In [1]:
```python
#Loading packages
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf
from sklearn.model_selection import train_test_split
from tensorflow import keras
```

In [3]:
```python
#Importing data
stroke_dta = pd.read_csv(r"C:\\Nithya\Healthcare_Stroke_Data.csv")
stroke_dta.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5110 entries, 0 to 5109
Data columns (total 12 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   id                 5110 non-null   int64
 1   gender             5110 non-null   object
 2   age                5110 non-null   float64
 3   hypertension       5110 non-null   int64
 4   heart_disease      5110 non-null   int64
 5   ever_married       5110 non-null   object
 6   work_type          5110 non-null   object
 7   Residence_type     5110 non-null   object
 8   avg_glucose_level  5110 non-null   float64
 9   bmi                4909 non-null   float64
 10  smoking_status     5110 non-null   object
 11  stroke             5110 non-null   int64
dtypes: float64(3), int64(4), object(5)
memory usage: 479.2+ KB
```

In [5]:
```python
#Replacing the null values with 0
stroke_dta=stroke_dta.fillna(0)
```

In [6]:
```python
#Dataset initial rows
stroke_dta.head(6)
```

Out[6]:

	id	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type
0	9046	Male	67.0	0	1	Yes	Private	Urban
1	51676	Female	61.0	0	0	Yes	Self-employed	Rural
2	31112	Male	80.0	0	1	Yes	Private	Rural
3	60182	Female	49.0	0	0	Yes	Private	Urban
4	1665	Female	79.0	1	0	Yes	Self-employed	Rural
5	56669	Male	81.0	0	0	Yes	Private	Urban

```
In [21]: #Dividing dataset into independent vrble and dependent vrble
         indpndnt = stroke_dta.drop(['id','smoking_status','stroke'],axis=1)
         dpndnt = stroke_dta.loc[:,'stroke']
```

```
In [22]: #Transforming categorical vrble into dummy vrble
         gender = pd.get_dummies(indpndnt['gender'],drop_first=True)
         ever_married=pd.get_dummies(indpndnt['ever_married'],drop_first=True)
         work_type=pd.get_dummies(indpndnt['work_type'],drop_first=True)
         Residence_type=pd.get_dummies(indpndnt['Residence_type'],drop_first=True)
```

```
In [23]: #Dropping not required columns
         indpndnt.drop(['gender','ever_married','work_type','Residence_type'],axis=1,in
```

```
In [24]: #Forming new independent variable dataset
         indpndnt = pd.concat([indpndnt,gender,ever_married,work_type,Residence_type],a
```

```
In [25]: indpndnt.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5110 entries, 0 to 5109
Data columns (total 13 columns):
 #   Column            Non-Null Count   Dtype
---  ------            --------------   -----
 0   age               5110 non-null    float64
 1   hypertension      5110 non-null    int64
 2   heart_disease     5110 non-null    int64
 3   avg_glucose_level 5110 non-null    float64
 4   bmi               5110 non-null    float64
 5   Male              5110 non-null    uint8
 6   Other             5110 non-null    uint8
 7   Yes               5110 non-null    uint8
 8   Never_worked      5110 non-null    uint8
 9   Private           5110 non-null    uint8
 10  Self-employed     5110 non-null    uint8
 11  children          5110 non-null    uint8
 12  Urban             5110 non-null    uint8
dtypes: float64(3), int64(2), uint8(8)
memory usage: 239.7 KB
```

```
In [26]: #Segregating Dataset - Training and Test
         X_trn, X_tst, Y_trn, Y_tst = train_test_split(indpndnt,dpndnt,test_size=0.30)
```

In [27]:
```python
#Converting the variables into Tensorflow type
features = [tf.feature_column.numeric_column('hypertension'),
            tf.feature_column.numeric_column('heart_disease'),
            tf.feature_column.numeric_column('avg_glucose_level'),
            tf.feature_column.numeric_column('bmi'),
            tf.feature_column.numeric_column('Male'),
            tf.feature_column.numeric_column('Other'),
            tf.feature_column.numeric_column('Yes'),
            tf.feature_column.numeric_column('Never_worked'),
            tf.feature_column.numeric_column('Private'),
            tf.feature_column.numeric_column('Self-employed'),
            tf.feature_column.numeric_column('children'),
            tf.feature_column.numeric_column('Urban')
           ]
```

In [28]:
```python
#Parameter value assignment function
def model_prmtrs(epochs_num,batches_num,shuffle):
    return tf.compat.v1.estimator.inputs.pandas_input_fn(
        x=X_trn,
        y=Y_trn,
        batch_size=batches_num,
        shuffle=shuffle,
        num_epochs=epochs_num
    )
```

