IDS

December 1, 2019

1 Building Intrusion Detection System using Artificial Neural Networks

1.1 Data Clean up and Pre-Processing

[1]:
```
#Importing desired modules
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

[2]:
```
dataset = pd.read_csv("ids.csv")
df = pd.DataFrame(dataset)
df.info()
```

```
/home/tulsyan/.local/lib/python3.6/site-
packages/IPython/core/interactiveshell.py:3058: DtypeWarning: Columns (14,15)
have mixed types. Specify dtype option on import or set low_memory=False.
  interactivity=interactivity, compiler=compiler, result=result)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 692703 entries, 0 to 692702
Data columns (total 79 columns):
 Destination Port               692703 non-null int64
 Flow Duration                  692703 non-null int64
 Total Fwd Packets              692703 non-null int64
 Total Backward Packets         692703 non-null int64
Total Length of Fwd Packets     692703 non-null int64
 Total Length of Bwd Packets    692703 non-null int64
 Fwd Packet Length Max          692703 non-null int64
 Fwd Packet Length Min          692703 non-null int64
 Fwd Packet Length Mean         692703 non-null float64
 Fwd Packet Length Std          692703 non-null float64
Bwd Packet Length Max           692703 non-null int64
 Bwd Packet Length Min          692703 non-null int64
 Bwd Packet Length Mean         692703 non-null float64
```

```
 Bwd Packet Length Std          692703 non-null float64
Flow Bytes/s                    691695 non-null object
 Flow Packets/s                 692703 non-null object
 Flow IAT Mean                  692703 non-null float64
 Flow IAT Std                   692703 non-null float64
 Flow IAT Max                   692703 non-null int64
 Flow IAT Min                   692703 non-null int64
Fwd IAT Total                   692703 non-null int64
 Fwd IAT Mean                   692703 non-null float64
 Fwd IAT Std                    692703 non-null float64
 Fwd IAT Max                    692703 non-null int64
 Fwd IAT Min                    692703 non-null int64
Bwd IAT Total                   692703 non-null int64
 Bwd IAT Mean                   692703 non-null float64
 Bwd IAT Std                    692703 non-null float64
 Bwd IAT Max                    692703 non-null int64
 Bwd IAT Min                    692703 non-null int64
Fwd PSH Flags                   692703 non-null int64
 Bwd PSH Flags                  692703 non-null int64
 Fwd URG Flags                  692703 non-null int64
 Bwd URG Flags                  692703 non-null int64
 Fwd Header Length              692703 non-null int64
 Bwd Header Length              692703 non-null int64
Fwd Packets/s                   692703 non-null float64
 Bwd Packets/s                  692703 non-null float64
 Min Packet Length              692703 non-null int64
 Max Packet Length              692703 non-null int64
 Packet Length Mean             692703 non-null float64
 Packet Length Std              692703 non-null float64
 Packet Length Variance         692703 non-null float64
FIN Flag Count                  692703 non-null int64
 SYN Flag Count                 692703 non-null int64
 RST Flag Count                 692703 non-null int64
 PSH Flag Count                 692703 non-null int64
 ACK Flag Count                 692703 non-null int64
 URG Flag Count                 692703 non-null int64
 CWE Flag Count                 692703 non-null int64
 ECE Flag Count                 692703 non-null int64
 Down/Up Ratio                  692703 non-null int64
 Average Packet Size            692703 non-null float64
 Avg Fwd Segment Size           692703 non-null float64
 Avg Bwd Segment Size           692703 non-null float64
 Fwd Header Length.1            692703 non-null int64
Fwd Avg Bytes/Bulk              692703 non-null int64
 Fwd Avg Packets/Bulk           692703 non-null int64
 Fwd Avg Bulk Rate              692703 non-null int64
 Bwd Avg Bytes/Bulk             692703 non-null int64
 Bwd Avg Packets/Bulk           692703 non-null int64
```

