DNN Lab

Objectives

- Understand basic DNN model building process using Keras
- Analyze model performance and capacity vs generalization tradeoff
- Modify models to reduce overfitting and improve performance

Exercises

- Build a DNN model for slump Test Problem
- Start with a model consisting of one hidden layer with 7 neurons
- Analyze results and explore improvements to model in terms of capacity, regularization

Step 1: Import Libraries

In [1]:
```
%tensorflow_version 2.x
from numpy.random import seed
seed(2)
import tensorflow as tf
from tensorflow import keras
from IPython import display
from matplotlib import cm
from matplotlib import gridspec
from matplotlib import pyplot as plt
import numpy as np
import pandas as pd
import os
import datetime
from tensorflow.python.data import Dataset
from sklearn import preprocessing
from sklearn.preprocessing import StandardScaler, StandardScaler, Normalizer
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix, accuracy_score
from sklearn import metrics
from sklearn.dummy import DummyRegressor

print(tf.__version__)
```

```
2.6.0
```

Step 2: Import Data

In [2]:
```
pd.options.display.max_rows = 10
pd.options.display.float_format = '{:.4f}'.format

clinic_data = pd.read_excel("OnlineUse.xlsx", sheet_name='OnlineUseData')

clinic_data = clinic_data.reindex(
    np.random.permutation(clinic_data.index))
```

Step 3: Preprocess

In [3]:
```
#missing data values is -98 or -97
clinic_data[clinic_data.eq(-98).any(1)]
clinic_data[clinic_data.eq(-97).any(1)]

#deleted records with missing Online Appointment use
delete_records =  clinic_data[clinic_data.OnlineAppointmentUse <-96].index
clinic_data.drop(delete_records, inplace = True)
```

In [4]:
```
#replacing the missing data value of -98 and -97 with np.nan
#can run a regression to predict the value instead of ultimately using the mea
n value!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
clinic_data = clinic_data.replace({-98 : np.NaN, -97 : np.NaN})

#checking if NaN values replacement worked
#checking which columns have NaN values
clinic_data[clinic_data.isnull().any(axis=1)]
#checking to see the # of NaN values present
len(clinic_data[clinic_data.isnull().any(axis=1)])

#replace the nan values with the mean
#change to np.NaN
clinic_data.fillna(clinic_data.mean(), inplace=True)
```

In [5]:
```
#remove columns vendor and numpats
clinic_data = clinic_data.drop(['vendor','numpats'],axis=1)

#clinic_data.shape
```

In [6]:
```
#baseline accuracy measure
clinic_data.iloc[:,1:2].mean()
```

Out[6]:
```
OnlineAppointmentUse   0.1371
dtype: float64
```

Train/Validation Split

In [7]:
```
#Creating a training and validation dataset with a 80/20 split
X_train,X_test, y_train, y_test = train_test_split(clinic_data.iloc[:,2:],clin
ic_data.iloc[:,1:2], test_size=0.2, random_state=1)
```

In [8]:
```
X_train.head()
```

Out[8]:

	malepct	unemp	age16to24	age25to34	age35to44	age45to54	age55to64	age65to74	age7
5129	0.4665	0.0137	0.0774	0.1087	0.1005	0.1838	0.2341	0.1994	(
4375	0.5677	0.0272	0.0935	0.2117	0.2163	0.1839	0.1059	0.0947	(
571	0.4646	0.0321	0.1099	0.1373	0.0707	0.2095	0.2085	0.1269	(
3926	0.4517	0.0280	0.0366	0.1619	0.1416	0.2058	0.2210	0.1210	(
3921	0.4278	0.0103	0.0952	0.1379	0.0643	0.1776	0.2155	0.1528	(

Step 4: Build Model

[https://www.tensorflow.org/api_docs/python/tf/keras/Model (https://www.tensorflow.org/api_docs/python/tf/keras/Model)](https://www.tensorflow.org/api_docs/python/tf/keras/Model)

