>....] - ETA: 0s - loss: 139868494.7265 -
mae: 8895.7959
## 7968/7968 [=====] - 0s 42us/step - loss: 137696881.1
406 - mae: 8828.6260 - val_loss: 142378024.9317 - val_mae: 8844.9785
## Epoch 11/50
##
## 32/7968 [.....] - ETA: 0s - loss: 160596992.0000 -
mae: 9825.8594
## 1376/7968 [====>.....] - ETA: 0s - loss: 128513635.9070 -
mae: 8575.1943
## 2848/7968 [=====>.....] - ETA: 0s - loss: 138936933.0787 -
mae: 8815.8467
## 4256/7968 [=====>.....] - ETA: 0s - loss: 136045808.8120 -
mae: 8777.2539

```

```
## 5760/7968 [=====>.....] - ETA: 0s - loss: 138557012.2444 -  
mae: 8832.1699  
## 7296/7968 [=====>...] - ETA: 0s - loss: 136245080.7544 -  
mae: 8778.9053  
## 7968/7968 [=====>] - 0s 41us/step - loss: 136189914.1  
526 - mae: 8758.0322 - val_loss: 140801113.7028 - val_mae: 8749.2217  
## Epoch 12/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 139764992.0000 -  
mae: 8938.4023  
## 1536/7968 [=====>.....] - ETA: 0s - loss: 129078918.6667 -  
mae: 8487.7988  
## 2944/7968 [=====>.....] - ETA: 0s - loss: 133446302.3478 -  
mae: 8655.6377  
## 4352/7968 [=====>.....] - ETA: 0s - loss: 131296379.2353 -  
mae: 8562.7148  
## 5856/7968 [=====>.....] - ETA: 0s - loss: 133397859.8033 -  
mae: 8618.1445  
## 7328/7968 [=====>...] - ETA: 0s - loss: 133783429.9039 -  
mae: 8662.7383  
## 7968/7968 [=====>] - 0s 41us/step - loss: 134216213.5  
261 - mae: 8671.5918 - val_loss: 138717994.3454 - val_mae: 8653.0059  
## Epoch 13/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 143498016.0000 -  
mae: 9902.8506  
## 1536/7968 [=====>.....] - ETA: 0s - loss: 124758309.9167 -  
mae: 8451.3057  
## 2848/7968 [=====>.....] - ETA: 0s - loss: 127738792.4045 -  
mae: 8554.4297  
## 4192/7968 [=====>.....] - ETA: 0s - loss: 127654729.9542 -  
mae: 8522.3672  
## 5696/7968 [=====>.....] - ETA: 0s - loss: 129551599.1910 -  
mae: 8536.7344  
## 7104/7968 [=====>...] - ETA: 0s - loss: 130291231.7297 -  
mae: 8505.1582  
## 7968/7968 [=====>] - 0s 41us/step - loss: 132611003.6  
466 - mae: 8574.5820 - val_loss: 136799592.8675 - val_mae: 8590.7227  
## Epoch 14/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 99927184.0000 -  
mae: 8093.6802  
## 1440/7968 [=====>.....] - ETA: 0s - loss: 142164501.0667 -  
mae: 8801.4463  
## 2816/7968 [=====>.....] - ETA: 0s - loss: 136079198.2273 -  
mae: 8648.9717  
## 4288/7968 [=====>.....] - ETA: 0s - loss: 135140009.2836 -  
mae: 8635.3721  
## 5792/7968 [=====>.....] - ETA: 0s - loss: 129663184.3094 -  
mae: 8459.9805  
## 7296/7968 [=====>...] - ETA: 0s - loss: 131020667.2982 -  
mae: 8506.7295  
## 7968/7968 [=====>] - 0s 40us/step - loss: 130437785.6  
064 - mae: 8487.3652 - val_loss: 135119113.7028 - val_mae: 8532.7490  
## Epoch 15/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 82834344.0000 -  
mae: 6922.1338
```

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## 1600/7968 [=====>.....] - ETA: 0s - loss: 141119494.4000 -
mae: 8667.4199
## 3040/7968 [=====>.....] - ETA: 0s - loss: 129984144.8421 -
mae: 8411.8447
## 4320/7968 [=====>.....] - ETA: 0s - loss: 128723106.5481 -
mae: 8358.3506
## 5856/7968 [=====>.....] - ETA: 0s - loss: 130364377.3333 -
mae: 8420.7725
## 7424/7968 [=====>.....] - ETA: 0s - loss: 131058784.4138 -
mae: 8477.2402
## 7968/7968 [=====>.....] - 0s 41us/step - loss: 130033864.1
606 - mae: 8452.6699 - val_loss: 134084878.9076 - val_mae: 8450.3574
## Epoch 16/50
##
## 32/7968 [.....] - ETA: 0s - loss: 90553896.0000 -
mae: 7580.9043
## 1536/7968 [=====>.....] - ETA: 0s - loss: 138267914.2500 -
mae: 8735.3740
## 2976/7968 [=====>.....] - ETA: 0s - loss: 130926716.9892 -
mae: 8476.8740
## 4288/7968 [=====>.....] - ETA: 0s - loss: 128595532.0896 -
mae: 8389.8896
## 5664/7968 [=====>.....] - ETA: 0s - loss: 129622566.8249 -
mae: 8430.0420
## 7168/7968 [=====>.....] - ETA: 0s - loss: 128388938.7500 -
mae: 8399.4971
## 7968/7968 [=====>.....] - 0s 42us/step - loss: 128154657.2
209 - mae: 8396.3408 - val_loss: 134005111.3896 - val_mae: 8476.3018
## Epoch 17/50
##
## 32/7968 [.....] - ETA: 0s - loss: 108644776.0000 -
mae: 8450.0391
## 1536/7968 [=====>.....] - ETA: 0s - loss: 130471187.0000 -
mae: 8379.0801
## 2976/7968 [=====>.....] - ETA: 0s - loss: 129915435.7849 -
mae: 8400.8955
## 4448/7968 [=====>.....] - ETA: 0s - loss: 131233984.0863 -
mae: 8462.8105
## 5824/7968 [=====>.....] - ETA: 0s - loss: 131134730.1319 -
mae: 8466.5635
## 7264/7968 [=====>.....] - ETA: 0s - loss: 128004502.3260 -
mae: 8376.6230
## 7968/7968 [=====>.....] - 0s 43us/step - loss: 127319097.0
442 - mae: 8348.0654 - val_loss: 132583522.0562 - val_mae: 8403.7979
## Epoch 18/50
##
## 32/7968 [.....] - ETA: 0s - loss: 115709368.0000 -
mae: 7808.6426
## 1504/7968 [=====>.....] - ETA: 0s - loss: 124340015.4043 -
mae: 8255.7148
## 3040/7968 [=====>.....] - ETA: 0s - loss: 127097594.5684 -
mae: 8331.0527
## 4448/7968 [=====>.....] - ETA: 0s - loss: 130001126.1871 -
mae: 8437.2871
## 5824/7968 [=====>.....] - ETA: 0s - loss: 126846862.8132 -
mae: 8340.5801
## 7360/7968 [=====>.....] - ETA: 0s - loss: 126383453.4783 -
mae: 8326.7500