In [29]:
```python
#Performance validation function
def model_performance(epochs_num,batches_num,shuffle):
    return tf.compat.v1.estimator.inputs.pandas_input_fn(
        x=X_tst,
        y=Y_tst,
        batch_size=batches_num,
        shuffle=shuffle,
        num_epochs=epochs_num
    )
```

In [30]:
```python
#Designing a Artificial Neural Model
Stroke_ann_model = tf.estimator.DNNClassifier(n_classes=3,
                                              optimizer='Adam',
                                              feature_columns=features,
                                              dropout=0.35,
                                              hidden_units=[1024,512,256,32,3],
                                              activation_fn=tf.nn.relu
                                             )
```

```
INFO:tensorflow:Using default config.
WARNING:tensorflow:Using temporary folder as model directory: C:\Users\alekh
\AppData\Local\Temp\tmpoehf1kbx
INFO:tensorflow:Using config: {'_model_dir': 'C:\\Users\\alekh\\AppData\\Loca
l\\Temp\\tmpoehf1kbx', '_tf_random_seed': None, '_save_summary_steps': 100,
'_save_checkpoints_steps': None, '_save_checkpoints_secs': 600, '_session_con
fig': allow_soft_placement: true
graph_options {
  rewrite_options {
    meta_optimizer_iterations: ONE
  }
}
, '_keep_checkpoint_max': 5, '_keep_checkpoint_every_n_hours': 10000, '_log_s
tep_count_steps': 100, '_train_distribute': None, '_device_fn': None, '_proto
col': None, '_eval_distribute': None, '_experimental_distribute': None, '_exp
erimental_max_worker_delay_secs': None, '_session_creation_timeout_secs': 720
0, '_checkpoint_save_graph_def': True, '_service': None, '_cluster_spec': Clu
sterSpec({}), '_task_type': 'worker', '_task_id': 0, '_global_id_in_cluster':
0, '_master': '', '_evaluation_master': '', '_is_chief': True, '_num_ps_repli
cas': 0, '_num_worker_replicas': 1}
```

In [31]: *#Artificial Neural Model Training using defined epochs and batches*
```python
Stroke_ann_model.train(input_fn=model_prmtrs(100,128,True),steps=1300)
```

```
INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Create CheckpointSaverHook.
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
WARNING:tensorflow:From C:\Users\alekh\anaconda3\lib\site-packages\tensorflow
\python\training\monitored_session.py:907: start_queue_runners (from tensorfl
ow.python.training.queue_runner_impl) is deprecated and will be removed in a
future version.
Instructions for updating:
To construct input pipelines, use the `tf.data` module.
INFO:tensorflow:Calling checkpoint listeners before saving checkpoint 0...
INFO:tensorflow:Saving checkpoints for 0 into C:\Users\alekh\AppData\Local\Te
mp\tmpoehf1kbx\model.ckpt.
INFO:tensorflow:Calling checkpoint listeners after saving checkpoint 0...
INFO:tensorflow:loss = 14.183951, step = 0
INFO:tensorflow:global_step/sec: 71.1179
INFO:tensorflow:loss = 0.9876656, step = 100 (1.406 sec)
INFO:tensorflow:global_step/sec: 79.7124
INFO:tensorflow:loss = 0.8074801, step = 200 (1.255 sec)
INFO:tensorflow:global_step/sec: 78.3157
INFO:tensorflow:loss = 0.46633348, step = 300 (1.279 sec)
INFO:tensorflow:global_step/sec: 80.8992
INFO:tensorflow:loss = 0.4272735, step = 400 (1.234 sec)
INFO:tensorflow:global_step/sec: 79.6305
INFO:tensorflow:loss = 0.37143102, step = 500 (1.256 sec)
INFO:tensorflow:global_step/sec: 79.0748
INFO:tensorflow:loss = 0.39005518, step = 600 (1.279 sec)
INFO:tensorflow:global_step/sec: 79.5934
INFO:tensorflow:loss = 0.31938824, step = 700 (1.242 sec)
INFO:tensorflow:global_step/sec: 78.7391
INFO:tensorflow:loss = 0.3900364, step = 800 (1.270 sec)
INFO:tensorflow:global_step/sec: 79.6755
INFO:tensorflow:loss = 0.44010615, step = 900 (1.255 sec)
INFO:tensorflow:global_step/sec: 79.8615
INFO:tensorflow:loss = 0.30028468, step = 1000 (1.252 sec)
INFO:tensorflow:global_step/sec: 71.6461
INFO:tensorflow:loss = 0.2507998, step = 1100 (1.397 sec)
INFO:tensorflow:global_step/sec: 76.2752
INFO:tensorflow:loss = 0.36268026, step = 1200 (1.310 sec)
INFO:tensorflow:Calling checkpoint listeners before saving checkpoint 1300...
INFO:tensorflow:Saving checkpoints for 1300 into C:\Users\alekh\AppData\Local
\Temp\tmpoehf1kbx\model.ckpt.
INFO:tensorflow:Calling checkpoint listeners after saving checkpoint 1300...
INFO:tensorflow:Loss for final step: 0.33722103.
```