```
Bwd Avg Bulk Rate              692703 non-null int64
Subflow Fwd Packets            692703 non-null int64
 Subflow Fwd Bytes             692703 non-null int64
 Subflow Bwd Packets           692703 non-null int64
 Subflow Bwd Bytes             692703 non-null int64
Init_Win_bytes_forward         692703 non-null int64
 Init_Win_bytes_backward       692703 non-null int64
 act_data_pkt_fwd              692703 non-null int64
 min_seg_size_forward          692703 non-null int64
Active Mean                    692703 non-null float64
 Active Std                    692703 non-null float64
 Active Max                    692703 non-null int64
 Active Min                    692703 non-null int64
Idle Mean                      692703 non-null float64
 Idle Std                      692703 non-null float64
 Idle Max                      692703 non-null int64
 Idle Min                      692703 non-null int64
 Label                         692703 non-null object
dtypes: float64(22), int64(54), object(3)
memory usage: 417.5+ MB
```

[3]:
```
df.columns
```

[3]:
```
Index([' Destination Port', ' Flow Duration', ' Total Fwd Packets',
       ' Total Backward Packets', 'Total Length of Fwd Packets',
       ' Total Length of Bwd Packets', ' Fwd Packet Length Max',
       ' Fwd Packet Length Min', ' Fwd Packet Length Mean',
       ' Fwd Packet Length Std', 'Bwd Packet Length Max',
       ' Bwd Packet Length Min', ' Bwd Packet Length Mean',
       ' Bwd Packet Length Std', 'Flow Bytes/s', ' Flow Packets/s',
       ' Flow IAT Mean', ' Flow IAT Std', ' Flow IAT Max', ' Flow IAT Min',
       'Fwd IAT Total', ' Fwd IAT Mean', ' Fwd IAT Std', ' Fwd IAT Max',
       ' Fwd IAT Min', 'Bwd IAT Total', ' Bwd IAT Mean', ' Bwd IAT Std',
       ' Bwd IAT Max', ' Bwd IAT Min', 'Fwd PSH Flags', ' Bwd PSH Flags',
       ' Fwd URG Flags', ' Bwd URG Flags', ' Fwd Header Length',
       ' Bwd Header Length', 'Fwd Packets/s', ' Bwd Packets/s',
       ' Min Packet Length', ' Max Packet Length', ' Packet Length Mean',
       ' Packet Length Std', ' Packet Length Variance', 'FIN Flag Count',
       ' SYN Flag Count', ' RST Flag Count', ' PSH Flag Count',
       ' ACK Flag Count', ' URG Flag Count', ' CWE Flag Count',
       ' ECE Flag Count', ' Down/Up Ratio', ' Average Packet Size',
       ' Avg Fwd Segment Size', ' Avg Bwd Segment Size',
       ' Fwd Header Length.1', 'Fwd Avg Bytes/Bulk', ' Fwd Avg Packets/Bulk',
       ' Fwd Avg Bulk Rate', ' Bwd Avg Bytes/Bulk', ' Bwd Avg Packets/Bulk',
       'Bwd Avg Bulk Rate', 'Subflow Fwd Packets', ' Subflow Fwd Bytes',
       ' Subflow Bwd Packets', ' Subflow Bwd Bytes', 'Init_Win_bytes_forward',
       ' Init_Win_bytes_backward', ' act_data_pkt_fwd',
```

