

DNNClassifier

June 10, 2018

1 Tensorflow Project

We'll use the [Bank Authentication Data Set](#) from the UCI repository.

The data consists of 5 columns:

- variance of Wavelet Transformed image (continuous)
- skewness of Wavelet Transformed image (continuous)
- curtosis of Wavelet Transformed image (continuous)
- entropy of image (continuous)
- class (integer)

Where class indicates whether or not a Bank Note was authentic.

```
In [1]: import pandas as pd
```

```
In [4]: data = pd.read_csv('bank_note_data.csv')
```

```
In [5]: data.head()
```

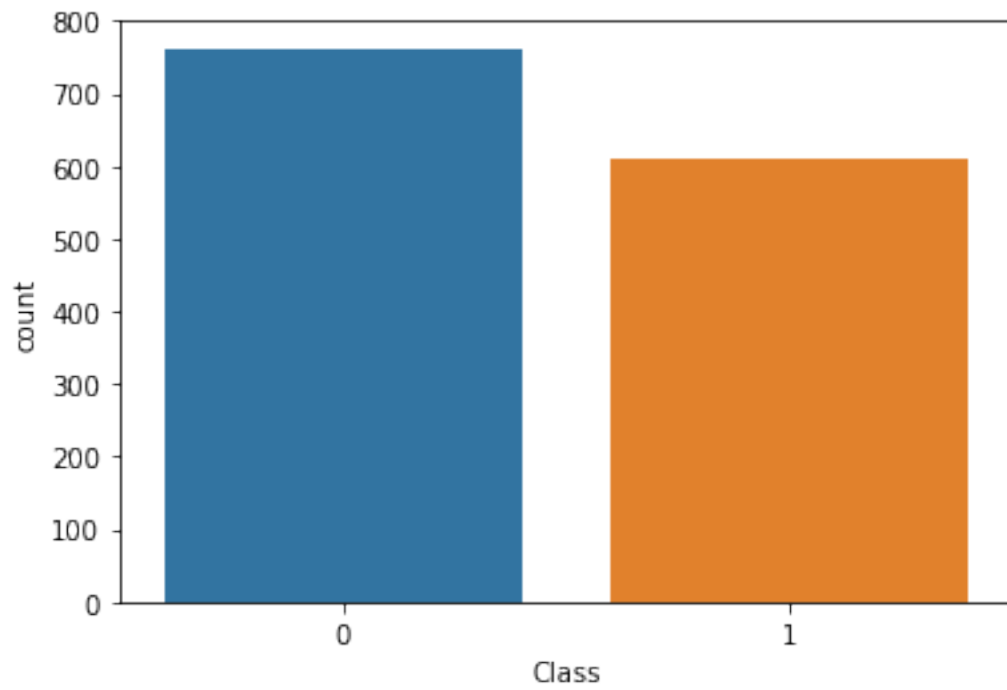
```
Out[5]:
```

	Image.Var	Image.Skew	Image.Curt	Entropy	Class
0	3.62160	8.6661	-2.8073	-0.44699	0
1	4.54590	8.1674	-2.4586	-1.46210	0
2	3.86600	-2.6383	1.9242	0.10645	0
3	3.45660	9.5228	-4.0112	-3.59440	0
4	0.32924	-4.4552	4.5718	-0.98880	0

```
In [6]: import seaborn as sns
        %matplotlib inline
```