[https://www.tensorflow.org/api_docs/python/tf/keras/layers/Dense (https://www.tensorflow.org/api_docs/python/tf/keras/layers/Dense)](https://www.tensorflow.org/api_docs/python/tf/keras/layers/Dense)

[https://keras.io/optimizers/ (https://keras.io/optimizers/)](https://keras.io/optimizers/)

Build Model

In [9]:
```
#model is continuous, so which is best
model1 = keras.Sequential()
model1.add(keras.layers.Dense(18, activation=tf.nn.leaky_relu,
                       input_shape=(X_train.shape[1],)))
keras.layers.Dropout(0.75),
model1.add(keras.layers.Dense(9, activation=tf.nn.relu
                       ))
keras.layers.Dropout(0.75),
model1.add(keras.layers.Dense(5, activation=tf.nn.leaky_relu
                       ))
keras.layers.Dropout(0.75),
#model1.add(keras.layers.Dense(3, activation=tf.nn.relu
#                       ))
#keras.layers.Dropout(0.75),
model1.add(keras.layers.Dense(1, activation=tf.nn.sigmoid))

#optimizer = tf.keras.optimizers.RMSprop(0.001)
#optimizer = tf.keras.optimizers.Adam()

model1.compile(loss='mse',
                optimizer='sgd',
                metrics=['mae'])
model1.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 18)                342
_________________________________________________________________
dense_1 (Dense)              (None, 9)                 171
_________________________________________________________________
dense_2 (Dense)              (None, 5)                 50
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 6
=================================================================
Total params: 569
Trainable params: 569
Non-trainable params: 0
_________________________________________________________________
```