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## 7968/7968 [=====] - 0s 41us/step - loss: 126381295.3
896 - mae: 8313.5049 - val_loss: 132717106.3133 - val_mae: 8367.1152
## Epoch 19/50
##
## 32/7968 [.....] - ETA: 0s - loss: 176520352.0000 -
mae: 9578.0254
## 1536/7968 [====>.....] - ETA: 0s - loss: 129751688.9167 -
mae: 8486.3779
## 3040/7968 [=====>.....] - ETA: 0s - loss: 128143984.8421 -
mae: 8441.8154
## 4512/7968 [=====>.....] - ETA: 0s - loss: 128577080.5674 -
mae: 8414.3018
## 5792/7968 [=====>.....] - ETA: 0s - loss: 127982000.2652 -
mae: 8373.9424
## 7296/7968 [=====>...] - ETA: 0s - loss: 126913311.0702 -
mae: 8308.2471
## 7968/7968 [=====] - 0s 40us/step - loss: 125702041.7
671 - mae: 8279.2295 - val_loss: 132147103.1325 - val_mae: 8372.3936
## Epoch 20/50
##
## 32/7968 [.....] - ETA: 0s - loss: 78422976.0000 -
mae: 6909.6680
## 1600/7968 [====>.....] - ETA: 0s - loss: 120692775.4400 -
mae: 8255.0742
## 3008/7968 [=====>.....] - ETA: 0s - loss: 123330292.8085 -
mae: 8295.9404
## 4480/7968 [=====>.....] - ETA: 0s - loss: 124681376.8286 -
mae: 8338.6514
## 5920/7968 [=====>.....] - ETA: 0s - loss: 124222580.5189 -
mae: 8275.5459
## 7424/7968 [=====>...] - ETA: 0s - loss: 126047681.1207 -
mae: 8284.5586
## 7968/7968 [=====] - 0s 40us/step - loss: 125119624.7
229 - mae: 8259.6836 - val_loss: 131970813.3333 - val_mae: 8354.3994
## Epoch 21/50
##
## 32/7968 [.....] - ETA: 0s - loss: 147288720.0000 -
mae: 9332.7773
## 1536/7968 [====>.....] - ETA: 0s - loss: 138406738.4167 -
mae: 8754.9121
## 3040/7968 [=====>.....] - ETA: 0s - loss: 130291842.3579 -
mae: 8445.8857
## 4608/7968 [=====>.....] - ETA: 0s - loss: 129326514.8611 -
mae: 8393.3438
## 6016/7968 [=====>.....] - ETA: 0s - loss: 127270162.1064 -
mae: 8313.2041
## 7488/7968 [=====>..] - ETA: 0s - loss: 125024925.2650 -
mae: 8259.6250
## 7968/7968 [=====] - 0s 40us/step - loss: 124755887.6
466 - mae: 8231.0508 - val_loss: 132592650.6024 - val_mae: 8406.0596
## Epoch 22/50
##
## 32/7968 [.....] - ETA: 0s - loss: 96195776.0000 -
mae: 7603.6924
## 1472/7968 [====>.....] - ETA: 0s - loss: 119998809.3478 -
mae: 8096.5732
## 2912/7968 [=====>.....] - ETA: 0s - loss: 119065073.1648 -
mae: 8081.0459

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## 4416/7968 [=====>.....] - ETA: 0s - loss: 120215733.1159 -
mae: 8086.0635
## 5888/7968 [=====>.....] - ETA: 0s - loss: 125889954.4457 -
mae: 8244.7480
## 7264/7968 [=====>...] - ETA: 0s - loss: 125953708.2203 -
mae: 8258.0918
## 7968/7968 [=====] - 0s 40us/step - loss: 125008855.3
333 - mae: 8233.5752 - val_loss: 131042334.0080 - val_mae: 8315.7490
## Epoch 23/50
##
## 32/7968 [.....] - ETA: 0s - loss: 63433736.0000 -
mae: 6470.3311
## 1408/7968 [====>.....] - ETA: 0s - loss: 111596158.8182 -
mae: 7859.4497
## 2880/7968 [=====>.....] - ETA: 0s - loss: 125189715.0667 -
mae: 8242.2686
## 4192/7968 [=====>.....] - ETA: 0s - loss: 123062516.1527 -
mae: 8237.7871
## 5408/7968 [=====>.....] - ETA: 0s - loss: 125706236.7337 -
mae: 8257.5928
## 6688/7968 [=====>.....] - ETA: 0s - loss: 126326007.4258 -
mae: 8290.5762
## 7968/7968 [=====] - 0s 45us/step - loss: 124718313.6
546 - mae: 8227.5068 - val_loss: 132483697.2209 - val_mae: 8438.8633
## Epoch 24/50
##
## 32/7968 [.....] - ETA: 0s - loss: 156282176.0000 -
mae: 9973.4521
## 1312/7968 [====>.....] - ETA: 0s - loss: 113050408.1951 -
mae: 7956.5952
## 2592/7968 [=====>.....] - ETA: 0s - loss: 118103156.7901 -
mae: 8052.4531
## 3808/7968 [=====>.....] - ETA: 0s - loss: 123701327.5966 -
mae: 8282.1787
## 5056/7968 [=====>.....] - ETA: 0s - loss: 126231970.9620 -
mae: 8331.7617
## 6240/7968 [=====>.....] - ETA: 0s - loss: 125007713.7026 -
mae: 8270.9121
## 7360/7968 [=====>...] - ETA: 0s - loss: 124981294.3130 -
mae: 8253.0029
## 7968/7968 [=====] - 0s 49us/step - loss: 124254230.8
273 - mae: 8221.7217 - val_loss: 131205201.2851 - val_mae: 8323.8477
## Epoch 25/50
##
## 32/7968 [.....] - ETA: 0s - loss: 70132120.0000 -
mae: 6953.7324
## 1248/7968 [====>.....] - ETA: 0s - loss: 126679169.8462 -
mae: 8362.4033
## 2304/7968 [=====>.....] - ETA: 0s - loss: 124446048.8889 -
mae: 8291.2061
## 3360/7968 [=====>.....] - ETA: 0s - loss: 126295008.0000 -
mae: 8319.6504
## 4512/7968 [=====>.....] - ETA: 0s - loss: 126177727.0922 -
mae: 8261.1963
## 5664/7968 [=====>.....] - ETA: 0s - loss: 126159698.5311 -
mae: 8273.3027
## 6848/7968 [=====>.....] - ETA: 0s - loss: 124307122.1869 -
mae: 8200.6748

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## 7968/7968 [=====] - 0s 52us/step - loss: 124662148.0
161 - mae: 8219.5342 - val_loss: 130882799.1004 - val_mae: 8266.1748
## Epoch 26/50
##
## 32/7968 [.....] - ETA: 0s - loss: 90083824.0000 -
mae: 6979.1104
## 1248/7968 [====>.....] - ETA: 0s - loss: 118413742.1538 -
mae: 8028.6235
## 2464/7968 [=====>.....] - ETA: 0s - loss: 120957283.5844 -
mae: 8044.5171
## 3616/7968 [=====>.....] - ETA: 0s - loss: 121149695.8584 -
mae: 8112.7329
## 5024/7968 [=====>.....] - ETA: 0s - loss: 121203616.3312 -
mae: 8122.9731
## 6400/7968 [=====>.....] - ETA: 0s - loss: 121235047.1600 -
mae: 8112.4062
## 7840/7968 [=====>.] - ETA: 0s - loss: 124496243.6571 -
mae: 8199.3428