```
       ' min_seg_size_forward', 'Active Mean', ' Active Std', ' Active Max',
       ' Active Min', 'Idle Mean', ' Idle Std', ' Idle Max', ' Idle Min',
       ' Label'],
      dtype='object')
```

[4]:
```
#Checking the shape of the complete datset
df.shape
#Rounding the data to two decimal places
df = df.round(2)
```

1.1.1 692703 rows × 79 columns is the size of the original data

[5]:
```
#Replacing infinity values with NaN
df.replace([np.inf, -np.inf], np.nan)
#Removing rows containing NaN
df.dropna(how="any", inplace = True)
```

[6]:
```
#Shape after removinf NaNs
df.shape
```

[6]:
```
(691695, 79)
```

[7]:
```
# Since the data contains 79 parameters,which will require quite a lot of␣
 ↪processing,
# so we are dropping columns with either constant value or very much divergent␣
 ↪values
df = df.drop(df.std()[df.std() < .3].index.values, axis=1)
df = df.drop(df.std()[df.std() > 1000].index.values, axis=1)
```

[8]:
```
#new shape of the dataset after dropping the columns with divergent values
df.shape
```

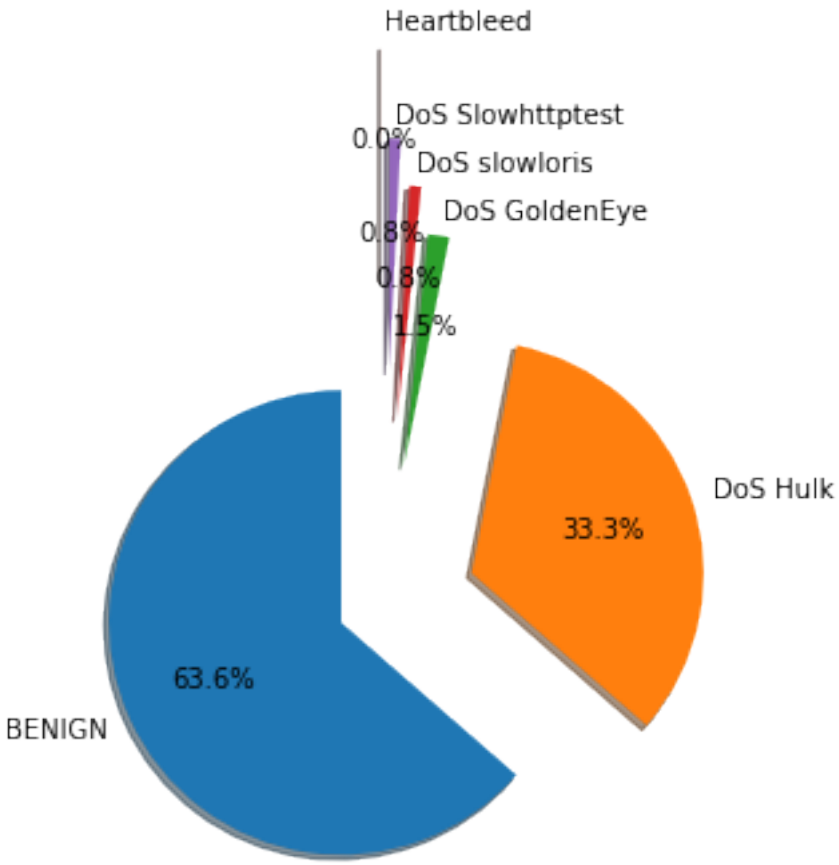
[8]:
```
(691695, 24)
```

[9]:
```
#Various types of labels associated with the dataset
df[' Label'].value_counts()
```

[9]:
```
BENIGN             439972
DoS Hulk           230124
DoS GoldenEye       10293
DoS slowloris        5796
DoS Slowhttptest     5499
Heartbleed             11
Name:  Label, dtype: int64
```

[10]:
```
#Pie chart representing share of different type of Label
labels = 'BENIGN', 'DoS Hulk', 'DoS GoldenEye', 'DoS slowloris', 'DoS␣
 ↪Slowhttptest', 'Heartbleed'
fig, ax = plt.subplots()
values = df[' Label'].value_counts()
explodeTuple = (0.2, 0.4, 0.6, 0.8, 1.0, 1.4)
ax.pie(values, explode = explodeTuple, labels=labels, autopct='%1.1f%%',
        shadow=True, startangle=90)
```

[10]:
```
([<matplotlib.patches.Wedge at 0x7f3f4bd7c518>,
  <matplotlib.patches.Wedge at 0x7f3f4bd7cf60>,
  <matplotlib.patches.Wedge at 0x7f3f4bd688d0>,
  <matplotlib.patches.Wedge at 0x7f3f0de35240>,
  <matplotlib.patches.Wedge at 0x7f3f0de35b70>,
  <matplotlib.patches.Wedge at 0x7f3f0de254e0>],
 [Text(-1.1830056228811299, -0.5389783819705855, 'BENIGN'),
  Text(1.4193539458189848, 0.4852158040378313, 'DoS Hulk'),
  Text(0.2531206438489331, 1.681050248998376, 'DoS GoldenEye'),
  Text(0.14497331574252167, 1.8944610678825309, 'DoS slowloris'),
  Text(0.05265301616305486, 2.099339815248816, 'DoS Slowhttptest'),
  Text(0.00012439429575789647, 2.499999996905212, 'Heartbleed')],
 [Text(-0.7280034602345413, -0.331679004289591, '63.6%'),