Fit Model

In [10]:
```
class PrintDot(keras.callbacks.Callback):
  def on_epoch_end(self, epoch, logs):
    if epoch % 100 == 0: print('')
    print('.', end='')

EPOCHS = 200
tf.random.set_seed(1)

# Store training stats
m1_history = model1.fit(X_train, y_train, epochs=EPOCHS,
                    validation_data= (X_test, y_test), verbose=1)
                    #callbacks=[PrintDot()])
```

```
Epoch 1/200
171/171 [==============================] - 1s 3ms/step - loss: 0.0574 - mae:
0.2074 - val_loss: 0.0147 - val_mae: 0.1040
Epoch 2/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0104 - mae:
0.0846 - val_loss: 0.0087 - val_mae: 0.0752
Epoch 3/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0085 - mae:
0.0741 - val_loss: 0.0080 - val_mae: 0.0701
Epoch 4/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0082 - mae:
0.0720 - val_loss: 0.0078 - val_mae: 0.0687
Epoch 5/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0081 - mae:
0.0713 - val_loss: 0.0077 - val_mae: 0.0681
Epoch 6/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0081 - mae:
0.0709 - val_loss: 0.0076 - val_mae: 0.0677
Epoch 7/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0080 - mae:
0.0706 - val_loss: 0.0076 - val_mae: 0.0675
Epoch 8/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0080 - mae:
0.0705 - val_loss: 0.0075 - val_mae: 0.0673
Epoch 9/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0080 - mae:
0.0702 - val_loss: 0.0075 - val_mae: 0.0671
Epoch 10/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0079 - mae:
0.0701 - val_loss: 0.0075 - val_mae: 0.0670
Epoch 11/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0079 - mae:
0.0699 - val_loss: 0.0074 - val_mae: 0.0669
Epoch 12/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0078 - mae:
0.0698 - val_loss: 0.0074 - val_mae: 0.0667
Epoch 13/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0078 - mae:
0.0696 - val_loss: 0.0074 - val_mae: 0.0666
Epoch 14/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0078 - mae:
0.0695 - val_loss: 0.0073 - val_mae: 0.0664
Epoch 15/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0077 - mae:
0.0694 - val_loss: 0.0073 - val_mae: 0.0662
Epoch 16/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0077 - mae:
0.0691 - val_loss: 0.0073 - val_mae: 0.0662
Epoch 17/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0077 - mae:
0.0691 - val_loss: 0.0072 - val_mae: 0.0659
Epoch 18/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0076 - mae:
0.0689 - val_loss: 0.0072 - val_mae: 0.0658
Epoch 19/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0076 - mae:
0.0687 - val_loss: 0.0072 - val_mae: 0.0657
```

```
Epoch 20/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0076 - mae:
0.0686 - val_loss: 0.0072 - val_mae: 0.0656
Epoch 21/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0075 - mae:
0.0685 - val_loss: 0.0071 - val_mae: 0.0654
Epoch 22/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0075 - mae:
0.0683 - val_loss: 0.0071 - val_mae: 0.0653
Epoch 23/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0075 - mae:
0.0681 - val_loss: 0.0071 - val_mae: 0.0652
Epoch 24/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0074 - mae:
0.0680 - val_loss: 0.0070 - val_mae: 0.0652
Epoch 25/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0074 - mae:
0.0679 - val_loss: 0.0070 - val_mae: 0.0650
Epoch 26/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0074 - mae:
0.0678 - val_loss: 0.0070 - val_mae: 0.0648
Epoch 27/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0073 - mae:
0.0676 - val_loss: 0.0070 - val_mae: 0.0647
Epoch 28/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0073 - mae:
0.0675 - val_loss: 0.0069 - val_mae: 0.0645
Epoch 29/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0073 - mae:
0.0673 - val_loss: 0.0069 - val_mae: 0.0644
Epoch 30/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0073 - mae:
0.0672 - val_loss: 0.0069 - val_mae: 0.0642
Epoch 31/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0072 - mae:
0.0670 - val_loss: 0.0068 - val_mae: 0.0641
Epoch 32/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0072 - mae:
0.0669 - val_loss: 0.0068 - val_mae: 0.0640
Epoch 33/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0072 - mae:
0.0667 - val_loss: 0.0068 - val_mae: 0.0639
Epoch 34/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0071 - mae:
0.0666 - val_loss: 0.0068 - val_mae: 0.0638
Epoch 35/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0071 - mae:
0.0664 - val_loss: 0.0067 - val_mae: 0.0637
Epoch 36/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0071 - mae:
0.0663 - val_loss: 0.0067 - val_mae: 0.0635
Epoch 37/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0070 - mae:
0.0661 - val_loss: 0.0067 - val_mae: 0.0634
Epoch 38/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0070 - mae:
0.0660 - val_loss: 0.0066 - val_mae: 0.0632
```

```
Epoch 39/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0070 - mae: 0.0658 - val_loss: 0.0066 - val_mae: 0.0631
Epoch 40/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0069 - mae: 0.0657 - val_loss: 0.0066 - val_mae: 0.0629