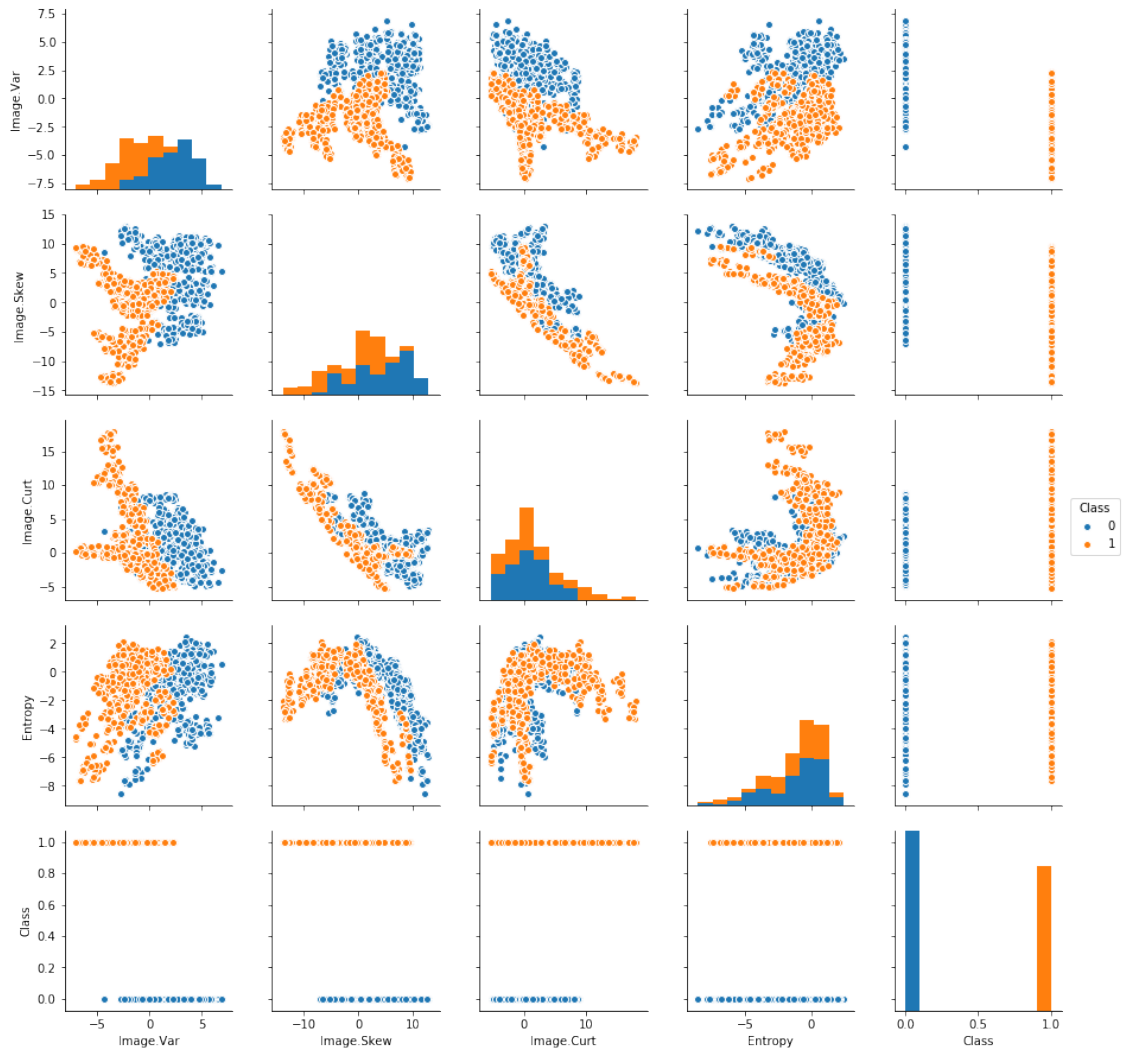
```
In [7]: sns.countplot(x='Class',data=data)
```

```
Out[7]: <matplotlib.axes._subplots.AxesSubplot at 0x112036cf8>
```



```
In [8]: sns.pairplot(data,hue='Class')
```

```
Out[8]: <seaborn.axisgrid.PairGrid at 0x1170c5128>
```



```
In [9]: from sklearn.preprocessing import StandardScaler
```

```
In [10]: # Standardize the data
         scaler = StandardScaler()
```

```
In [11]: scaler.fit(data.drop('Class',axis=1))
```

```
Out[11]: StandardScaler(copy=True, with_mean=True, with_std=True)
```

```
In [12]: scaled_features = scaler.fit_transform(data.drop('Class', axis=1))
```

```
In [16]: # Move standardize data into a dataframe
```

```
df_feat = pd.DataFrame(scaled_features,columns=data.columns[:-1])
df_feat.head()
```