  Text(0.9462359638793232, 0.3234772026918875, '33.3%'),
  Text(0.17867339565807042, 1.1866237051753241, '1.5%'),
  Text(0.10682244317870018, 1.3959186815976543, '0.8%'),
  Text(0.040116583743279886, 1.5994970020943362, '0.8%'),
  Text(9.951543660631718e-05, 1.9999999975241696, '0.0%')])
```



[11]:
```
# Since distribution opf various Denial of Service (DoS) is highly irregular,␣
 ↪we have clubbed them for better results
df = df.replace('Heartbleed', 'DoS')
df = df.replace('DoS GoldenEye', 'DoS')
df = df.replace('DoS Slowhttptest', 'DoS')
df = df.replace('DoS slowloris', 'DoS')
df = df.replace('DoS Hulk', 'DoS')
df[' Label'].value_counts()
```

[11]:
```
BENIGN    439972
DoS       251723
Name:  Label, dtype: int64
```

[12]:
```
df = df[~df['Flow Bytes/s'].isin(['Infinity'])]
df = df[~df[' Flow Packets/s'].isin(['Infinity'])]
df.shape
```

[12]:
```
(691406, 24)
```

[13]:
```
#Processing aroung 700k data is quite a time consuming task, we are taking only␣
↪100k for our training and testing our model
df = df.iloc[:100000]
```

[14]:
```
#Final shape of the data after cleanup and pre-processing
df.shape
```

[14]:
```
(100000, 24)
```

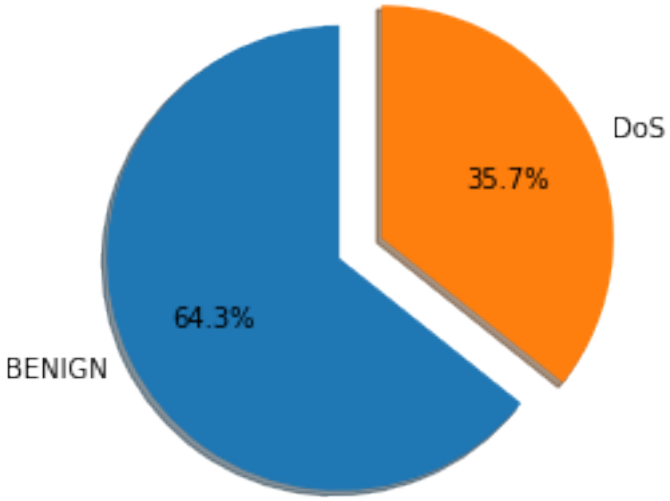
1.1.2 100000 rows × 24 columns is the size of the new data

[15]:
```
df[' Label'].value_counts()
```

[15]:
```
BENIGN    64282
DoS       35718
Name:  Label, dtype: int64
```

[16]:
```
#Plotting pie chart of labels associated with row to show ratio of both types␣
↪of Labels
label = 'BENIGN', 'DoS'
value = df[' Label'].value_counts()
fig1, ax1 = plt.subplots()
explodeTuple = (0.1, 0.1)
ax1.pie(value, explode = explodeTuple, labels = label, autopct='%1.1f%%',
        shadow=True, startangle=90)
```

[16]:
```
([<matplotlib.patches.Wedge at 0x7f3f4a9854e0>,
  <matplotlib.patches.Wedge at 0x7f3f4a985e10>],
 [Text(-1.0812233877505313, -0.5205343271881928, 'BENIGN'),
  Text(1.0812233877505315, 0.5205343271881923, 'DoS')],
 [Text(-0.6307136428544765, -0.30364502419311246, '64.3%'),
  Text(0.6307136428544767, 0.3036450241931121, '35.7%')])
```



[17]:
```
#Importing various packages and libraries
from sklearn.model_selection import train_test_split
from sklearn import preprocessing
from IPython.display import SVG
import keras
from keras.models import Sequential
from keras.layers import Dense, Dropout, Activation
from keras.optimizers import SGD
from keras.utils.vis_utils import model_to_dot
from keras.models import Sequential
from keras.layers import Dense, Activation
```