Epoch 41/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0069 - mae: 0.0656 - val_loss: 0.0065 - val_mae: 0.0627
Epoch 42/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0068 - mae: 0.0653 - val_loss: 0.0065 - val_mae: 0.0626
Epoch 43/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0068 - mae: 0.0653 - val_loss: 0.0065 - val_mae: 0.0623
Epoch 44/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0068 - mae: 0.0649 - val_loss: 0.0064 - val_mae: 0.0623
Epoch 45/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0067 - mae: 0.0648 - val_loss: 0.0064 - val_mae: 0.0622
Epoch 46/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0067 - mae: 0.0647 - val_loss: 0.0064 - val_mae: 0.0619
Epoch 47/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0066 - mae: 0.0644 - val_loss: 0.0063 - val_mae: 0.0618
Epoch 48/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0066 - mae: 0.0643 - val_loss: 0.0063 - val_mae: 0.0615
Epoch 49/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0065 - mae: 0.0639 - val_loss: 0.0062 - val_mae: 0.0614
Epoch 50/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0065 - mae: 0.0637 - val_loss: 0.0062 - val_mae: 0.0612
Epoch 51/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0064 - mae: 0.0635 - val_loss: 0.0061 - val_mae: 0.0608
Epoch 52/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0064 - mae: 0.0631 - val_loss: 0.0060 - val_mae: 0.0606
Epoch 53/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0063 - mae: 0.0628 - val_loss: 0.0060 - val_mae: 0.0604
Epoch 54/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0062 - mae: 0.0624 - val_loss: 0.0059 - val_mae: 0.0600
Epoch 55/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0061 - mae: 0.0621 - val_loss: 0.0058 - val_mae: 0.0596
Epoch 56/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0060 - mae: 0.0616 - val_loss: 0.0058 - val_mae: 0.0593
Epoch 57/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0060 - mae: 0.0613 - val_loss: 0.0057 - val_mae: 0.0590
```

```
Epoch 58/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0059 - mae:
0.0610 - val_loss: 0.0057 - val_mae: 0.0586
Epoch 59/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0059 - mae:
0.0606 - val_loss: 0.0056 - val_mae: 0.0584
Epoch 60/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0058 - mae:
0.0603 - val_loss: 0.0056 - val_mae: 0.0582
Epoch 61/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0058 - mae:
0.0601 - val_loss: 0.0055 - val_mae: 0.0578
Epoch 62/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0057 - mae:
0.0598 - val_loss: 0.0055 - val_mae: 0.0574
Epoch 63/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0057 - mae:
0.0595 - val_loss: 0.0054 - val_mae: 0.0572
Epoch 64/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0056 - mae:
0.0592 - val_loss: 0.0054 - val_mae: 0.0570
Epoch 65/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0056 - mae:
0.0589 - val_loss: 0.0053 - val_mae: 0.0569
Epoch 66/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0055 - mae:
0.0587 - val_loss: 0.0053 - val_mae: 0.0566
Epoch 67/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0055 - mae:
0.0584 - val_loss: 0.0052 - val_mae: 0.0563
Epoch 68/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0054 - mae:
0.0581 - val_loss: 0.0052 - val_mae: 0.0562
Epoch 69/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0054 - mae:
0.0578 - val_loss: 0.0051 - val_mae: 0.0559
Epoch 70/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0053 - mae:
0.0575 - val_loss: 0.0051 - val_mae: 0.0559
Epoch 71/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0053 - mae:
0.0574 - val_loss: 0.0051 - val_mae: 0.0555
Epoch 72/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0052 - mae:
0.0571 - val_loss: 0.0050 - val_mae: 0.0552
Epoch 73/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0052 - mae:
0.0568 - val_loss: 0.0050 - val_mae: 0.0550
Epoch 74/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0051 - mae:
0.0565 - val_loss: 0.0049 - val_mae: 0.0547
Epoch 75/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0051 - mae:
0.0563 - val_loss: 0.0049 - val_mae: 0.0544
Epoch 76/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0050 - mae:
0.0560 - val_loss: 0.0048 - val_mae: 0.0542
```

```
Epoch 77/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0050 - mae:
0.0557 - val_loss: 0.0048 - val_mae: 0.0540
Epoch 78/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0049 - mae:
0.0555 - val_loss: 0.0047 - val_mae: 0.0537
Epoch 79/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0049 - mae:
0.0551 - val_loss: 0.0047 - val_mae: 0.0535
Epoch 80/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0048 - mae:
0.0549 - val_loss: 0.0047 - val_mae: 0.0534
Epoch 81/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0048 - mae:
0.0547 - val_loss: 0.0046 - val_mae: 0.0531
Epoch 82/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0047 - mae:
0.0544 - val_loss: 0.0046 - val_mae: 0.0528
Epoch 83/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0047 - mae:
0.0541 - val_loss: 0.0045 - val_mae: 0.0526
Epoch 84/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0046 - mae:
0.0538 - val_loss: 0.0045 - val_mae: 0.0523
Epoch 85/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0046 - mae:
0.0535 - val_loss: 0.0044 - val_mae: 0.0520
Epoch 86/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0045 - mae:
0.0532 - val_loss: 0.0044 - val_mae: 0.0521
Epoch 87/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0045 - mae:
0.0530 - val_loss: 0.0044 - val_mae: 0.0517
Epoch 88/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0045 - mae:
0.0528 - val_loss: 0.0043 - val_mae: 0.0513
Epoch 89/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0044 - mae:
0.0524 - val_loss: 0.0043 - val_mae: 0.0510
Epoch 90/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0044 - mae:
0.0522 - val_loss: 0.0042 - val_mae: 0.0507
Epoch 91/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0043 - mae:
0.0519 - val_loss: 0.0042 - val_mae: 0.0504
Epoch 92/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0043 - mae:
0.0516 - val_loss: 0.0042 - val_mae: 0.0503
Epoch 93/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0042 - mae:
0.0513 - val_loss: 0.0041 - val_mae: 0.0501
Epoch 94/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0042 - mae:
0.0511 - val_loss: 0.0041 - val_mae: 0.0499
Epoch 95/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0042 - mae:
0.0509 - val_loss: 0.0040 - val_mae: 0.0496
```

```
Epoch 96/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0041 - mae:
0.0506 - val_loss: 0.0040 - val_mae: 0.0494
Epoch 97/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0041 - mae:
0.0503 - val_loss: 0.0040 - val_mae: 0.0490
Epoch 98/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0040 - mae:
0.0500 - val_loss: 0.0039 - val_mae: 0.0488
Epoch 99/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0040 - mae:
0.0498 - val_loss: 0.0039 - val_mae: 0.0488
Epoch 100/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0040 - mae:
0.0495 - val_loss: 0.0039 - val_mae: 0.0486
Epoch 101/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0039 - mae:
0.0493 - val_loss: 0.0038 - val_mae: 0.0485
Epoch 102/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0039 - mae:
0.0491 - val_loss: 0.0038 - val_mae: 0.0480
Epoch 103/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0038 - mae:
0.0488 - val_loss: 0.0038 - val_mae: 0.0479
Epoch 104/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0038 - mae:
0.0486 - val_loss: 0.0037 - val_mae: 0.0475
Epoch 105/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0038 - mae:
0.0483 - val_loss: 0.0037 - val_mae: 0.0474
Epoch 106/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0037 - mae:
0.0481 - val_loss: 0.0037 - val_mae: 0.0471
Epoch 107/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0037 - mae:
0.0478 - val_loss: 0.0036 - val_mae: 0.0470
Epoch 108/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0037 - mae:
0.0477 - val_loss: 0.0036 - val_mae: 0.0467
Epoch 109/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0036 - mae:
0.0474 - val_loss: 0.0036 - val_mae: 0.0464
Epoch 110/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0036 - mae:
0.0471 - val_loss: 0.0035 - val_mae: 0.0464
Epoch 111/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0036 - mae:
0.0470 - val_loss: 0.0035 - val_mae: 0.0462
Epoch 112/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0035 - mae:
0.0468 - val_loss: 0.0035 - val_mae: 0.0459
Epoch 113/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0035 - mae:
0.0466 - val_loss: 0.0035 - val_mae: 0.0457
Epoch 114/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0035 - mae:
0.0463 - val_loss: 0.0034 - val_mae: 0.0456
```

```
Epoch 115/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0035 - mae: 0.0461 - val_loss: 0.0034 - val_mae: 0.0455
Epoch 116/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0034 - mae: 0.0460 - val_loss: 0.0034 - val_mae: 0.0452
Epoch 117/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0034 - mae: 0.0458 - val_loss: 0.0033 - val_mae: 0.0448
Epoch 118/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0034 - mae: 0.0455 - val_loss: 0.0033 - val_mae: 0.0449
Epoch 119/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0034 - mae: 0.0454 - val_loss: 0.0033 - val_mae: 0.0447
Epoch 120/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0033 - mae: 0.0452 - val_loss: 0.0033 - val_mae: 0.0445
Epoch 121/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0033 - mae: 0.0450 - val_loss: 0.0033 - val_mae: 0.0444
Epoch 122/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0033 - mae: 0.0449 - val_loss: 0.0033 - val_mae: 0.0442
Epoch 123/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0033 - mae: 0.0447 - val_loss: 0.0032 - val_mae: 0.0440
Epoch 124/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0032 - mae: 0.0445 - val_loss: 0.0032 - val_mae: 0.0438
Epoch 125/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0032 - mae: 0.0444 - val_loss: 0.0032 - val_mae: 0.0436