## 7968/7968 [=====] - 0s 45us/step - loss: 124127709.3
976 - mae: 8191.7222 - val_loss: 130826904.1606 - val_mae: 8341.8105
## Epoch 27/50
##
## 32/7968 [.....] - ETA: 0s - loss: 220220816.0000 -
mae: 11041.1865
## 1408/7968 [====>.....] - ETA: 0s - loss: 123137811.6364 -
mae: 8086.7285
## 2912/7968 [=====>.....] - ETA: 0s - loss: 121817853.4945 -
mae: 8128.2319
## 4288/7968 [=====>.....] - ETA: 0s - loss: 122447826.8060 -
mae: 8161.2397
## 5632/7968 [=====>.....] - ETA: 0s - loss: 124886037.7500 -
mae: 8207.5967
## 7040/7968 [=====>....] - ETA: 0s - loss: 124743949.2909 -
mae: 8220.5166
## 7968/7968 [=====] - 0s 42us/step - loss: 124177781.1
245 - mae: 8212.9248 - val_loss: 131937703.8394 - val_mae: 8275.0527
## Epoch 28/50
##
## 32/7968 [.....] - ETA: 0s - loss: 94462272.0000 -
mae: 7294.7100
## 1536/7968 [====>.....] - ETA: 0s - loss: 125115813.0000 -
mae: 8175.7246
## 3008/7968 [=====>.....] - ETA: 0s - loss: 125258065.4468 -
mae: 8134.1011
## 4448/7968 [=====>.....] - ETA: 0s - loss: 126965684.6619 -
mae: 8202.4521
## 5856/7968 [=====>.....] - ETA: 0s - loss: 123888083.8907 -
mae: 8163.8442
## 7328/7968 [=====>...] - ETA: 0s - loss: 124343888.6463 -
mae: 8199.4102
## 7968/7968 [=====] - 0s 40us/step - loss: 124044930.2
329 - mae: 8199.3311 - val_loss: 130706507.7590 - val_mae: 8256.8398
## Epoch 29/50
##
## 32/7968 [.....] - ETA: 0s - loss: 167879312.0000 -
mae: 9729.2354
## 1536/7968 [====>.....] - ETA: 0s - loss: 124193670.6667 -
mae: 8160.0181
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## 3072/7968 [=====>.....] - ETA: 0s - loss: 123881465.8750 -  
mae: 8158.7075  
## 4544/7968 [=====>.....] - ETA: 0s - loss: 125497972.1408 -  
mae: 8221.0938  
## 5984/7968 [=====>.....] - ETA: 0s - loss: 127058409.1123 -  
mae: 8274.8242  
## 7424/7968 [=====>...] - ETA: 0s - loss: 125403165.8793 -  
mae: 8229.3633  
## 7968/7968 [=====>] - 0s 41us/step - loss: 124040994.9  
719 - mae: 8195.0576 - val_loss: 131076478.1365 - val_mae: 8372.3643  
## Epoch 30/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 93349272.0000 -  
mae: 7585.6426  
## 1472/7968 [=====>.....] - ETA: 0s - loss: 122257544.9565 -  
mae: 8096.8228  
## 2944/7968 [=====>.....] - ETA: 0s - loss: 123639102.1304 -  
mae: 8189.3384  
## 4480/7968 [=====>.....] - ETA: 0s - loss: 120199704.1714 -  
mae: 8066.8223  
## 5760/7968 [=====>.....] - ETA: 0s - loss: 121110904.3333 -  
mae: 8110.6196  
## 7136/7968 [=====>...] - ETA: 0s - loss: 123210584.4664 -  
mae: 8181.1904  
## 7968/7968 [=====>] - 0s 42us/step - loss: 123761255.5  
984 - mae: 8188.6914 - val_loss: 131289811.7912 - val_mae: 8389.3701  
## Epoch 31/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 97482400.0000 -  
mae: 7156.7979  
## 1536/7968 [=====>.....] - ETA: 0s - loss: 120090654.1667 -  
mae: 8118.7441  
## 3072/7968 [=====>.....] - ETA: 0s - loss: 119764802.6250 -  
mae: 8101.2993  
## 4640/7968 [=====>.....] - ETA: 0s - loss: 120704381.1310 -  
mae: 8121.5898  
## 5984/7968 [=====>.....] - ETA: 0s - loss: 122626292.1925 -  
mae: 8166.7759  
## 7264/7968 [=====>...] - ETA: 0s - loss: 123444962.7665 -  
mae: 8182.5771  
## 7968/7968 [=====>] - 0s 41us/step - loss: 124128978.4  
739 - mae: 8213.5166 - val_loss: 132489696.8996 - val_mae: 8433.8740  
## Epoch 32/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 112909376.0000 -  
mae: 8195.0967  
## 1472/7968 [=====>.....] - ETA: 0s - loss: 128519815.3043 -  
mae: 8281.8193  
## 2848/7968 [=====>.....] - ETA: 0s - loss: 128920119.7753 -  
mae: 8308.4346  
## 4352/7968 [=====>.....] - ETA: 0s - loss: 124304468.0294 -  
mae: 8208.5811  
## 5824/7968 [=====>.....] - ETA: 0s - loss: 123844087.9121 -  
mae: 8216.6094  
## 7072/7968 [=====>...] - ETA: 0s - loss: 124142061.9005 -  
mae: 8198.0049  
## 7968/7968 [=====>] - 0s 41us/step - loss: 123634229.9  
438 - mae: 8190.0308 - val_loss: 130667710.9719 - val_mae: 8285.3271
```

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## Epoch 33/50
##
## 32/7968 [.....] - ETA: 0s - loss: 75826720.0000 -
mae: 6658.4854
## 1440/7968 [====>.....] - ETA: 0s - loss: 119350486.4889 -
mae: 7969.4951
## 2784/7968 [=====>.....] - ETA: 0s - loss: 114966407.1264 -
mae: 7900.9102
## 4384/7968 [=====>.....] - ETA: 0s - loss: 119028237.6642 -
mae: 8043.5137
## 5984/7968 [=====>.....] - ETA: 0s - loss: 123123938.3529 -
mae: 8156.6050
## 7392/7968 [=====>...] - ETA: 0s - loss: 123441808.9177 -
mae: 8171.6821
## 7968/7968 [=====>] - 0s 40us/step - loss: 123131506.6
506 - mae: 8159.6787 - val_loss: 131032473.5743 - val_mae: 8326.9775
## Epoch 34/50
##
## 32/7968 [.....] - ETA: 0s - loss: 135766768.0000 -
mae: 8111.9878
## 1504/7968 [====>.....] - ETA: 0s - loss: 125504509.6170 -
mae: 8337.6543
## 3008/7968 [=====>.....] - ETA: 0s - loss: 122389179.8298 -
mae: 8156.1982
## 4544/7968 [=====>.....] - ETA: 0s - loss: 121796720.0563 -
mae: 8097.0396
## 6144/7968 [=====>.....] - ETA: 0s - loss: 122528044.9583 -
mae: 8166.6777
## 7616/7968 [=====>..] - ETA: 0s - loss: 122862060.1681 -
mae: 8162.4668