Out[31]: <tensorflow_estimator.python.estimator.canned.dnn.DNNClassifierV2 at 0x1c909d
16a00>

In [32]: ```python
#Artificial Neural Network Model performance validation
Stroke_ann_model.evaluate(input_fn=model_performance(100,128,True),steps=1300)
```

```
INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Starting evaluation at 2023-03-03T18:29:57
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Restoring parameters from C:\Users\alekh\AppData\Local\Temp\t
mpoehf1kbx\model.ckpt-1300
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Evaluation [130/1300]
INFO:tensorflow:Evaluation [260/1300]
INFO:tensorflow:Evaluation [390/1300]
INFO:tensorflow:Evaluation [520/1300]
INFO:tensorflow:Evaluation [650/1300]
INFO:tensorflow:Evaluation [780/1300]
INFO:tensorflow:Evaluation [910/1300]
INFO:tensorflow:Evaluation [1040/1300]
INFO:tensorflow:Evaluation [1170/1300]
INFO:tensorflow:Inference Time : 5.59842s
INFO:tensorflow:Finished evaluation at 2023-03-03-18:30:03
INFO:tensorflow:Saving dict for global step 1300: accuracy = 0.94781476, aver
age_loss = 0.20391344, global_step = 1300, loss = 0.2039025
INFO:tensorflow:Saving 'checkpoint_path' summary for global step 1300: C:\Use
rs\alekh\AppData\Local\Temp\tmpoehf1kbx\model.ckpt-1300
```

Out[32]: ```
{'accuracy': 0.94781476,
 'average_loss': 0.20391344,
 'loss': 0.2039025,
 'global_step': 1300}
```

In [33]: ```python
#Merging Artificial Neural Model and Linear Classifier model
Stroke_ann_linr_model = tf.estimator.DNNLinearCombinedClassifier(n_classes=3,c
```

```
INFO:tensorflow:Using default config.
WARNING:tensorflow:Using temporary folder as model directory: C:\Users\alekh
\AppData\Local\Temp\tmperii8y22
INFO:tensorflow:Using config: {'_model_dir': 'C:\\Users\\alekh\\AppData\\Loca
l\\Temp\\tmperii8y22', '_tf_random_seed': None, '_save_summary_steps': 100,
'_save_checkpoints_steps': None, '_save_checkpoints_secs': 600, '_session_con
fig': allow_soft_placement: true
graph_options {
  rewrite_options {
    meta_optimizer_iterations: ONE
  }
}
, '_keep_checkpoint_max': 5, '_keep_checkpoint_every_n_hours': 10000, '_log_s
tep_count_steps': 100, '_train_distribute': None, '_device_fn': None, '_proto
col': None, '_eval_distribute': None, '_experimental_distribute': None, '_exp
erimental_max_worker_delay_secs': None, '_session_creation_timeout_secs': 720
0, '_checkpoint_save_graph_def': True, '_service': None, '_cluster_spec': Clu
sterSpec({}), '_task_type': 'worker', '_task_id': 0, '_global_id_in_cluster':
0, '_master': '', '_evaluation_master': '', '_is_chief': True, '_num_ps_repli
cas': 0, '_num_worker_replicas': 1}
```

In [34]: *#Merging Artificial Neural Model and Linear Classifier model training using de*
         Stroke_ann_linr_model.train(input_fn=model_prmtrs(100,128,True),steps=1300)

```
INFO:tensorflow:Calling model_fn.