Epoch 126/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0032 - mae: 0.0442 - val_loss: 0.0032 - val_mae: 0.0437
Epoch 127/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0032 - mae: 0.0441 - val_loss: 0.0032 - val_mae: 0.0435
Epoch 128/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0032 - mae: 0.0439 - val_loss: 0.0031 - val_mae: 0.0433
Epoch 129/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0031 - mae: 0.0438 - val_loss: 0.0031 - val_mae: 0.0434
Epoch 130/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0031 - mae: 0.0437 - val_loss: 0.0031 - val_mae: 0.0431
Epoch 131/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0031 - mae: 0.0435 - val_loss: 0.0031 - val_mae: 0.0431
Epoch 132/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0031 - mae: 0.0434 - val_loss: 0.0031 - val_mae: 0.0431
Epoch 133/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0031 - mae: 0.0433 - val_loss: 0.0031 - val_mae: 0.0429
```

```
Epoch 134/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0031 - mae:
0.0432 - val_loss: 0.0031 - val_mae: 0.0427
Epoch 135/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0031 - mae:
0.0431 - val_loss: 0.0030 - val_mae: 0.0425
Epoch 136/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0030 - mae:
0.0429 - val_loss: 0.0030 - val_mae: 0.0424
Epoch 137/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0030 - mae:
0.0428 - val_loss: 0.0030 - val_mae: 0.0424
Epoch 138/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0030 - mae:
0.0427 - val_loss: 0.0030 - val_mae: 0.0422
Epoch 139/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0030 - mae:
0.0426 - val_loss: 0.0030 - val_mae: 0.0422
Epoch 140/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0030 - mae:
0.0425 - val_loss: 0.0030 - val_mae: 0.0421
Epoch 141/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0030 - mae:
0.0424 - val_loss: 0.0030 - val_mae: 0.0421
Epoch 142/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0030 - mae:
0.0423 - val_loss: 0.0030 - val_mae: 0.0420
Epoch 143/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0030 - mae:
0.0423 - val_loss: 0.0030 - val_mae: 0.0417
Epoch 144/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0422 - val_loss: 0.0030 - val_mae: 0.0417
Epoch 145/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0421 - val_loss: 0.0029 - val_mae: 0.0415
Epoch 146/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0420 - val_loss: 0.0029 - val_mae: 0.0417
Epoch 147/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0420 - val_loss: 0.0029 - val_mae: 0.0415
Epoch 148/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0419 - val_loss: 0.0029 - val_mae: 0.0416
Epoch 149/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0418 - val_loss: 0.0029 - val_mae: 0.0416
Epoch 150/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0418 - val_loss: 0.0029 - val_mae: 0.0413
Epoch 151/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0417 - val_loss: 0.0029 - val_mae: 0.0411
Epoch 152/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0416 - val_loss: 0.0029 - val_mae: 0.0412
```

```
Epoch 153/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0415 - val_loss: 0.0029 - val_mae: 0.0412
Epoch 154/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0415 - val_loss: 0.0029 - val_mae: 0.0412
Epoch 155/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0029 - mae:
0.0414 - val_loss: 0.0029 - val_mae: 0.0411
Epoch 156/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0414 - val_loss: 0.0029 - val_mae: 0.0410
Epoch 157/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0413 - val_loss: 0.0029 - val_mae: 0.0409
Epoch 158/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0413 - val_loss: 0.0029 - val_mae: 0.0409
Epoch 159/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0412 - val_loss: 0.0029 - val_mae: 0.0409
Epoch 160/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0411 - val_loss: 0.0029 - val_mae: 0.0409
Epoch 161/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0411 - val_loss: 0.0029 - val_mae: 0.0408
Epoch 162/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0411 - val_loss: 0.0029 - val_mae: 0.0408
Epoch 163/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0410 - val_loss: 0.0029 - val_mae: 0.0408
Epoch 164/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0410 - val_loss: 0.0028 - val_mae: 0.0405
Epoch 165/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0409 - val_loss: 0.0028 - val_mae: 0.0405
Epoch 166/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0409 - val_loss: 0.0028 - val_mae: 0.0406
Epoch 167/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0409 - val_loss: 0.0028 - val_mae: 0.0406
Epoch 168/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0408 - val_loss: 0.0028 - val_mae: 0.0406
Epoch 169/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0408 - val_loss: 0.0028 - val_mae: 0.0403
Epoch 170/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0407 - val_loss: 0.0028 - val_mae: 0.0404
Epoch 171/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0407 - val_loss: 0.0028 - val_mae: 0.0404
```