## 7968/7968 [=====>] - 0s 39us/step - loss: 123383636.0
803 - mae: 8171.7651 - val_loss: 131036269.3012 - val_mae: 8304.9053
## Epoch 35/50
##
## 32/7968 [.....] - ETA: 0s - loss: 110666832.0000 -
mae: 8131.7949
## 1632/7968 [====>.....] - ETA: 0s - loss: 124039618.3529 -
mae: 8193.3701
## 3136/7968 [=====>.....] - ETA: 0s - loss: 118902241.4694 -
mae: 8035.0576
## 4672/7968 [=====>.....] - ETA: 0s - loss: 119168395.2329 -
mae: 8000.2329
## 6272/7968 [=====>.....] - ETA: 0s - loss: 122366528.0816 -
mae: 8142.6768
## 7840/7968 [=====>.] - ETA: 0s - loss: 122923062.4327 -
mae: 8173.4297
## 7968/7968 [=====>] - 0s 39us/step - loss: 122730932.9
799 - mae: 8163.5312 - val_loss: 130999158.0402 - val_mae: 8355.3105
## Epoch 36/50
##
## 32/7968 [.....] - ETA: 0s - loss: 136486880.0000 -
mae: 9157.0713
## 1504/7968 [====>.....] - ETA: 0s - loss: 116370466.7234 -
mae: 8110.0845
## 3040/7968 [=====>.....] - ETA: 0s - loss: 118520264.8421 -
mae: 8121.3394
## 4480/7968 [=====>.....] - ETA: 0s - loss: 118187137.6000 -
mae: 8055.8828
```

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## 6144/7968 [=====>.....] - ETA: 0s - loss: 121705762.8750 -  
mae: 8131.4829  
## 7680/7968 [=====>..] - ETA: 0s - loss: 123586780.8500 -  
mae: 8194.3018  
## 7968/7968 [=====>] - 0s 38us/step - loss: 123308656.4  
016 - mae: 8187.5498 - val_loss: 134804599.2610 - val_mae: 8590.9639  
## Epoch 37/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 75770680.0000 -  
mae: 6608.2480  
## 1632/7968 [=====>.....] - ETA: 0s - loss: 107997593.6471 -  
mae: 7689.7188  
## 3168/7968 [=====>.....] - ETA: 0s - loss: 115035379.7576 -  
mae: 7914.6880  
## 4704/7968 [=====>.....] - ETA: 0s - loss: 120383778.9116 -  
mae: 8051.9609  
## 6208/7968 [=====>.....] - ETA: 0s - loss: 121330330.0000 -  
mae: 8094.8052  
## 7744/7968 [=====>..] - ETA: 0s - loss: 121792789.2397 -  
mae: 8130.5083  
## 7968/7968 [=====>] - 0s 39us/step - loss: 123326607.2  
450 - mae: 8172.8472 - val_loss: 131087898.4096 - val_mae: 8362.5703  
## Epoch 38/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 100413232.0000 -  
mae: 8224.0352  
## 1536/7968 [=====>.....] - ETA: 0s - loss: 132803134.9167 -  
mae: 8551.0947  
## 3072/7968 [=====>.....] - ETA: 0s - loss: 127127547.2083 -  
mae: 8347.6963  
## 4544/7968 [=====>.....] - ETA: 0s - loss: 125137729.0704 -  
mae: 8271.8252  
## 6112/7968 [=====>.....] - ETA: 0s - loss: 123934326.6806 -  
mae: 8203.1260  
## 7680/7968 [=====>..] - ETA: 0s - loss: 122342459.6333 -  
mae: 8156.1982  
## 7968/7968 [=====>] - 0s 38us/step - loss: 122827635.3  
735 - mae: 8162.2046 - val_loss: 131410666.1847 - val_mae: 8293.7354  
## Epoch 39/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 94029296.0000 -  
mae: 7247.9019  
## 1440/7968 [=====>.....] - ETA: 0s - loss: 130104664.0000 -  
mae: 8302.4678  
## 2848/7968 [=====>.....] - ETA: 0s - loss: 125355571.2360 -  
mae: 8217.9990  
## 4448/7968 [=====>.....] - ETA: 0s - loss: 124333915.2230 -  
mae: 8179.6504  
## 5856/7968 [=====>.....] - ETA: 0s - loss: 125842162.7978 -  
mae: 8258.7080  
## 7232/7968 [=====>...] - ETA: 0s - loss: 124622846.1062 -  
mae: 8218.3887  
## 7968/7968 [=====>] - 0s 40us/step - loss: 122881537.6  
867 - mae: 8172.4092 - val_loss: 131548293.8474 - val_mae: 8371.9912  
## Epoch 40/50  
##  
## 32/7968 [.....] - ETA: 0s - loss: 193206640.0000 -  
mae: 9238.9385
```

```
## 1568/7968 [====>.....] - ETA: 0s - loss: 122048677.4694 -
mae: 8125.0415
## 3008/7968 [=====>.....] - ETA: 0s - loss: 124938872.4255 -
mae: 8231.5732
## 4512/7968 [=====>.....] - ETA: 0s - loss: 123069563.5177 -
mae: 8178.4204
## 5920/7968 [=====>.....] - ETA: 0s - loss: 124024879.0919 -
mae: 8173.8604
## 7360/7968 [=====>...] - ETA: 0s - loss: 124116049.3565 -
mae: 8197.4062
## 7968/7968 [=====>] - 0s 41us/step - loss: 122937473.2
369 - mae: 8165.9956 - val_loss: 133644765.7510 - val_mae: 8436.5215
## Epoch 41/50
##
## 32/7968 [.....] - ETA: 0s - loss: 154743712.0000 -
mae: 9091.5293
## 1664/7968 [====>.....] - ETA: 0s - loss: 131185091.2308 -
mae: 8410.0078
## 3136/7968 [=====>.....] - ETA: 0s - loss: 122944332.8980 -
mae: 8189.2661
## 4704/7968 [=====>.....] - ETA: 0s - loss: 121583139.5918 -
mae: 8113.1333
## 6304/7968 [=====>.....] - ETA: 0s - loss: 123097620.0406 -
mae: 8166.1914
## 7904/7968 [=====>.] - ETA: 0s - loss: 122422202.6235 -
mae: 8175.1484
## 7968/7968 [=====>] - 0s 37us/step - loss: 122678337.6
064 - mae: 8180.6499 - val_loss: 132669888.9639 - val_mae: 8301.9219
## Epoch 42/50
##
## 32/7968 [.....] - ETA: 0s - loss: 89745824.0000 -
mae: 7762.6201
## 1536/7968 [====>.....] - ETA: 0s - loss: 124746832.2500 -
mae: 8373.2461
## 3104/7968 [=====>.....] - ETA: 0s - loss: 124035948.2474 -
mae: 8295.4209
## 4512/7968 [=====>.....] - ETA: 0s - loss: 121968092.5106 -
mae: 8226.5801
## 5984/7968 [=====>.....] - ETA: 0s - loss: 124080644.8770 -
mae: 8244.1807
## 7584/7968 [=====>..] - ETA: 0s - loss: 123142008.5570 -
mae: 8193.8086
## 7968/7968 [=====>] - 0s 39us/step - loss: 122697344.4
016 - mae: 8164.3774 - val_loss: 131293078.6185 - val_mae: 8370.4219
## Epoch 43/50
##
## 32/7968 [.....] - ETA: 0s - loss: 148689472.0000 -
mae: 8472.1484