Out[16]:	Image.Var	Image.Skew	Image.Curt	Entropy
0	1.121806	1.149455	-0.975970	0.354561
1	1.447066	1.064453	-0.895036	-0.128767
2	1.207810	-0.777352	0.122218	0.618073
3	1.063742	1.295478	-1.255397	-1.144029
4	-0.036772	-1.087038	0.736730	0.096587

```
In [22]: X = df_feat
```

```
In [23]: y = data['Class']
```

In [24]: *# Use .as_matrix() for tensorflow to accept data in Numpy Array instead of pd series*

```
X = X.as_matrix()
y = y.as_matrix()
```

```
In [25]: from sklearn.cross_validation import train_test_split
```

```
/Users/Momin/anaconda3/lib/python3.6/site-packages/sklearn/cross_validation.py:41: DeprecationWarning:
    "This module will be removed in 0.20.", DeprecationWarning)
```

```
In [34]: X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3)
```

```
In [35]: import tensorflow as tf
```

```
In [64]: feature_columns = [tf.contrib.layers.real_valued_column("", dimension=4)]
```

[illegible]

```
INFO:tensorflow:Using default config.
```

```
INFO:tensorflow:Using config: {'_task_type': None, '_task_id': 0, '_cluster_spec': <tensorflow
    per_process_gpu_memory_fraction: 1.0
}
```

```
, '_tf_random_seed': None, '_save_summary_steps': 100, '_save_checkpoints_secs': 600, '_log_st
```

```
In [56]: classifier.fit(X_train, y_train, steps=200, batch_size=20)
```

WARNING:tensorflow:float64 is not supported by many models, consider casting to float32.

WARNING:tensorflow: Casting <dtype: 'int64'> labels to bool.

WARNING:tensorflow: Casting <dtype: 'int64'> labels to bool.

WARNING:tensorflow:Trapezoidal rule is known to produce incorrect PR-AUCs; please switch to "cubic"

WARNING:tensorflow:Trapezoidal rule is known to produce incorrect PR-AUCs; please switch to "cubic"

```
INFO:tensorflow:Create CheckpointSaverHook.
```

INFO:tensorflow:Graph was finalized.

```
INFO:tensorflow:Restoring parameters from ./output/model.ckpt-2400
```

```

-----

NotFoundError                                Traceback (most recent call last)

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/client/session.py in _do_call
1321     try:
-> 1322         return fn(*args)
1323     except errors.OpError as e:

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/client/session.py in _run_fn
1306     return self._call_tf_sessionrun(
-> 1307         options, feed_dict, fetch_list, target_list, run_metadata)
1308

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/client/session.py in _call_tf_sessionrun
1408     self._session, options, feed_dict, fetch_list, target_list,
-> 1409     run_metadata)
1410     else:

```

```

NotFoundError: Key dnn/binary_logistic_head/dnn/learning_rate not found in checkpoint
[[Node: save/RestoreV2 = RestoreV2[dtypes=[DT_FLOAT, DT_FLOAT, DT_FLOAT, DT_FLOAT]

```

During handling of the above exception, another exception occurred:

```

NotFoundError                                Traceback (most recent call last)

<ipython-input-56-8a632f8d43c3> in <module>()
----> 1 classifier.fit(X_train, y_train, steps=200, batch_size=20)

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/util/deprecation.py in new_func
430     'in a future version' if date is None else ('after %s' % date),
431     instructions)
--> 432     return func(*args, **kwargs)
433     return tf_decorator.make_decorator(func, new_func, 'deprecated',
434                                         _add_deprecated_arg_notice_to_docstring(

~/anaconda3/lib/python3.6/site-packages/tensorflow/contrib/learn/python/learn/estimator.py
506     _verify_input_args(x, y, input_fn, None, batch_size)
507     if x is not None:
--> 508         SKCompat(self).fit(x, y, batch_size, steps, max_steps, monitors)