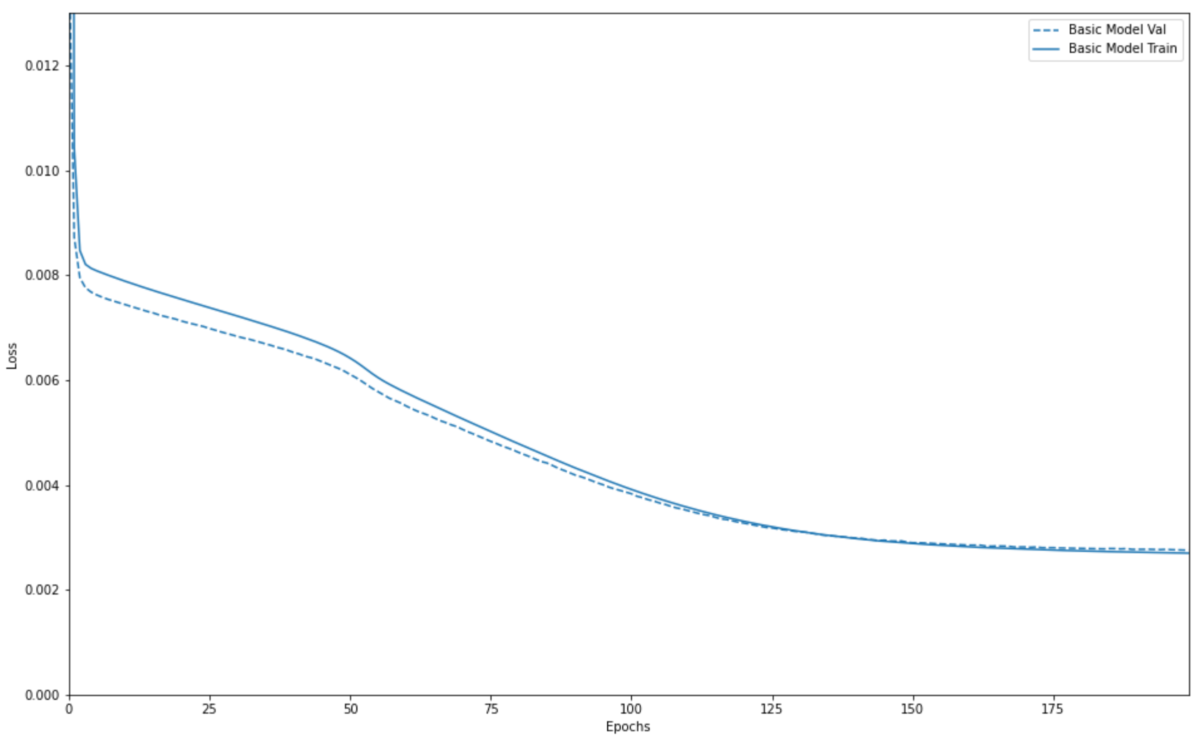
```
Epoch 172/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0407 - val_loss: 0.0028 - val_mae: 0.0403
Epoch 173/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0406 - val_loss: 0.0028 - val_mae: 0.0404
Epoch 174/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0406 - val_loss: 0.0028 - val_mae: 0.0402
Epoch 175/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0406 - val_loss: 0.0028 - val_mae: 0.0403
Epoch 176/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0405 - val_loss: 0.0028 - val_mae: 0.0403
Epoch 177/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0028 - mae:
0.0405 - val_loss: 0.0028 - val_mae: 0.0402
Epoch 178/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0405 - val_loss: 0.0028 - val_mae: 0.0402
Epoch 179/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0405 - val_loss: 0.0028 - val_mae: 0.0402
Epoch 180/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0404 - val_loss: 0.0028 - val_mae: 0.0401
Epoch 181/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0404 - val_loss: 0.0028 - val_mae: 0.0401
Epoch 182/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0404 - val_loss: 0.0028 - val_mae: 0.0401
Epoch 183/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0404 - val_loss: 0.0028 - val_mae: 0.0400
Epoch 184/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0404 - val_loss: 0.0028 - val_mae: 0.0400
Epoch 185/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0403 - val_loss: 0.0028 - val_mae: 0.0400
Epoch 186/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0403 - val_loss: 0.0028 - val_mae: 0.0401
Epoch 187/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0403 - val_loss: 0.0028 - val_mae: 0.0401
Epoch 188/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0403 - val_loss: 0.0028 - val_mae: 0.0400
Epoch 189/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0402 - val_loss: 0.0028 - val_mae: 0.0401
Epoch 190/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0402 - val_loss: 0.0028 - val_mae: 0.0399
```

```
Epoch 191/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0402 - val_loss: 0.0028 - val_mae: 0.0399
Epoch 192/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0402 - val_loss: 0.0028 - val_mae: 0.0399
Epoch 193/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0401 - val_loss: 0.0028 - val_mae: 0.0399
Epoch 194/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0402 - val_loss: 0.0028 - val_mae: 0.0399
Epoch 195/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0401 - val_loss: 0.0028 - val_mae: 0.0398
Epoch 196/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0401 - val_loss: 0.0028 - val_mae: 0.0399
Epoch 197/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0401 - val_loss: 0.0028 - val_mae: 0.0398
Epoch 198/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0401 - val_loss: 0.0028 - val_mae: 0.0398
Epoch 199/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0401 - val_loss: 0.0028 - val_mae: 0.0397
Epoch 200/200
171/171 [==============================] - 0s 2ms/step - loss: 0.0027 - mae:
0.0400 - val_loss: 0.0028 - val_mae: 0.0396
```