```
/usr/lib/python3/dist-packages/h5py/__init__.py:36: FutureWarning: Conversion of
the second argument of issubdtype from `float` to `np.floating` is deprecated.
In future, it will be treated as `np.float64 == np.dtype(float).type`.
  from ._conv import register_converters as _register_converters
Using TensorFlow backend.
/usr/local/lib/python3.6/dist-
packages/tensorflow/python/framework/dtypes.py:516: FutureWarning: Passing
(type, 1) or '1type' as a synonym of type is deprecated; in a future version of
numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorflow/python/framework/dtypes.py:517: FutureWarning: Passing
(type, 1) or '1type' as a synonym of type is deprecated; in a future version of
numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
```

```
/usr/local/lib/python3.6/dist-
packages/tensorflow/python/framework/dtypes.py:518: FutureWarning: Passing
(type, 1) or '1type' as a synonym of type is deprecated; in a future version of
numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorflow/python/framework/dtypes.py:519: FutureWarning: Passing
(type, 1) or '1type' as a synonym of type is deprecated; in a future version of
numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorflow/python/framework/dtypes.py:520: FutureWarning: Passing
(type, 1) or '1type' as a synonym of type is deprecated; in a future version of
numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorflow/python/framework/dtypes.py:525: FutureWarning: Passing
(type, 1) or '1type' as a synonym of type is deprecated; in a future version of
numpy, it will be understood as (type, (1,)) / '(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorboard/compat/tensorflow_stub/dtypes.py:541: FutureWarning:
Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorboard/compat/tensorflow_stub/dtypes.py:542: FutureWarning:
Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorboard/compat/tensorflow_stub/dtypes.py:543: FutureWarning:
Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorboard/compat/tensorflow_stub/dtypes.py:544: FutureWarning:
Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorboard/compat/tensorflow_stub/dtypes.py:545: FutureWarning:
Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/usr/local/lib/python3.6/dist-
packages/tensorboard/compat/tensorflow_stub/dtypes.py:550: FutureWarning:
Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
```