## 1632/7968 [====>.....] - ETA: 0s - loss: 124113489.6471 -
mae: 8298.4238
## 3168/7968 [=====>.....] - ETA: 0s - loss: 124763685.4141 -
mae: 8259.9658
## 4704/7968 [=====>.....] - ETA: 0s - loss: 124751706.8299 -
mae: 8232.3242
## 6208/7968 [=====>.....] - ETA: 0s - loss: 124318264.1237 -
mae: 8205.7979
## 7872/7968 [=====>.] - ETA: 0s - loss: 123065387.6423 -
mae: 8182.5757
```

```
## 7968/7968 [=====] - 0s 37us/step - loss: 123276185.9
598 - mae: 8190.9102 - val_loss: 131051003.5020 - val_mae: 8308.7637
## Epoch 44/50
##
## 32/7968 [.....] - ETA: 0s - loss: 147786528.0000 -
mae: 8734.2822
## 1536/7968 [====>.....] - ETA: 0s - loss: 119897253.7500 -
mae: 8091.3745
## 2944/7968 [=====>.....] - ETA: 0s - loss: 126805444.9130 -
mae: 8333.2480
## 4416/7968 [=====>.....] - ETA: 0s - loss: 123744359.7681 -
mae: 8198.2686
## 5760/7968 [=====>.....] - ETA: 0s - loss: 123298600.0444 -
mae: 8190.9570
## 7296/7968 [=====>...] - ETA: 0s - loss: 122365771.8772 -
mae: 8145.1289
## 7968/7968 [=====] - 0s 40us/step - loss: 123016839.5
663 - mae: 8169.2603 - val_loss: 136567360.7711 - val_mae: 8647.6016
## Epoch 45/50
##
## 32/7968 [.....] - ETA: 0s - loss: 164937776.0000 -
mae: 9480.4121
## 1504/7968 [====>.....] - ETA: 0s - loss: 113115800.3404 -
mae: 7945.2827
## 3072/7968 [=====>.....] - ETA: 0s - loss: 121590887.0417 -
mae: 8138.2930
## 4704/7968 [=====>.....] - ETA: 0s - loss: 123177495.1293 -
mae: 8188.3672
## 6144/7968 [=====>.....] - ETA: 0s - loss: 123476889.0417 -
mae: 8167.9946
## 7424/7968 [=====>...] - ETA: 0s - loss: 123853809.1207 -
mae: 8194.6318
## 7968/7968 [=====] - 0s 40us/step - loss: 123407169.6
546 - mae: 8196.3965 - val_loss: 130651016.4819 - val_mae: 8293.2246
## Epoch 46/50
##
## 32/7968 [.....] - ETA: 0s - loss: 102110704.0000 -
mae: 7351.9854
## 1376/7968 [====>.....] - ETA: 0s - loss: 129725807.2558 -
mae: 8406.7012
## 2656/7968 [=====>.....] - ETA: 0s - loss: 119580999.4217 -
mae: 8071.0073
## 3936/7968 [=====>.....] - ETA: 0s - loss: 123643411.9350 -
mae: 8212.4912
## 5248/7968 [=====>.....] - ETA: 0s - loss: 122986564.9756 -
mae: 8184.9854
## 6336/7968 [=====>.....] - ETA: 0s - loss: 122463025.8990 -
mae: 8157.7349
## 7616/7968 [=====>..] - ETA: 0s - loss: 123151736.6891 -
mae: 8159.1738
## 7968/7968 [=====] - 0s 47us/step - loss: 122500239.6
787 - mae: 8146.8149 - val_loss: 132434530.6345 - val_mae: 8411.8047
## Epoch 47/50
##
## 32/7968 [.....] - ETA: 0s - loss: 118176448.0000 -
mae: 8112.7266
## 1472/7968 [====>.....] - ETA: 0s - loss: 123897016.6087 -
mae: 8049.7915
```

```

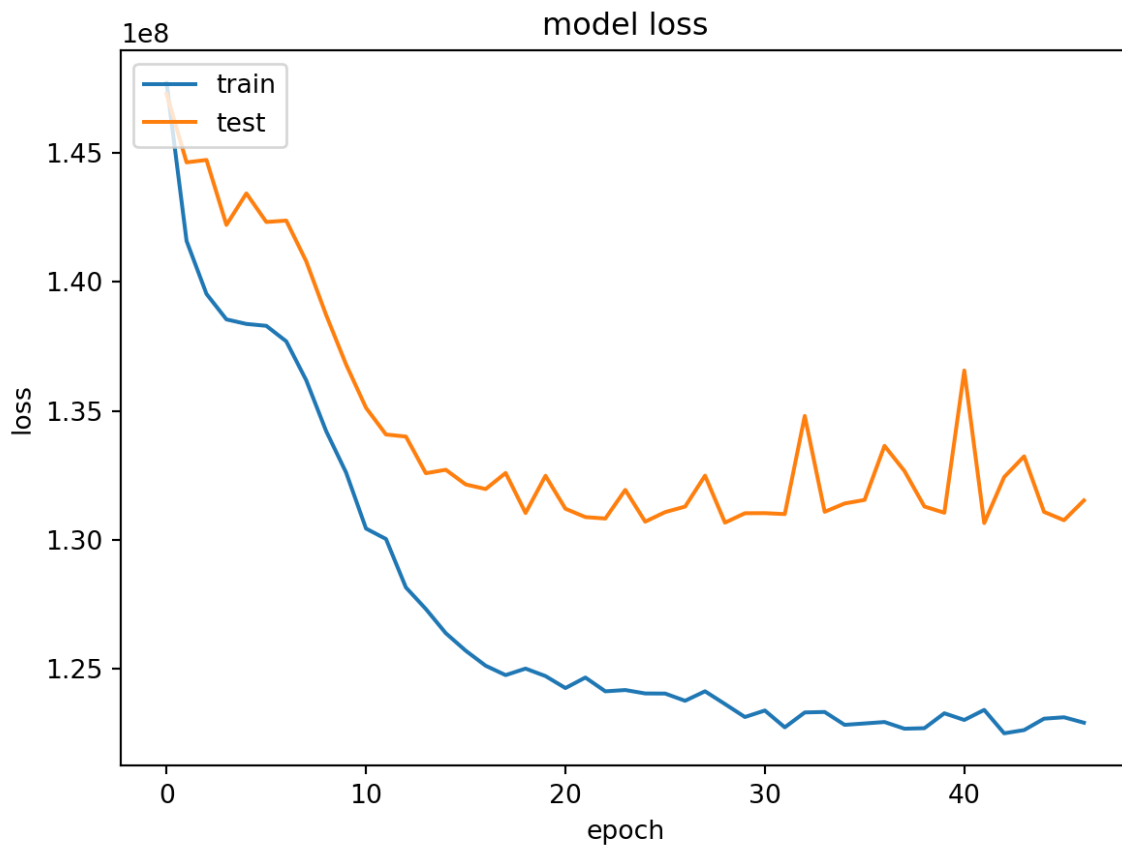
## 2912/7968 [=====>.....] - ETA: 0s - loss: 121130606.0659 -
mae: 8054.6216
## 4384/7968 [=====>.....] - ETA: 0s - loss: 122931991.0073 -
mae: 8187.7993
## 5888/7968 [=====>.....] - ETA: 0s - loss: 120884208.9348 -
mae: 8137.8833
## 7328/7968 [=====>...] - ETA: 0s - loss: 121494769.1004 -
mae: 8135.7520
## 7968/7968 [=====>] - 0s 41us/step - loss: 122625137.7
831 - mae: 8183.3657 - val_loss: 133238124.9799 - val_mae: 8469.8936
## Epoch 48/50
##
## 32/7968 [.....] - ETA: 0s - loss: 144078816.0000 -
mae: 9562.0430
## 1472/7968 [====>.....] - ETA: 0s - loss: 116565112.3478 -
mae: 8098.1006
## 3008/7968 [=====>.....] - ETA: 0s - loss: 125553977.6596 -
mae: 8259.0713
## 4512/7968 [=====>.....] - ETA: 0s - loss: 125597311.4894 -
mae: 8263.3955
## 6048/7968 [=====>.....] - ETA: 0s - loss: 123904170.6667 -
mae: 8209.7490
## 7456/7968 [=====>..] - ETA: 0s - loss: 123726413.7682 -
mae: 8184.6572
## 7968/7968 [=====>] - 0s 40us/step - loss: 123067317.3
655 - mae: 8167.9185 - val_loss: 131083904.0000 - val_mae: 8363.2988
## Epoch 49/50
##
## 32/7968 [.....] - ETA: 0s - loss: 111452320.0000 -
mae: 8724.8398
## 1568/7968 [====>.....] - ETA: 0s - loss: 125945166.9388 -
mae: 8275.9199
## 3168/7968 [=====>.....] - ETA: 0s - loss: 125501299.4343 -
mae: 8220.5830
## 4608/7968 [=====>.....] - ETA: 0s - loss: 122751892.1667 -
mae: 8135.6851
## 6016/7968 [=====>.....] - ETA: 0s - loss: 123998127.7234 -
mae: 8192.3740
## 7360/7968 [=====>...] - ETA: 0s - loss: 123081529.3739 -
mae: 8172.2949
## 7968/7968 [=====>] - 0s 40us/step - loss: 123121235.4
538 - mae: 8171.7485 - val_loss: 130761060.6908 - val_mae: 8282.1494
## Epoch 50/50
##
## 32/7968 [.....] - ETA: 0s - loss: 62971100.0000 -
mae: 5980.1709
## 1504/7968 [====>.....] - ETA: 0s - loss: 130330884.3404 -
mae: 8201.5967
## 3040/7968 [=====>.....] - ETA: 0s - loss: 126010711.9579 -
mae: 8238.2588
## 4640/7968 [=====>.....] - ETA: 0s - loss: 124075662.4276 -
mae: 8233.2725
## 6080/7968 [=====>.....] - ETA: 0s - loss: 123948119.3053 -
mae: 8193.7549
## 7552/7968 [=====>..] - ETA: 0s - loss: 123271699.2203 -
mae: 8185.9268
## 7968/7968 [=====>] - 0s 39us/step - loss: 122911214.4
900 - mae: 8173.5576 - val_loss: 131529674.9237 - val_mae: 8377.4160

```

```
##
```

```
## WARNING:tensorflow:From C:\Users\k4hansen\Documents\.conda\envs\r-reticulate  
\lib\site-packages\keras\backend\tensorflow_backend.py:422: The name tf.global_v  
ariables is deprecated. Please use tf.compat.v1.global_variables instead.