```

```

509         return self
510

~/anaconda3/lib/python3.6/site-packages/tensorflow/contrib/learn/python/learn/estimator.py
1525         steps=steps,
1526         max_steps=max_steps,
-> 1527         monitors=all_monitors)
1528     return self
1529

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/util/deprecation.py in new_func
430         'in a future version' if date is None else ('after %s' % date),
431         instructions)
--> 432     return func(*args, **kwargs)
433     return tf_decorator.make_decorator(func, new_func, 'deprecated',
434                                         _add_deprecated_arg_notice_to_docstring(

~/anaconda3/lib/python3.6/site-packages/tensorflow/contrib/learn/python/learn/estimator.py
522         hooks.append(basic_session_run_hooks.StopAtStepHook(steps, max_steps))
523
--> 524     loss = self._train_model(input_fn=input_fn, hooks=hooks)
525     logging.info('Loss for final step: %s.', loss)
526     return self

~/anaconda3/lib/python3.6/site-packages/tensorflow/contrib/learn/python/learn/estimator.py
1089         save_checkpoint_secs=0, # Saving is handled by a hook.
1090         save_summaries_steps=self._config.save_summary_steps,
-> 1091         config=self._session_config) as mon_sess:
1092         loss = None
1093         while not mon_sess.should_stop():

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitored_session.py
403     all_hooks.extend(hooks)
404     return MonitoredSession(session_creator=session_creator, hooks=all_hooks,
--> 405                             stop_grace_period_secs=stop_grace_period_secs)
406
407

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitored_session.py
814     super(MonitoredSession, self).__init__(
815         session_creator, hooks, should_recover=True,
--> 816         stop_grace_period_secs=stop_grace_period_secs)

```

```

817
818

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitored_session.py
537         stop_grace_period_secs=stop_grace_period_secs)
538     if should_recover:
--> 539         self._sess = _RecoverableSession(self._coordinated_creator)
540     else:
541         self._sess = self._coordinated_creator.create_session()

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitored_session.py
1000     """
1001     self._sess_creator = sess_creator
-> 1002     _WrappedSession.__init__(self, self._create_session())
1003
1004     def _create_session(self):

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitored_session.py
1005     while True:
1006         try:
-> 1007             return self._sess_creator.create_session()
1008         except _PREEMPTION_ERRORS as e:
1009             logging.info('An error was raised while a session was being created. '

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitored_session.py
694     """Creates a coordinated session."""
695     # Keep the tf_sess for unit testing.
--> 696     self.tf_sess = self._session_creator.create_session()
697     # We don't want coordinator to suppress any exception.
698     self.coord = coordinator.Coordinator(clean_stop_exception_types=[])

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitored_session.py
465     init_op=self._scaffold.init_op,
466     init_feed_dict=self._scaffold.init_feed_dict,
--> 467     init_fn=self._scaffold.init_fn)
468
469

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/session_manager.py
277     wait_for_checkpoint=wait_for_checkpoint,
278     max_wait_secs=max_wait_secs,
--> 279     config=config)