```
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
```

[18]:
```
#Replacing labels with 1 and 0 for convenience
df.replace(to_replace ="BENIGN", value = 1, inplace = True)
df.replace(to_replace ="DoS", value = 0, inplace = True)
```

[19]:
```
#First five rows of the data
df.head()
```

[19]:

	Total Fwd Packets	Total Backward Packets	Fwd Packet Length Max	\
0	1	1	6	
1	11	5	79	
2	10	6	1575	
3	17	12	1313	
4	9	6	1575	

	Fwd Packet Length Min	Fwd Packet Length Mean	Fwd Packet Length Std	\
0	6	6.00	0.00	
1	0	15.64	31.45	
2	0	315.00	632.56	
3	0	203.06	425.78	
4	0	350.00	694.51	

	Bwd Packet Length Min	Bwd Packet Length Mean	Flow Bytes/s	\
0	6	6.00	313.250496	
1	0	65.20	1039665.971	
2	0	525.00	5753424.658	
3	0	555.00	665000.6576	
4	0	525.33	5771062.271	

	Flow Packets/s	…	ACK Flag Count	Down/Up Ratio	Average Packet Size	\
0	52.208416	…	1	1	9.00	
1	33402.92276	…	0	0	31.12	
2	14611.87215	…	0	0	393.75	
3	1907.141918	…	0	0	348.69	
4	13736.26374	…	0	0	420.13	

	Avg Fwd Segment Size	Avg Bwd Segment Size	Subflow Fwd Packets	\
0	6.00	6.00	1	
1	15.64	65.20	11	
2	315.00	525.00	10	
3	203.06	555.00	17	
4	350.00	525.33	9	

	Subflow Bwd Packets	act_data_pkt_fwd	min_seg_size_forward	Label
0	1	0	20	1

```
1                    5                    4                   32        1
2                    6                    3                   32        1
3                   12                   10                   32        1
4                    6                    2                   32        1

[5 rows x 24 columns]
```

[20]:
```
x = df.drop(' Label', 1)
y = df[' Label']
```

[21]:
```
#Splitting data into train and test set
X_train, X_test, y_train, y_test = train_test_split(x, y, test_size=0.2)
```

[22]:
```
X_train = np.array(X_train)
X_test = np.array(X_test)
y_train = np.array(y_train)
y_test = np.array(y_test)
```

[23]:
```
min_max_scaler = preprocessing.MinMaxScaler()
X_train = min_max_scaler.fit_transform(X_train)
X_test = min_max_scaler.fit_transform(X_test)
```

[24]:
```
print('Train images shape:', X_train.shape)
print('Train labels shape:', y_train.shape)
print('Test images shape:', X_test.shape)
print('Test labels shape:', y_test.shape)
print('Train labels:', y_train)
print('Test labels:', y_test)
```

```
Train images shape: (80000, 23)
Train labels shape: (80000,)
Test images shape: (20000, 23)
Test labels shape: (20000,)
Train labels: [0 1 1 … 0 1 1]
Test labels: [0 1 0 … 0 0 0]
```

[25]:
```
model = Sequential()
model.add(Dense(256, activation='relu', input_dim = 23))
model.add(Dropout(0.5))
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.25))
model.add(Dense(1, activation='sigmoid'))
```

[26]:
```
# For a binary classification problem
from keras.optimizers import SGD
opt = SGD(lr=0.01)
```

```
model.compile(loss = "binary_crossentropy", optimizer = opt, metrics =␣
↪['accuracy'])
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/tensorflow/python/ops/nn_impl.py:180:
add_dispatch_support.<locals>.wrapper (from tensorflow.python.ops.array_ops) is
deprecated and will be removed in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
```

[27]:
```
history = model.fit(X_train, y_train, epochs=20,
          verbose=1, batch_size=100)
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:422: The name tf.global_variables
is deprecated. Please use tf.compat.v1.global_variables instead.