```

```
plt.plot(history.history['loss'][3:50])  
plt.plot(history.history['val_loss'][3:50])  
plt.title('model loss')  
plt.ylabel('loss')  
plt.xlabel('epoch')  
plt.legend(['train', 'test'], loc='upper left')  
plt.show()
```



Ok - we will stop training at epoch 22 like in the R version. So we re-train using the full training data and form out test predictions:

```
## re-train
model = Sequential()
model.add(Dense(8, input_dim=Xtrain_enc.shape[1], activation='relu'))
model.add(Dense(8, activation='relu'))
model.add(Dense(1))

# compile the keras model
opt = adam(lr=0.04)
model.compile(loss='mse', optimizer=opt, metrics=['mae'])

# fit the keras model on the dataset
history = model.fit(Xtrain_enc, yTrain, epochs=22, batch_size=32)

## get test predictions
```



```

## Epoch 1/22
##
## 32/9960 [.....] - ETA: 1:02 - loss: 4340515840.000
0 - mae: 58703.0508
## 1088/9960 [==>.....] - ETA: 2s - loss: 3719395328.0000
- mae: 53809.3008
## 2144/9960 [=====>.....] - ETA: 1s - loss: 3517790700.8955
- mae: 51554.9453
## 3136/9960 [=====>.....] - ETA: 0s - loss: 2885625734.5306
- mae: 44822.2969
## 4192/9960 [=====>.....] - ETA: 0s - loss: 2341827389.0687
- mae: 39136.1758
## 5472/9960 [=====>.....] - ETA: 0s - loss: 1922605297.7778
- mae: 34436.0352
## 6592/9960 [=====>.....] - ETA: 0s - loss: 1667361917.6699
- mae: 31434.4316
## 7840/9960 [=====>.....] - ETA: 0s - loss: 1455767493.1592
- mae: 28692.0977
## 9088/9960 [=====>...] - ETA: 0s - loss: 1295516087.3803
- mae: 26547.4199
## 9960/9960 [=====>] - 1s 65us/step - loss: 1205447510.
1558 - mae: 25318.4238
## Epoch 2/22
##
## 32/9960 [.....] - ETA: 0s - loss: 198387168.0000 -
mae: 9958.3281
## 1504/9960 [==>.....] - ETA: 0s - loss: 234212447.3191 -
mae: 11428.4424
## 2784/9960 [=====>.....] - ETA: 0s - loss: 228143724.7816 -
mae: 11311.8242
## 4096/9960 [=====>.....] - ETA: 0s - loss: 216946642.6875 -
mae: 11013.7900
## 5568/9960 [=====>.....] - ETA: 0s - loss: 206909981.5632 -
mae: 10730.0664
## 6656/9960 [=====>.....] - ETA: 0s - loss: 201231760.9231 -
mae: 10583.8398
## 7552/9960 [=====>.....] - ETA: 0s - loss: 198062137.7627 -
mae: 10500.8848
## 8512/9960 [=====>.....] - ETA: 0s - loss: 194186945.1429 -
mae: 10408.3271
## 9600/9960 [=====>..] - ETA: 0s - loss: 189406563.2667 -
mae: 10267.5732
## 9960/9960 [=====>] - 0s 42us/step - loss: 187404919.6
273 - mae: 10216.4844
## Epoch 3/22
##
## 32/9960 [.....] - ETA: 0s - loss: 127974888.0000 -
mae: 8831.1309
## 1376/9960 [==>.....] - ETA: 0s - loss: 136340864.0000 -
mae: 8895.5410
## 2848/9960 [=====>.....] - ETA: 0s - loss: 142278732.9438 -
mae: 9022.8896
## 4064/9960 [=====>.....] - ETA: 0s - loss: 142925922.7717 -
mae: 9042.6309
## 5408/9960 [=====>.....] - ETA: 0s - loss: 143795106.4615 -
mae: 9064.4785
## 6752/9960 [=====>.....] - ETA: 0s - loss: 144277519.8294 -

```

```
mae: 9043.3555
## 8256/9960 [=====>.....] - ETA: 0s - loss: 144428139.5194 -
mae: 9045.0830
## 9792/9960 [=====>.] - ETA: 0s - loss: 145416767.3856 -
mae: 9064.6240
## 9960/9960 [=====] - 0s 36us/step - loss: 145751426.8
916 - mae: 9077.1553
## Epoch 4/22
##
## 32/9960 [.....] - ETA: 0s - loss: 112524504.0000 -
mae: 8145.2827
## 1536/9960 [=====>.....] - ETA: 0s - loss: 137585074.0000 -
mae: 8857.7295
## 3008/9960 [=====>.....] - ETA: 0s - loss: 135180870.2553 -
mae: 8773.2285
## 4544/9960 [=====>.....] - ETA: 0s - loss: 136179063.8310 -
mae: 8807.1924
## 6048/9960 [=====>.....] - ETA: 0s - loss: 137143585.5661 -
mae: 8826.0869
## 7552/9960 [=====>.....] - ETA: 0s - loss: 139430324.0678 -
mae: 8881.8496
## 8928/9960 [=====>....] - ETA: 0s - loss: 140387257.7204 -
mae: 8903.1729
## 9960/9960 [=====] - 0s 34us/step - loss: 139449666.4
932 - mae: 8861.2949
## Epoch 5/22
##
## 32/9960 [.....] - ETA: 0s - loss: 161728192.0000 -
mae: 9526.3086
## 1568/9960 [=====>.....] - ETA: 0s - loss: 139949694.3673 -
mae: 8855.4463
## 3040/9960 [=====>.....] - ETA: 0s - loss: 139885696.5895 -
mae: 8834.2998
## 4384/9960 [=====>.....] - ETA: 0s - loss: 137411652.8759 -
mae: 8755.1973
## 5792/9960 [=====>.....] - ETA: 0s - loss: 134071607.0276 -
mae: 8643.4824
## 7136/9960 [=====>.....] - ETA: 0s - loss: 135416202.7265 -
mae: 8717.9170
## 8640/9960 [=====>....] - ETA: 0s - loss: 136391722.5778 -
mae: 8741.6250
## 9960/9960 [=====] - 0s 35us/step - loss: 136839470.9
462 - mae: 8750.9824
## Epoch 6/22
##
## 32/9960 [.....] - ETA: 0s - loss: 114515328.0000 -
mae: 8142.6265
## 1472/9960 [=====>.....] - ETA: 0s - loss: 126731881.3043 -
mae: 8343.6191
## 3008/9960 [=====>.....] - ETA: 0s - loss: 132206202.0000 -
mae: 8528.0068
## 4288/9960 [=====>.....] - ETA: 0s - loss: 130565448.0299 -
mae: 8515.0391
## 5632/9960 [=====>.....] - ETA: 0s - loss: 131761373.8636 -
mae: 8579.3418
## 6880/9960 [=====>.....] - ETA: 0s - loss: 132777986.1209 -
mae: 8595.0684
## 8224/9960 [=====>.....] - ETA: 0s - loss: 133810263.9222 -
```

```

mae: 8613.6309
## 9600/9960 [=====>..] - ETA: 0s - loss: 134428994.8133 -
mae: 8636.9355
## 9960/9960 [=====] - 0s 37us/step - loss: 133916385.0
538 - mae: 8619.6035
## Epoch 7/22
##
## 32/9960 [.....] - ETA: 0s - loss: 210678816.0000 -
mae: 10688.4434
## 1408/9960 [====>.....] - ETA: 0s - loss: 131220793.0909 -
mae: 8452.7119
## 2656/9960 [=====>.....] - ETA: 0s - loss: 132476343.0361 -
mae: 8547.3848
## 3936/9960 [=====>.....] - ETA: 0s - loss: 127855896.7805 -
mae: 8400.1240
## 5152/9960 [=====>.....] - ETA: 0s - loss: 128010224.3975 -
mae: 8393.0205
## 6400/9960 [=====>.....] - ETA: 0s - loss: 127219639.3600 -
mae: 8392.7930