Lowest Validation Error

Step 5: Plot Results

In [11]:
```
import matplotlib.pyplot as plt

def plot_history(histories, key='loss'):
  plt.figure(figsize=(16,10))
  for name, history in histories:
    val = plt.plot(m1_history.epoch, m1_history.history['val_'+key],
                   '--', label=name.title()+' Val')
    plt.plot(m1_history.epoch, m1_history.history[key], color=val[0].get_color
(),
             label=name.title()+' Train')

  plt.xlabel('Epochs')
  plt.ylabel(key.replace('_',' ').title())
  plt.legend()

  plt.xlim([0,max(m1_history.epoch)])
  plt.ylim([0,0.013])

plot_history([('Basic Model', m1_history)])

#Plot Multiple Model Results

#plot_history([('Plain', m1_history),('L1',model1)])
```



In [12]:
```
y_pred = np.round(model1.predict_on_batch(X_test),5)
print(y_pred)
```

```
[[0.17354]
 [0.2654 ]
 [0.12504]
 ...
 [0.07051]
 [0.09799]
 [0.07332]]
```

In [13]:
```
#Our accuracy measure for the validation dataset
print(min(m1_history.history['val_mae']))
```

```
0.039643026888370514
```

Goal: Predict the percentage of patients that will use the Online Appointment System. After researching online it stated to use the mean of the target. The mean of Online Appointment use is 13.71%.

In the model my min Mean Absolute Error for the validation data was .03964 or .40. In the graph the training and validation model converge, so we don't have any overfitting, underfitting or generalization issues.