Epoch 1/20
80000/80000 [==============================] - 2s 26us/step - loss: 0.6034 -
accuracy: 0.7245
Epoch 2/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.4835 -
accuracy: 0.8191
Epoch 3/20
80000/80000 [==============================] - 2s 24us/step - loss: 0.4340 -
accuracy: 0.8240
Epoch 4/20
80000/80000 [==============================] - 2s 25us/step - loss: 0.4011 -
accuracy: 0.8285
Epoch 5/20
80000/80000 [==============================] - 2s 25us/step - loss: 0.3689 -
accuracy: 0.8339
Epoch 6/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.3353 -
accuracy: 0.8479
Epoch 7/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.3027 -
accuracy: 0.8633
Epoch 8/20
80000/80000 [==============================] - 2s 21us/step - loss: 0.2759 -
accuracy: 0.8735
Epoch 9/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.2575 -
accuracy: 0.8778
Epoch 10/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.2435 -
accuracy: 0.8811
Epoch 11/20
```

```
80000/80000 [==============================] - 2s 22us/step - loss: 0.2324 -
accuracy: 0.8849
Epoch 12/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.2255 -
accuracy: 0.8867
Epoch 13/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.2179 -
accuracy: 0.8901
Epoch 14/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.2126 -
accuracy: 0.8924
Epoch 15/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.2072 -
accuracy: 0.8952
Epoch 16/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.2021 -
accuracy: 0.8974
Epoch 17/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.1983 -
accuracy: 0.9003
Epoch 18/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.1947 -
accuracy: 0.9014
Epoch 19/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.1913 -
accuracy: 0.9037
Epoch 20/20
80000/80000 [==============================] - 2s 22us/step - loss: 0.1868 -
accuracy: 0.9066
```

[28]:
```
score = model.evaluate(X_test, y_test, verbose=1)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

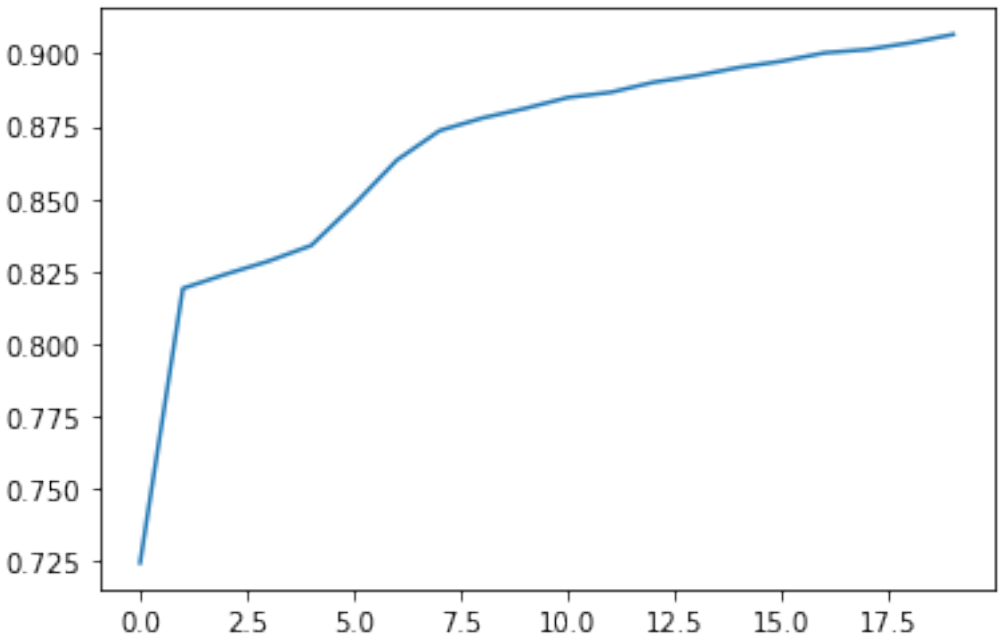
```
20000/20000 [==============================] - 0s 16us/step
Test loss: 0.19741094299554826
Test accuracy: 0.8965499997138977
```

[29]:
```
# list all data in history
print(history.history.keys())
# summarize history for accuracy
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
```

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

```
dict_keys(['loss', 'accuracy'])
```