## 7488/9960 [=====>.....] - ETA: 0s - loss: 128863640.3419 -
mae: 8435.6992
## 8480/9960 [=====>.....] - ETA: 0s - loss: 129643131.3811 -
mae: 8460.6787
## 9152/9960 [=====>...] - ETA: 0s - loss: 131478455.6364 -
mae: 8511.8984
## 9960/9960 [=====] - 0s 46us/step - loss: 131177145.7
221 - mae: 8501.2334
## Epoch 8/22
##
## 32/9960 [.....] - ETA: 0s - loss: 139965376.0000 -
mae: 8598.3301
## 960/9960 [=>.....] - ETA: 0s - loss: 131266316.8000 -
mae: 8593.3027
## 1952/9960 [====>.....] - ETA: 0s - loss: 132131238.8197 -
mae: 8625.4844
## 3008/9960 [=====>.....] - ETA: 0s - loss: 129372163.1064 -
mae: 8530.2715
## 3936/9960 [=====>.....] - ETA: 0s - loss: 131580992.2927 -
mae: 8597.7002
## 4800/9960 [=====>.....] - ETA: 0s - loss: 130354009.6267 -
mae: 8511.7188
## 5632/9960 [=====>.....] - ETA: 0s - loss: 129006514.6818 -
mae: 8472.0381
## 6560/9960 [=====>.....] - ETA: 0s - loss: 128034571.5707 -
mae: 8435.4814
## 7488/9960 [=====>.....] - ETA: 0s - loss: 128803638.1368 -
mae: 8439.4785
## 8448/9960 [=====>.....] - ETA: 0s - loss: 128602004.2576 -
mae: 8428.2148
## 9376/9960 [=====>..] - ETA: 0s - loss: 129244645.5017 -
mae: 8434.9541
## 9960/9960 [=====] - 1s 55us/step - loss: 129861922.8
273 - mae: 8447.0068
## Epoch 9/22
##
## 32/9960 [.....] - ETA: 0s - loss: 111687392.0000 -
mae: 7669.1685
## 896/9960 [=>.....] - ETA: 0s - loss: 136148629.1429 -

```

```

mae: 8718.2822
## 1856/9960 [====>.....] - ETA: 0s - loss: 125905891.4483 -
mae: 8453.4092
## 2848/9960 [=====>.....] - ETA: 0s - loss: 126670990.0674 -
mae: 8484.8145
## 3872/9960 [=====>.....] - ETA: 0s - loss: 128722496.6612 -
mae: 8490.2744
## 4768/9960 [=====>.....] - ETA: 0s - loss: 125901352.4832 -
mae: 8393.9141
## 5760/9960 [=====>.....] - ETA: 0s - loss: 127966592.4000 -
mae: 8438.8232
## 6720/9960 [=====>.....] - ETA: 0s - loss: 127407850.5333 -
mae: 8385.6465
## 7776/9960 [=====>.....] - ETA: 0s - loss: 128847999.0288 -
mae: 8406.8164
## 8928/9960 [=====>....] - ETA: 0s - loss: 128473620.5878 -
mae: 8393.7139
## 9960/9960 [=====>.....] - 0s 50us/step - loss: 128495873.0
924 - mae: 8393.7285
## Epoch 10/22
##
## 32/9960 [.....] - ETA: 0s - loss: 93266472.0000 -
mae: 7722.7700
## 1440/9960 [====>.....] - ETA: 0s - loss: 129627795.1111 -
mae: 8455.8408
## 2816/9960 [=====>.....] - ETA: 0s - loss: 133888411.6818 -
mae: 8494.7744
## 4256/9960 [=====>.....] - ETA: 0s - loss: 131044059.3985 -
mae: 8439.3936
## 5600/9960 [=====>.....] - ETA: 0s - loss: 127318775.9771 -
mae: 8315.9805
## 7072/9960 [=====>.....] - ETA: 0s - loss: 128070010.0452 -
mae: 8329.1494
## 8576/9960 [=====>.....] - ETA: 0s - loss: 126019830.7463 -
mae: 8283.8691
## 9960/9960 [=====>.....] - 0s 36us/step - loss: 127935431.3
639 - mae: 8343.8057
## Epoch 11/22
##
## 32/9960 [.....] - ETA: 0s - loss: 116418416.0000 -
mae: 7819.5356
## 1536/9960 [====>.....] - ETA: 0s - loss: 125834789.8333 -
mae: 8371.5439
## 2976/9960 [=====>.....] - ETA: 0s - loss: 124723085.1183 -
mae: 8262.5244
## 4416/9960 [=====>.....] - ETA: 0s - loss: 124663329.1884 -
mae: 8276.2627
## 5888/9960 [=====>.....] - ETA: 0s - loss: 125122932.2391 -
mae: 8295.2959
## 7424/9960 [=====>.....] - ETA: 0s - loss: 126243115.0690 -
mae: 8293.3291
## 8832/9960 [=====>....] - ETA: 0s - loss: 126449576.4058 -
mae: 8293.6768
## 9960/9960 [=====>.....] - 0s 34us/step - loss: 127115694.1
880 - mae: 8319.8633
## Epoch 12/22
##
## 32/9960 [.....] - ETA: 0s - loss: 89428904.0000 -

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mae: 8060.9751
## 1408/9960 [====>.....] - ETA: 0s - loss: 130237125.0909 -
mae: 8533.1797
## 2784/9960 [=====>.....] - ETA: 0s - loss: 131101276.6897 -
mae: 8429.7803
## 4256/9960 [=====>.....] - ETA: 0s - loss: 129178510.4060 -
mae: 8337.5166
## 5696/9960 [=====>.....] - ETA: 0s - loss: 126665193.9101 -
mae: 8278.9375
## 7168/9960 [=====>.....] - ETA: 0s - loss: 125887679.5179 -
mae: 8276.9570
## 8672/9960 [=====>....] - ETA: 0s - loss: 125651239.1882 -
mae: 8258.9941
## 9960/9960 [=====>.....] - 0s 35us/step - loss: 126244231.6
980 - mae: 8277.4521
## Epoch 13/22
##
## 32/9960 [.....] - ETA: 0s - loss: 67979536.0000 -
mae: 6801.9766
## 1600/9960 [====>.....] - ETA: 0s - loss: 127631916.8800 -
mae: 8281.5703
## 3040/9960 [=====>.....] - ETA: 0s - loss: 127373414.6526 -
mae: 8293.0049
## 4576/9960 [=====>.....] - ETA: 0s - loss: 126623623.0490 -
mae: 8302.3613
## 6080/9960 [=====>.....] - ETA: 0s - loss: 127324346.5895 -
mae: 8316.9541
## 7648/9960 [=====>.....] - ETA: 0s - loss: 127634693.6402 -
mae: 8317.7461
## 9088/9960 [=====>....] - ETA: 0s - loss: 126219587.8310 -
mae: 8275.6064
## 9960/9960 [=====>.....] - 0s 33us/step - loss: 125629912.7
133 - mae: 8254.1328
## Epoch 14/22
##
## 32/9960 [.....] - ETA: 0s - loss: 89259200.0000 -
mae: 7107.1699
## 1568/9960 [====>.....] - ETA: 0s - loss: 123363449.3878 -
mae: 8158.1704
## 2976/9960 [=====>.....] - ETA: 0s - loss: 127025590.2796 -
mae: 8293.8760
## 4416/9960 [=====>.....] - ETA: 0s - loss: 124862373.0435 -
mae: 8187.7637
## 5888/9960 [=====>.....] - ETA: 0s - loss: 124175335.4348 -
mae: 8193.7891
## 7392/9960 [=====>.....] - ETA: 0s - loss: 123186736.5714 -
mae: 8180.3330
## 8992/9960 [=====>....] - ETA: 0s - loss: 123855310.2918 -
mae: 8202.4395
## 9960/9960 [=====>.....] - 0s 34us/step - loss: 125547659.1
550 - mae: 8247.2285
## Epoch 15/22
##
## 32/9960 [.....] - ETA: 0s - loss: 117124256.0000 -
mae: 8925.9951
## 1472/9960 [====>.....] - ETA: 0s - loss: 125902631.9130 -
mae: 8269.9160