```

```

280     if not is_loaded_from_checkpoint:
281         if init_op is None and not init_fn and self._local_init_op is None:

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/session_manager.py :
205
206     # Loads the checkpoint.
--> 207     saver.restore(sess, ckpt.model_checkpoint_path)
208     saver.recover_last_checkpoints(ckpt.all_model_checkpoint_paths)
209     return sess, True

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/saver.py in restore
1800     else:
1801         sess.run(self.saver_def.restore_op_name,
-> 1802                 {self.saver_def.filename_tensor_name: save_path})
1803
1804     @staticmethod

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/client/session.py in run(self,
898     try:
899         result = self._run(None, fetches, feed_dict, options_ptr,
--> 900                          run_metadata_ptr)
901         if run_metadata:
902             proto_data = tf_session.TF_GetBuffer(run_metadata_ptr)

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/client/session.py in _run(self,
1133     if final_fetches or final_targets or (handle and feed_dict_tensor):
1134         results = self._do_run(handle, final_targets, final_fetches,
-> 1135                               feed_dict_tensor, options, run_metadata)
1136     else:
1137         results = []

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/client/session.py in _do_run
1314     if handle is None:
1315         return self._do_call(_run_fn, feeds, fetches, targets, options,
-> 1316                             run_metadata)
1317     else:
1318         return self._do_call(_prun_fn, handle, feeds, fetches)

~/anaconda3/lib/python3.6/site-packages/tensorflow/python/client/session.py in _do_call
1333     except KeyError:
1334         pass
-> 1335     raise type(e)(node_def, op, message)

```


1336

1337 def _extend_graph(self):

NotFoundError: Key dnn/binary_logistic_head/dnn/learning_rate not found in checkpoint
[[Node: save/RestoreV2 = RestoreV2[dtypes=[DT_FLOAT, DT_FLOAT, DT_FLOAT, DT_FLOAT

Caused by op 'save/RestoreV2', defined at:

File "/Users/Momin/anaconda3/lib/python3.6/runpy.py", line 193, in _run_module_as_main
 "__main__", mod_spec)
File "/Users/Momin/anaconda3/lib/python3.6/runpy.py", line 85, in _run_code
 exec(code, run_globals)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py", line 16
 app.launch_new_instance()
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/traitlets/config/application.py", line 467
 app.start()
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/ipykernel/kernelapp.py", line 423
 ioloop.IOLoop.instance().start()
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/zmq/eventloop/ioloop.py", line 163
 super(ZMQIOLoop, self).start()
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tornado/ioloop.py", line 888, in start
 handler_func(fd_obj, events)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tornado/stack_context.py", line 275
 return fn(*args, **kwargs)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/zmq/eventloop/zmqstream.py", line 545
 self._handle_recv()
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/zmq/eventloop/zmqstream.py", line 519
 self._run_callback(callback, msg)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/zmq/eventloop/zmqstream.py", line 519
 callback(*args, **kwargs)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tornado/stack_context.py", line 275
 return fn(*args, **kwargs)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/ipykernel/kernelbase.py", line 483
 return self.dispatch_shell(stream, msg)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/ipykernel/kernelbase.py", line 455
 handler(stream, idents, msg)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/ipykernel/kernelbase.py", line 423
 user_expressions, allow_stdin)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/ipykernel/ipkernel.py", line 196
 res = shell.run_cell(code, store_history=store_history, silent=silent)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/ipykernel/zmqshell.py", line 533
 return super(ZMQInteractiveShell, self).run_cell(*args, **kwargs)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/IPython/core/interactiveshell.py", line 2691
 interactivity=interactivity, compiler=compiler, result=result)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/IPython/core/interactiveshell.py", line 2661
 if self.run_code(code, result):
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/IPython/core/interactiveshell.py", line 2661
 exec(code_obj, self.user_global_ns, self.user_ns)

```

File "<ipython-input-56-8a632f8d43c3>", line 1, in <module>
    classifier.fit(X_train, y_train, steps=200, batch_size=20)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/util/deprecation.py", line 261, in wrapper
    return func(*args, **kwargs)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/contrib/learn/python/learn/python_logging.py", line 100, in fit
    SKCompat(self).fit(x, y, batch_size, steps, max_steps, monitors)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/contrib/learn/python/learn/python_logging.py", line 100, in fit
    monitors=all_monitors)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/util/deprecation.py", line 261, in wrapper
    return func(*args, **kwargs)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/contrib/learn/python/learn/python_logging.py", line 100, in fit
    loss = self._train_model(input_fn=input_fn, hooks=hooks)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/contrib/learn/python/learn/python_logging.py", line 100, in fit
    config=self._session_config) as mon_sess:
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitors.py", line 100, in fit
    stop_grace_period_secs=stop_grace_period_secs)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitors.py", line 100, in fit
    stop_grace_period_secs=stop_grace_period_secs)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitors.py", line 100, in fit
    self._sess = _RecoverableSession(self._coordinated_creator)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitors.py", line 100, in fit
    _WrappedSession.__init__(self, self._create_session())
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitors.py", line 100, in fit
    return self._sess_creator.create_session()
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitors.py", line 100, in fit
    self.tf_sess = self._session_creator.create_session()
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitors.py", line 100, in fit
    self._scaffold.finalize()
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/monitors.py", line 100, in fit
    self._saver.build()
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/saver.py", line 100, in fit
    self._build(self._filename, build_save=True, build_restore=True)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/saver.py", line 100, in fit
    build_save=build_save, build_restore=build_restore)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/saver.py", line 100, in fit
    restore_sequentially, reshape)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/saver.py", line 100, in fit
    name="restore_shard"))
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/saver.py", line 100, in fit
    restore_sequentially)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/training/saver.py", line 100, in fit
    return io_ops.restore_v2(filename_tensor, names, slices, dtypes)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/ops/gen_io_ops.py", line 100, in fit
    shape_and_slices=shape_and_slices, dtypes=dtypes, name=name)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/framework/op_def_registry.py", line 100, in fit
    op_def=op_def)
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/framework/ops.py", line 100, in fit
    op_def=op_def)