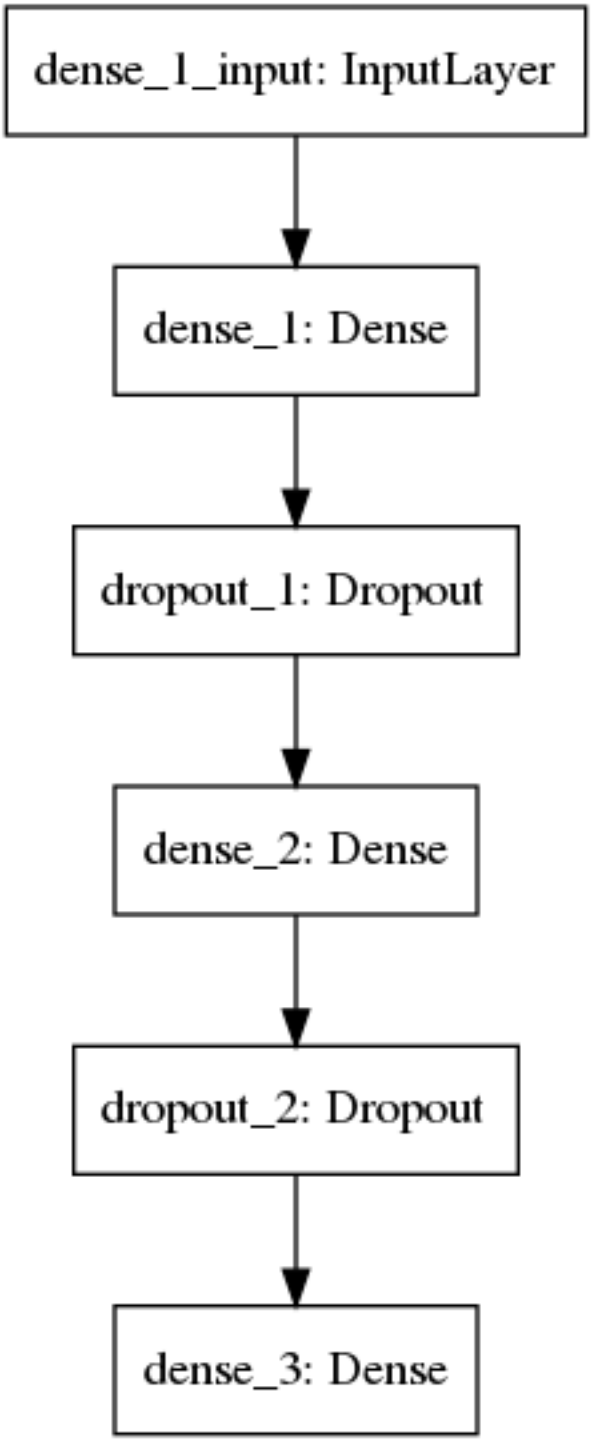
```
       ␣
↪---------------------------------------------------------------------------

       KeyError                                  Traceback (most recent call␣
↪last)

       <ipython-input-29-7dab07ad3420> in <module>
         3 # summarize history for accuracy
         4 plt.plot(history.history['accuracy'])
   ----> 5 plt.plot(history.history['val_accuracy'])
         6 plt.title('model accuracy')
         7 plt.ylabel('accuracy')


       KeyError: 'val_accuracy'
```



[30]:
```
def plot_keras_model(model, show_shapes=True, show_layer_names=True):
    from IPython.display import SVG
    from keras.utils.vis_utils import model_to_dot
    return SVG(model_to_dot(model, show_shapes=show_shapes,␣
 ↪show_layer_names=show_layer_names).create(prog='dot', format='svg'))
```

[31]:
```
from keras.utils import plot_model
plot_model(model, to_file='model.png')
```

[31]:



[32]:
```
y_pred = model.predict(X_test)
y_pred = (y_pred > 0.5)
```

[33]:
```
# Creating the Confusion Matrix
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_test, y_pred)
cm
```

[33]:
```
array([[ 7171,    54],
       [ 2015, 10760]])
```