## 2784/9960 [=====>.....] - ETA: 0s - loss: 127922637.2414 -

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mae: 8313.2959
## 4192/9960 [=====>.....] - ETA: 0s - loss: 125849226.1374 -
mae: 8240.9004
## 5728/9960 [=====>.....] - ETA: 0s - loss: 127422135.4190 -
mae: 8287.5811
## 7200/9960 [=====>.....] - ETA: 0s - loss: 125923827.2000 -
mae: 8263.3145
## 8736/9960 [=====>....] - ETA: 0s - loss: 124795567.1355 -
mae: 8233.9785
## 9960/9960 [=====>.....] - 0s 35us/step - loss: 125851615.7
687 - mae: 8260.3818
## Epoch 16/22
##
## 32/9960 [.....] - ETA: 0s - loss: 98465088.0000 -
mae: 6917.7891
## 1600/9960 [=====>.....] - ETA: 0s - loss: 123778030.6400 -
mae: 8135.8350
## 3136/9960 [=====>.....] - ETA: 0s - loss: 125416698.0816 -
mae: 8130.4131
## 4640/9960 [=====>.....] - ETA: 0s - loss: 123094116.8276 -
mae: 8126.9604
## 6144/9960 [=====>.....] - ETA: 0s - loss: 123752136.4792 -
mae: 8163.1909
## 7488/9960 [=====>.....] - ETA: 0s - loss: 124156342.6325 -
mae: 8172.6519
## 8992/9960 [=====>....] - ETA: 0s - loss: 123738944.8399 -
mae: 8175.3540
## 9960/9960 [=====>.....] - 0s 34us/step - loss: 125396366.6
570 - mae: 8225.1973
## Epoch 17/22
##
## 32/9960 [.....] - ETA: 0s - loss: 54674344.0000 -
mae: 5883.8799
## 1632/9960 [=====>.....] - ETA: 0s - loss: 122884508.6275 -
mae: 8206.7754
## 3072/9960 [=====>.....] - ETA: 0s - loss: 119361461.7500 -
mae: 8098.5796
## 4576/9960 [=====>.....] - ETA: 0s - loss: 121848698.4056 -
mae: 8143.9868
## 6208/9960 [=====>.....] - ETA: 0s - loss: 126264732.7423 -
mae: 8270.3203
## 7712/9960 [=====>.....] - ETA: 0s - loss: 124716144.8299 -
mae: 8245.6240
## 9280/9960 [=====>....] - ETA: 0s - loss: 124934620.9517 -
mae: 8238.4189
## 9960/9960 [=====>.....] - 0s 33us/step - loss: 125386780.1
703 - mae: 8241.1562
## Epoch 18/22
##
## 32/9960 [.....] - ETA: 0s - loss: 114068448.0000 -
mae: 8515.0527
## 1600/9960 [=====>.....] - ETA: 0s - loss: 123707697.2000 -
mae: 8214.9072
## 3104/9960 [=====>.....] - ETA: 0s - loss: 128177103.6289 -
mae: 8314.7500
## 4576/9960 [=====>.....] - ETA: 0s - loss: 124174810.3776 -
mae: 8200.9053
## 5984/9960 [=====>.....] - ETA: 0s - loss: 125811456.6203 -
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mae: 8248.5098
## 7456/9960 [=====>.....] - ETA: 0s - loss: 126741270.5064 -
mae: 8290.1992
## 9056/9960 [=====>...] - ETA: 0s - loss: 124672110.7703 -
mae: 8227.2979
## 9960/9960 [=====] - 0s 34us/step - loss: 125346928.9
012 - mae: 8230.7510
## Epoch 19/22
##
## 32/9960 [.....] - ETA: 0s - loss: 118397192.0000 -
mae: 8042.8545
## 1408/9960 [=====>.....] - ETA: 0s - loss: 119409844.8182 -
mae: 8127.4927
## 2592/9960 [=====>.....] - ETA: 0s - loss: 123598316.0988 -
mae: 8254.4443
## 3936/9960 [=====>.....] - ETA: 0s - loss: 124420320.1626 -
mae: 8279.5010
## 5312/9960 [=====>.....] - ETA: 0s - loss: 123472322.2892 -
mae: 8199.3262
## 6784/9960 [=====>.....] - ETA: 0s - loss: 123421661.6981 -
mae: 8166.3901
## 8224/9960 [=====>.....] - ETA: 0s - loss: 124656402.4436 -
mae: 8206.6650
## 9760/9960 [=====>.] - ETA: 0s - loss: 125469324.2623 -
mae: 8240.4951
## 9960/9960 [=====] - 0s 37us/step - loss: 125255265.7
863 - mae: 8238.1162
## Epoch 20/22
##
## 32/9960 [.....] - ETA: 0s - loss: 66376808.0000 -
mae: 6733.5088
## 1408/9960 [=====>.....] - ETA: 0s - loss: 122680959.6364 -
mae: 8187.0801
## 2528/9960 [=====>.....] - ETA: 0s - loss: 126810175.4937 -
mae: 8231.3594
## 3840/9960 [=====>.....] - ETA: 0s - loss: 125812173.5667 -
mae: 8189.8604
## 5216/9960 [=====>.....] - ETA: 0s - loss: 124146574.9448 -
mae: 8177.4961
## 6528/9960 [=====>.....] - ETA: 0s - loss: 126734608.9020 -
mae: 8259.6533
## 7904/9960 [=====>.....] - ETA: 0s - loss: 125541925.7004 -
mae: 8240.5703
## 9248/9960 [=====>...] - ETA: 0s - loss: 124813304.5675 -
mae: 8220.5000
## 9960/9960 [=====] - 0s 39us/step - loss: 125339553.6
129 - mae: 8233.4912
## Epoch 21/22
##
## 32/9960 [.....] - ETA: 0s - loss: 146720768.0000 -
mae: 9179.6621
## 1312/9960 [=====>.....] - ETA: 0s - loss: 130770041.7561 -
mae: 8377.8096
## 2656/9960 [=====>.....] - ETA: 0s - loss: 128750764.7229 -
mae: 8356.8633
## 3904/9960 [=====>.....] - ETA: 0s - loss: 125861752.8197 -
mae: 8274.1318
## 5248/9960 [=====>.....] - ETA: 0s - loss: 124488842.2073 -

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```

mae: 8218.8887
## 6624/9960 [=====>.....] - ETA: 0s - loss: 12355245.1884 -
mae: 8177.3364
## 7904/9960 [=====>.....] - ETA: 0s - loss: 125334098.0648 -
mae: 8235.9990
## 9216/9960 [=====>...] - ETA: 0s - loss: 125097169.0486 -
mae: 8227.7598
## 9960/9960 [=====] - 0s 39us/step - loss: 124833587.3
735 - mae: 8221.5996
## Epoch 22/22
##
## 32/9960 [.....] - ETA: 0s - loss: 90124800.0000 -
mae: 7538.0410
## 1088/9960 [==>.....] - ETA: 0s - loss: 126748343.4118 -
mae: 8276.9893
## 2496/9960 [=====>.....] - ETA: 0s - loss: 125695164.1026 -
mae: 8248.1260
## 3872/9960 [=====>.....] - ETA: 0s - loss: 123803822.8760 -
mae: 8205.2305
## 5184/9960 [=====>.....] - ETA: 0s - loss: 124728478.0494 -
mae: 8215.6045
## 6592/9960 [=====>.....] - ETA: 0s - loss: 123553218.1165 -
mae: 8191.3467
## 7936/9960 [=====>.....] - ETA: 0s - loss: 123514164.5161 -
mae: 8183.4722
## 9216/9960 [=====>...] - ETA: 0s - loss: 124939750.1944 -
mae: 8230.0859
## 9960/9960 [=====] - 0s 39us/step - loss: 124525635.6
080 - mae: 8219.1016

```

```

yPredict = model.predict(Xtest_enc)

mean_absolute_error(yTest, yPredict)

```

```

## 8276.058937507843

```

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