```

```
File "/Users/Momin/anaconda3/lib/python3.6/site-packages/tensorflow/python/framework/ops
self._traceback = self._graph._extract_stack() # pylint: disable=protected-access
```

```
NotFoundError (see above for traceback): Key dnn/binary_logistic_head/dnn/learning_rate no
[[Node: save/RestoreV2 = RestoreV2[dtypes=[DT_FLOAT, DT_FLOAT, DT_FLOAT, DT_FLOAT
```

```
In [ ]: # Making predictions from X_test
```

```
note_predictions = list(classifier.predict(X_test))
```

```
In [ ]: from sklearn.metrics import classification_report, confusion_matrix
```

```
In [66]: print(confusion_matrix(y_test, note_predictions))
```

```
[[220  2]
 [ 0 190]]
```

```
In [67]: print(classification_report(y_test, note_predictions))
```

	precision	recall	f1-score	support
0	1.00	0.99	1.00	222
1	0.99	1.00	0.99	190
avg / total	1.00	1.00	1.00	412

```
In [58]: # Import RandomForestClassifier
```

```
from sklearn.ensemble import RandomForestClassifier
```

```
In [59]: # Comparison with DNN classifier of RandomForestClassifier
```

```
rfc = RandomForestClassifier(n_estimators=200)
```

```
In [60]: rfc.fit(X_train, y_train)
```

```
Out[60]: RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
max_depth=None, max_features='auto', max_leaf_nodes=None,
min_impurity_decrease=0.0, min_impurity_split=None,
min_samples_leaf=1, min_samples_split=2,
min_weight_fraction_leaf=0.0, n_estimators=200, n_jobs=1,
oob_score=False, random_state=None, verbose=0,
warm_start=False)
```

```
In [61]: rfc_preds = rfc.predict(X_test)
```

```
In [62]: print(classification_report(y_test,rfc_preds))
          print('\n')
          print(confusion_matrix(y_test,rfc_preds))
```

	precision	recall	f1-score	support
0	0.99	0.98	0.98	222
1	0.98	0.98	0.98	190
avg / total	0.98	0.98	0.98	412

```
[[218  4]
 [ 3 187]]
```

**** Although the RandomForestClassifier performs very well, The DNN model performs better than the RandomForestClassifier. ****