C:\Users\alekh\anaconda3\lib\site-packages\tensorflow\python\keras\engine\bas
e_layer_v1.py:1700: UserWarning: `layer.add_variable` is deprecated and will
be removed in a future version. Please use `layer.add_weight` method instead.
  warnings.warn('`layer.add_variable` is deprecated and '

WARNING:tensorflow:From C:\Users\alekh\anaconda3\lib\site-packages\tensorflow
\python\keras\optimizer_v2\ftrl.py:148: calling Constant.__init__ (from tenso
rflow.python.ops.init_ops) with dtype is deprecated and will be removed in a
future version.
Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to th
e constructor
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Create CheckpointSaverHook.
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Calling checkpoint listeners before saving checkpoint 0...
INFO:tensorflow:Saving checkpoints for 0 into C:\Users\alekh\AppData\Local\Te
mp\tmperii8y22\model.ckpt.
INFO:tensorflow:Calling checkpoint listeners after saving checkpoint 0...
INFO:tensorflow:loss = 4.1216173, step = 0
INFO:tensorflow:global_step/sec: 66.4381
INFO:tensorflow:loss = 0.26113474, step = 100 (1.505 sec)
INFO:tensorflow:global_step/sec: 76.3587
INFO:tensorflow:loss = 0.20946643, step = 200 (1.311 sec)
INFO:tensorflow:global_step/sec: 65.289
INFO:tensorflow:loss = 0.20310056, step = 300 (1.530 sec)
INFO:tensorflow:global_step/sec: 69.6645
INFO:tensorflow:loss = 0.2599422, step = 400 (1.436 sec)
INFO:tensorflow:global_step/sec: 73.8259
INFO:tensorflow:loss = 0.20830502, step = 500 (1.355 sec)
INFO:tensorflow:global_step/sec: 68.5466
INFO:tensorflow:loss = 0.1275499, step = 600 (1.459 sec)
INFO:tensorflow:global_step/sec: 74.0679
INFO:tensorflow:loss = 0.17187399, step = 700 (1.348 sec)
INFO:tensorflow:global_step/sec: 69.9662
INFO:tensorflow:loss = 0.20161879, step = 800 (1.430 sec)
INFO:tensorflow:global_step/sec: 73.4029
INFO:tensorflow:loss = 0.12579398, step = 900 (1.362 sec)
INFO:tensorflow:global_step/sec: 75.1998
INFO:tensorflow:loss = 0.05388005, step = 1000 (1.329 sec)
INFO:tensorflow:global_step/sec: 68.5724
INFO:tensorflow:loss = 0.13457847, step = 1100 (1.460 sec)
INFO:tensorflow:global_step/sec: 76.3753
INFO:tensorflow:loss = 0.2343122, step = 1200 (1.310 sec)
INFO:tensorflow:Calling checkpoint listeners before saving checkpoint 1300...
INFO:tensorflow:Saving checkpoints for 1300 into C:\Users\alekh\AppData\Local
\Temp\tmperii8y22\model.ckpt.
INFO:tensorflow:Calling checkpoint listeners after saving checkpoint 1300...
INFO:tensorflow:Loss for final step: 0.084088154.
```

Out[34]: `<tensorflow_estimator.python.estimator.canned.dnn_linear_combined.DNNLinearCombinedClassifierV2 at 0x1c909d7c430>`

In [35]:
```python
#Merging Artificial Neural Model and Linear Classifier model performance valid
Stroke_ann_linr_model.evaluate(input_fn=model_performance(100,128,True),steps=
```

```
INFO:tensorflow:Calling model_fn.

C:\Users\alekh\anaconda3\lib\site-packages\tensorflow\python\keras\engine\base_layer_v1.py:1700: UserWarning: `layer.add_variable` is deprecated and will
be removed in a future version. Please use `layer.add_weight` method instead.
  warnings.warn('`layer.add_variable` is deprecated and '

INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Starting evaluation at 2023-03-03T18:33:34
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Restoring parameters from C:\Users\alekh\AppData\Local\Temp\tmperii8y22\model.ckpt-1300
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Evaluation [130/1300]
INFO:tensorflow:Evaluation [260/1300]
INFO:tensorflow:Evaluation [390/1300]
INFO:tensorflow:Evaluation [520/1300]
INFO:tensorflow:Evaluation [650/1300]
INFO:tensorflow:Evaluation [780/1300]
INFO:tensorflow:Evaluation [910/1300]
INFO:tensorflow:Evaluation [1040/1300]
INFO:tensorflow:Evaluation [1170/1300]
INFO:tensorflow:Inference Time : 5.89233s
INFO:tensorflow:Finished evaluation at 2023-03-03-18:33:40
INFO:tensorflow:Saving dict for global step 1300: accuracy = 0.94781476, average_loss = 0.20430002, global_step = 1300, loss = 0.20428191
INFO:tensorflow:Saving 'checkpoint_path' summary for global step 1300: C:\Users\alekh\AppData\Local\Temp\tmperii8y22\model.ckpt-1300
```

Out[35]:
```
{'accuracy': 0.94781476,
 'average_loss': 0.20430002,
 'loss': 0.20428191,
 'global_step': 1300}
```

In [ ]: