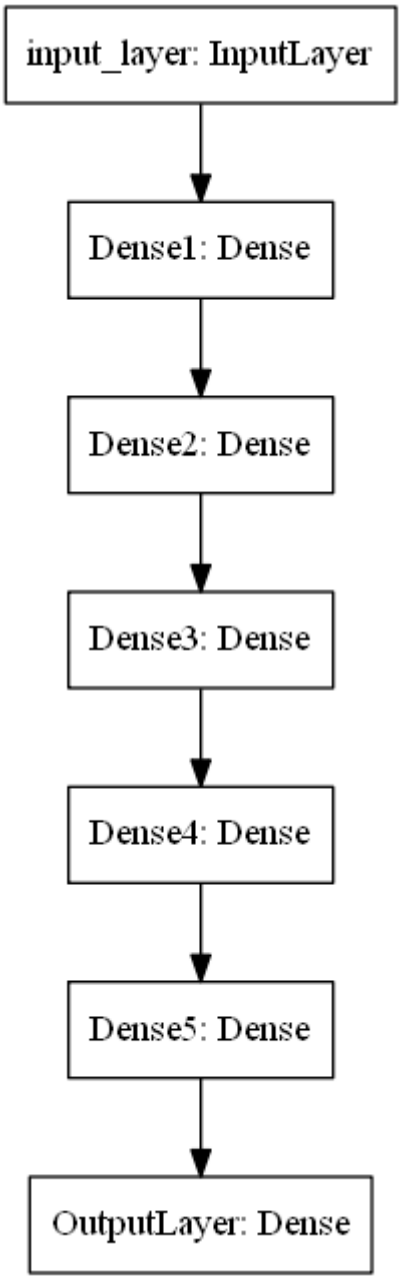
1. Download the data from here (https://drive.google.com/file/d/15dCNcmKskcFVjs7R0ElQkR61Ex53uJpM/view?usp=sharing)

2. Code the model to classify data like below image



3. Write your own callback function, that has to print the micro F1 score and AUC score after each epoch.

4. Save your model at every epoch if your validation accuracy is improved from previous epoch.

5. you have to decay learning based on below conditions
        Cond1. If your validation accuracy at that epoch is less than previous epoch accuracy, you have to decrese the
                learning rate by 10%.
        Cond2. For every 3rd epoch, decay your learning rate by 5%.

6. If you are getting any NaN values(either weigths or loss) while training, you have to terminate your training.

7. You have to stop the training if your validation accuracy is not increased in last 2 epochs.

8. Use tensorboard for every model and analyse your gradients. (you need to uplo ad the screenshots for each model for evaluation)

9. use cross entropy as loss function

10. Try the architecture params as given below.

Model-1

1. Use tanh as an activation for every layer except output layer.
2. use SGD with momentum as optimizer.
3. use RandomUniform(0,1) as initilizer.
3. Analyze your output and training process.

Model-2

1. Use relu as an activation for every layer except output layer.
2. use SGD with momentum as optimizer.
3. use RandomUniform(0,1) as initilizer.
3. Analyze your output and training process.

Model-3

1. Use relu as an activation for every layer except output layer.
2. use SGD with momentum as optimizer.
3. use he_uniform() as initilizer.
3. Analyze your output and training process.

Model-4

1. Try with any values to get better accuracy/f1 score.

In [1]:
```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from tensorflow.keras.layers import Dense,Input,Activation
from tensorflow.keras.models import Model
import random as rn
import tensorflow as tf
from sklearn.metrics import f1_score
from sklearn.metrics import roc_auc_score
from tensorflow.keras.callbacks import ModelCheckpoint
from tensorflow.keras.callbacks import EarlyStopping
from tensorflow.keras.callbacks import LearningRateScheduler
import datetime
```

In [2]:
```
data = pd.read_csv('data.csv')
data.head()
```

Out[2]:

	f1	f2	label
0	0.450564	1.074305	0.0
1	0.085632	0.967682	0.0
2	0.117326	0.971521	1.0
3	0.982179	-0.380408	0.0
4	-0.720352	0.955850	0.0

In [3]:
```
data.shape
```

Out[3]:
```
(20000, 3)
```

In [4]:
```
X = data.drop(['label'],axis=1).values
y = data['label'].values

X_train,X_test,y_train,y_test = train_test_split(X , y , test_size=0.30, stratify=y)
print(X_train.shape)
print(y_train.shape)
print(X_test.shape)
print(y_test.shape)
```

```
(14000, 2)
(14000,)
(6000, 2)
(6000,)
```

Writing Custom callbacks

In [16]:

```
# Writing a callback function that prints micro F1 score and AUC score after each epoch.

class Metrics(tf.keras.callbacks.Callback):
    def __init__(self,val_data):
        self.x_val = val_data[0]
        self.y_val = val_data[1]

    def on_train_begin(self,log={}):
        self.f1= []

    def on_epoch_end(self, epoch, logs={}):
        val_predict = (np.asarray(self.model.predict(self.x_val))).round()
        val_f1 = f1_score(self.y_val, val_predict,average='micro')

        self.f1.append(val_f1)
        print('f1_score: '+'{:.4f}'.format(val_f1))
        return

class auc(tf.keras.callbacks.Callback):
    def __init__(self,train_data,val_data):
        self.x = train_data[0]
        self.y = train_data[1]
        self.x_val = val_data[0]
        self.y_val = val_data[1]

    def on_train_begin(self,logs={}):
        self.auc_score=[]

    def on_epoch_end(self,epoch,logs={}):
        y_pred_train = (np.asarray(self.model.predict(self.x)))
        train_auc = roc_auc_score(self.y,y_pred_train)

        y_pred_val = (np.asarray(self.model.predict(self.x_val)))
        val_auc = roc_auc_score(self.y_val,y_pred_val)

        print('auc_train: %s - auc_val: %s'%(str(round(train_auc,4)),str(round(val_auc,4
        return

metric = Metrics(val_data=(X_test,y_test))
auc_score = auc(train_data=(X_train,y_train),val_data=(X_test,y_test))
```

In [17]:
```
#input layer
input_layer = Input(shape=(2,))

#dense layer
layer1 = Dense(5, activation='tanh', kernel_initializer= tf.keras.initializers.RandomUni

#output layer
output = Dense(1,activation = 'sigmoid',kernel_initializer= tf.keras.initializers.Random

#Creating a model
model = Model(inputs=input_layer,outputs=output)

optimizer = tf.keras.optimizers.SGD(learning_rate=0.01, momentum=0.9, nesterov=False, na

model.compile(optimizer=optimizer, loss='BinaryCrossentropy')

model.fit(X_train,y_train, epochs = 5, validation_data= (X_test,y_test), batch_size = 25
```

```
Epoch 1/5
560/560 [==============================] - 1s 1ms/step - loss: 0.7005 - val_loss: 0.68
72
f1_score: 0.5710
auc_train: 0.6126 - auc_val: 0.5976
Epoch 2/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6824 - val_loss: 0.67
91
f1_score: 0.5793
auc_train: 0.621 - auc_val: 0.6097
Epoch 3/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6733 - val_loss: 0.67
07
f1_score: 0.5895
auc_train: 0.6477 - auc_val: 0.6348
Epoch 4/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6586 - val_loss: 0.65
32
f1_score: 0.6187
auc_train: 0.7168 - auc_val: 0.6998
Epoch 5/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6365 - val_loss: 0.63
20
f1_score: 0.6593
auc_train: 0.7358 - auc_val: 0.7232
```

Out[17]:
```
<keras.callbacks.History at 0x4f615198>
```

ModelCheckpoint

In [18]:
```
#Saving the model at every epoch if the validation accuracy is improved from previous ep

#input layer
input_layer = Input(shape=(2,))

#dense layer
layer1 = Dense(5, activation='tanh', kernel_initializer= tf.keras.initializers.RandomUni

#output layer
output = Dense(1,activation = 'sigmoid',kernel_initializer= tf.keras.initializers.Random

#Creating a model
model = Model(inputs=input_layer,outputs=output)

filepath = "D:\ipython notebook\Working with callbacks\model\model_save5/weights-{epoch:
checkpoint = ModelCheckpoint(filepath=filepath, monitor='val_accuracy',  verbose=1, save

optimizer = tf.keras.optimizers.SGD(learning_rate=0.01, momentum=0.9, nesterov=False, na

model.compile(optimizer=optimizer, loss='BinaryCrossentropy', metrics=['accuracy'])

model.fit(X_train,y_train, epochs = 5, validation_data= (X_test,y_test), batch_size = 25
```

```
Epoch 1/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6956 - accuracy: 0.50
99 - val_loss: 0.6900 - val_accuracy: 0.5350

Epoch 00001: val_accuracy improved from -inf to 0.53500, saving model to D:\ipython no
tebook\Working with callbacks\model\model_save5\weights-01-0.5350.hdf5
Epoch 2/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6849 - accuracy: 0.56
42 - val_loss: 0.6820 - val_accuracy: 0.5768

Epoch 00002: val_accuracy improved from 0.53500 to 0.57683, saving model to D:\ipython
notebook\Working with callbacks\model\model_save5\weights-02-0.5768.hdf5
Epoch 3/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6772 - accuracy: 0.57
82 - val_loss: 0.6763 - val_accuracy: 0.5765

Epoch 00003: val_accuracy did not improve from 0.57683
Epoch 4/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6711 - accuracy: 0.58
81 - val_loss: 0.6694 - val_accuracy: 0.5858

Epoch 00004: val_accuracy improved from 0.57683 to 0.58583, saving model to D:\ipython
notebook\Working with callbacks\model\model_save5\weights-04-0.5858.hdf5
Epoch 5/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6560 - accuracy: 0.62
20 - val_loss: 0.6492 - val_accuracy: 0.6313

Epoch 00005: val_accuracy improved from 0.58583 to 0.63133, saving model to D:\ipython
notebook\Working with callbacks\model\model_save5\weights-05-0.6313.hdf5
```

Out[18]:
```
<keras.callbacks.History at 0x5126e6a0>
```

EarlyStopping

In [19]:
```
# Writing the call back to terminate training if loss is 'NaN'

class TerminateNaN(tf.keras.callbacks.Callback):
    def on_epoch_end(self,epoch,log={}):
        loss= log.get('loss')
        if loss is not None:
            if np.isnan(loss) or np.isinf(loss):
                print("Invalid loss and terminated at epoch {}".format(epoch))
                self.model.stop_training = True

    def epoch_end(self,epoch,log={}):
        loss= log.get('loss')
        model_weights = self.model.get_weights()
        if model_weights is not None:
            if np.any([np.any(np.isnan(x)) for x in model_weights]):
                print("Invalid weights and terminated at epoch {}".format(epoch))
                self.model.stop_training = True

Terminate = TerminateNaN()
```

In [20]:
```
# Stop the training if the validation accuracy is not increased in last 2 epochs

#input layer
input_layer = Input(shape=(2,))

#dense layer
layer1 = Dense(5, activation='tanh', kernel_initializer= tf.keras.initializers.RandomUni

#output layer
output = Dense(1,activation = 'sigmoid',kernel_initializer= tf.keras.initializers.Random

#Creating a model
model = Model(inputs=input_layer,outputs=output)

earlystop = EarlyStopping(monitor='val_accuracy', min_delta=0.2, patience=2, verbose=1)

optimizer = tf.keras.optimizers.SGD(learning_rate=0.01, momentum=0.9, nesterov=False, na

model.compile(optimizer=optimizer, loss='BinaryCrossentropy', metrics=['accuracy'])

model.fit(X_train,y_train, epochs = 5, validation_data= (X_test,y_test), batch_size = 25
```

```
Epoch 1/5
560/560 [==============================] - 1s 1ms/step - loss: 0.7016 - accuracy: 0.52
38 - val_loss: 0.6885 - val_accuracy: 0.5315
Epoch 2/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6840 - accuracy: 0.57
17 - val_loss: 0.6796 - val_accuracy: 0.5915
Epoch 3/5
560/560 [==============================] - 1s 1ms/step - loss: 0.6726 - accuracy: 0.60
01 - val_loss: 0.6706 - val_accuracy: 0.5778
Epoch 00003: early stopping
```

Out[20]:
```
<keras.callbacks.History at 0x515a3fd0>
```

LearningRateScheduler

In [21]:
```
def changeLearningRate(epoch,lr):
    if ((epoch+1) % 3 == 0):
        lr=0.95*lr
    return lr
```

In [22]:
```
%load_ext tensorboard
```

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

Model-1

In [40]:
```
#input layer
input_layer = Input(shape=(2,))

#dense layer
layer1 = Dense(5, activation='tanh', kernel_initializer= tf.keras.initializers.RandomUni

#output layer
output = Dense(1,activation = 'sigmoid',kernel_initializer= tf.keras.initializers.Random

#Creating a model
model = Model(inputs=input_layer,outputs=output)

lrschedule = LearningRateScheduler(changeLearningRate, verbose= 1)

filepath = "D:\ipython notebook\Working with callbacks\model\model_save5/weights-{epoch:
checkpoint = ModelCheckpoint(filepath=filepath, monitor='val_accuracy',  verbose=1, save

earlystop = EarlyStopping(monitor='val_accuracy', min_delta=0, patience=3, verbose=1)

log_dir="D:\ipython notebook\Working with callbacks\logs/fit/" + datetime.datetime.now()
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir, histogram_freq=1,

callback_list=[metric,auc_score,checkpoint,Terminate,earlystop,lrschedule,tensorboard_ca

optimizer = tf.keras.optimizers.SGD(learning_rate=0.01, momentum=0.9, nesterov=False, na

model.compile(optimizer=optimizer, loss='BinaryCrossentropy', metrics=['accuracy'])

model.fit(X_train,y_train, epochs = 20, validation_data= (X_test,y_test), batch_size = 2
```

```
Epoch 00011: LearningRateScheduler setting learning rate to 0.008573750033974648.
560/560 [==============================] - 1s 1ms/step - loss: 0.6061 - accuracy: 0.
6701 - val_loss: 0.6116 - val_accuracy: 0.6637
f1_score: 0.6637
auc_train: 0.7344 - auc_val: 0.7282

Epoch 00011: val_accuracy did not improve from 0.66450
Epoch 12/20

Epoch 00012: LearningRateScheduler setting learning rate to 0.008145062532275914.
560/560 [==============================] - 1s 1ms/step - loss: 0.6051 - accuracy: 0.
6688 - val_loss: 0.6109 - val_accuracy: 0.6630
f1_score: 0.6630
auc_train: 0.7358 - auc_val: 0.7281

Epoch 00012: val_accuracy did not improve from 0.66450
Epoch 00012: early stopping
```

Out[40]:
```
<keras.callbacks.History at 0x56f7bc50>
```

Observations:

After training the above model with tanh activation function for the hidden layers and with sigmoid function for the output layer and with uniform initialization of weights, we can notice the following:

1)Maximum accuracy of 0.6645 can be observed in the 9th epoch.

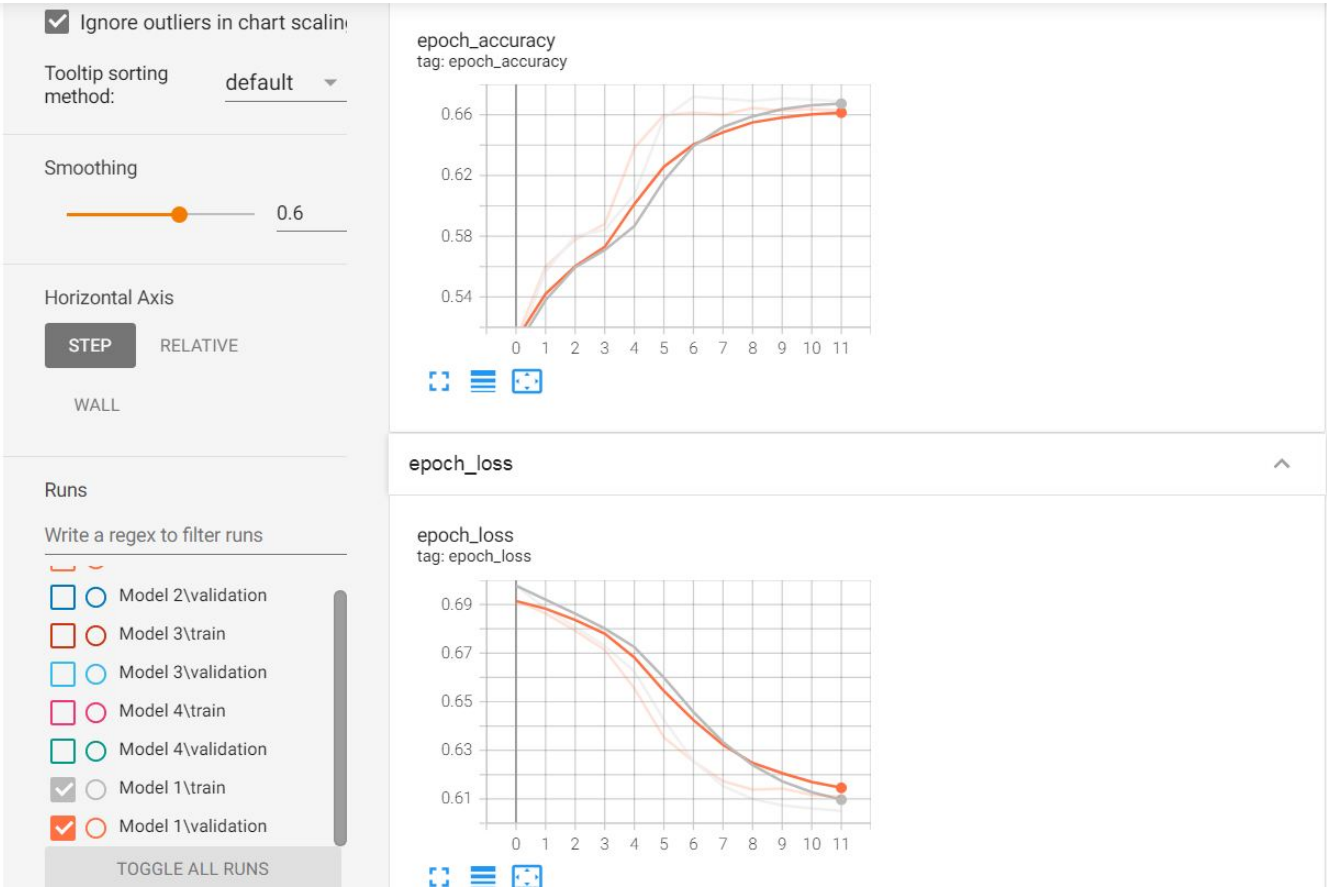
2)The val_accuracy gradually increases until the 9th epoch but tapers off later hence the model is stopped early as we are using patience is equal to 3.

3)The convergence can also be observed with the decrease in val_loss as the number of epoch increases.

Tensorboard results for model 1

In [46]:
```
from IPython.display import Image
Image(filename='Model1.png',width=800, height=400)
```

Out[46]:



Model-2

In [28]:
```
#input layer
input_layer = Input(shape=(2,))

#dense layer
layer1 = Dense(5, activation='relu', kernel_initializer= tf.keras.initializers.RandomUni

#output layer
output = Dense(1,activation = 'sigmoid',kernel_initializer= tf.keras.initializers.Random

#Creating a model
model = Model(inputs=input_layer,outputs=output)

lrschedule = LearningRateScheduler(changeLearningRate, verbose= 1)

filepath = "D:\ipython notebook\Working with callbacks\model\model_save5/weights-{epoch:
checkpoint = ModelCheckpoint(filepath=filepath, monitor='val_accuracy',  verbose=1, save

earlystop = EarlyStopping(monitor='val_accuracy', min_delta=0, patience=3, verbose=1)

log_dir="D:\ipython notebook\Working with callbacks\logs/fit/" + datetime.datetime.now()
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir, histogram_freq=1,

callback_list=[metric,auc_score,checkpoint,Terminate,earlystop,lrschedule,tensorboard_ca

optimizer = tf.keras.optimizers.SGD(learning_rate=0.01, momentum=0.9, nesterov=False, na

model.compile(optimizer=optimizer, loss='BinaryCrossentropy', metrics=['accuracy'])

model.fit(X_train,y_train, epochs = 20, validation_data= (X_test,y_test), batch_size = 2
```

```
Epoch 00010: LearningRateScheduler setting learning rate to 0.008573750033974648.
560/560 [==============================] - 1s 1ms/step - loss: 0.6184 - accuracy: 0.
6532 - val_loss: 0.6178 - val_accuracy: 0.6527
f1_score: 0.6527
auc_train: 0.7239 - auc_val: 0.7175

Epoch 00010: val_accuracy improved from 0.64650 to 0.65267, saving model to D:\ipyth
on notebook\Working with callbacks\model\model_save5\weights-10-0.6527.hdf5
Epoch 11/20

Epoch 00011: LearningRateScheduler setting learning rate to 0.008573750033974648.
560/560 [==============================] - 1s 1ms/step - loss: 0.6172 - accuracy: 0.
6594 - val_loss: 0.6174 - val_accuracy: 0.6508
f1_score: 0.6508
auc_train: 0.7233 - auc_val: 0.7156

Epoch 00011: val_accuracy did not improve from 0.65267
Epoch 12/20

Epoch 00012: LearningRateScheduler setting learning rate to 0.008145062532275914.
```

Observations:

After training the above model with relu activation function for the hidden layers and with sigmoid function for the output layer and with uniform initialization of weights, we can notice the following:

1)Maximum accuracy of 0.65267 can be observed in the 10th epoch but this model is the least accurate compared to others.

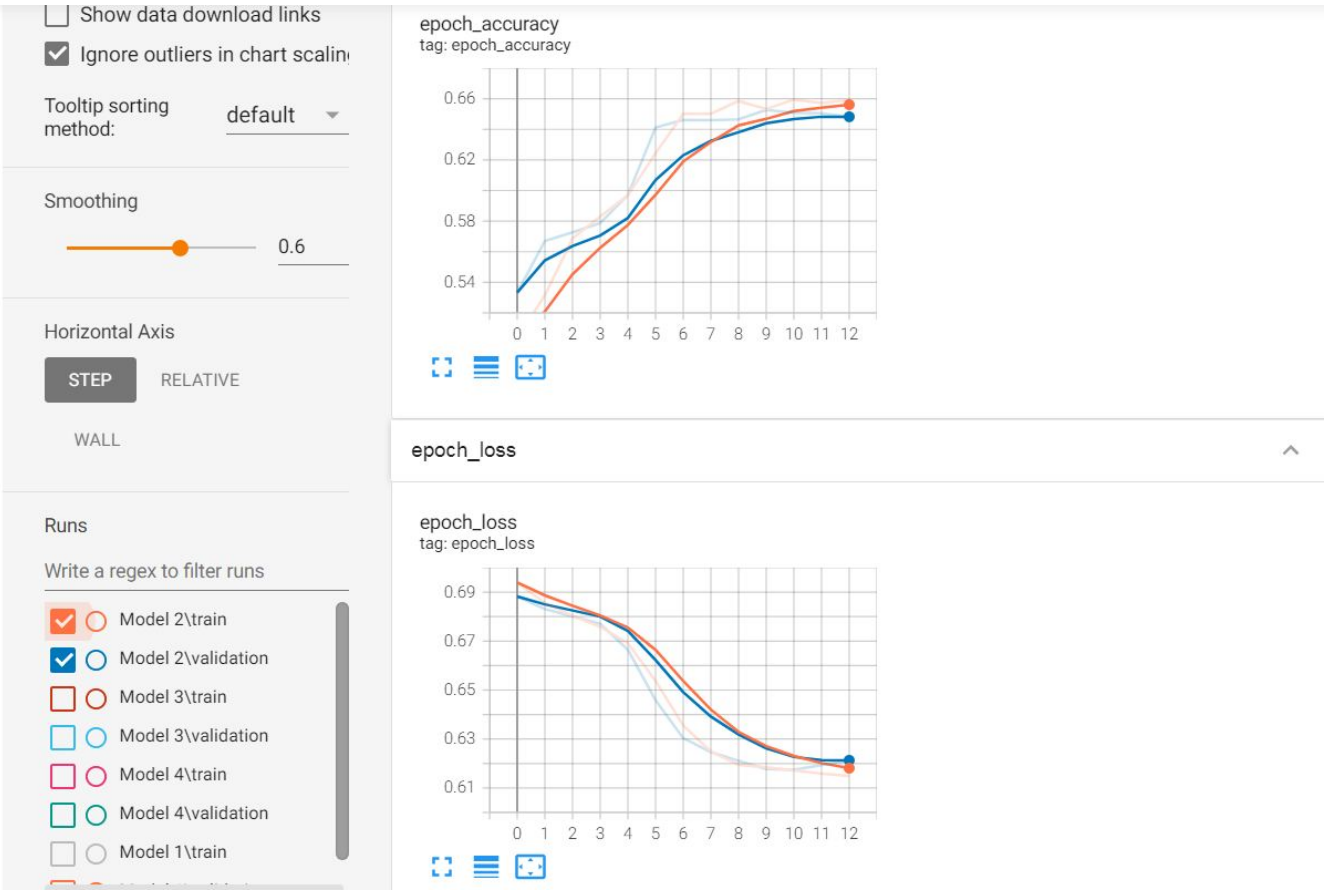
2)A gradual increase in the val_accuracy can be observed as the epoch number increases.As the val_accuracy starts to move sideways then decreasing the learning rate might help increasing the val_accuracy.

3)The increase in accuracy and reduction of loss is comparatively low as regard to other models.

Tensorboard results for model 2

In [49]:
```
from IPython.display import Image
Image(filename='Model2.png',width=800, height=400)
```

Out[49]:



Model-3

In [35]:
```
#input layer
input_layer = Input(shape=(2,))

#dense layer
layer1 = Dense(5, activation='relu', kernel_initializer= tf.keras.initializers.he_unifor

#output layer
output = Dense(1,activation = 'sigmoid',kernel_initializer= tf.keras.initializers.he_uni

#Creating a model
model = Model(inputs=input_layer,outputs=output)

lrschedule = LearningRateScheduler(changeLearningRate, verbose= 1)

filepath = "D:\ipython notebook\Working with callbacks\model\model_save5/weights-{epoch:
checkpoint = ModelCheckpoint(filepath=filepath, monitor='val_accuracy',  verbose=1, save

earlystop = EarlyStopping(monitor='val_accuracy', min_delta=0, patience=3, verbose=1)

log_dir="D:\ipython notebook\Working with callbacks\logs/fit/" + datetime.datetime.now()
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir, histogram_freq=1,

callback_list=[metric,auc_score,checkpoint,Terminate,earlystop,lrschedule,tensorboard_ca

optimizer = tf.keras.optimizers.SGD(learning_rate=0.01, momentum=0.9, nesterov=False, na

model.compile(optimizer=optimizer, loss='BinaryCrossentropy', metrics=['accuracy'])

model.fit(X_train,y_train, epochs = 20, validation_data= (X_test,y_test), batch_size = 2
```

```
WARNING:tensorflow:`write_grads` will be ignored in TensorFlow 2.0 for the `TensorBoar
d` Callback.
Epoch 1/20

Epoch 00001: LearningRateScheduler setting learning rate to 0.009999999776482582.
  3/560 [..............................] - ETA: 1:45 - loss: 0.6891 - accuracy: 0.5867
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch
time (batch time: 0.0012s vs `on_train_batch_end` time: 0.0628s). Check your callback
s.
560/560 [==============================] - 2s 2ms/step - loss: 0.6843 - accuracy: 0.57
74 - val_loss: 0.6602 - val_accuracy: 0.6095
f1_score: 0.6095
auc_train: 0.6751 - auc_val: 0.6686

Epoch 00001: val_accuracy improved from -inf to 0.60950, saving model to D:\ipython no
tebook\Working with callbacks\model\model_save5\weights-01-0.6095.hdf5
Epoch 2/20

Epoch 00002: LearningRateScheduler setting learning rate to 0.009999999776482582.
560/560 [==============================] - 1s 1ms/step - loss: 0.6447 - accuracy: 0.63
90 - val_loss: 0.6335 - val_accuracy: 0.6548
f1_score: 0.6548
auc_train: 0.7209 - auc_val: 0.7125

Epoch 00002: val_accuracy improved from 0.60950 to 0.65483, saving model to D:\ipython
notebook\Working with callbacks\model\model_save5\weights-02-0.6548.hdf5
Epoch 3/20

Epoch 00003: LearningRateScheduler setting learning rate to 0.009949999787658453.
560/560 [==============================] - 1s 1ms/step - loss: 0.6227 - accuracy: 0.66
08 - val_loss: 0.6211 - val_accuracy: 0.6598
f1_score: 0.6598
auc_train: 0.7299 - auc_val: 0.7191
```

```
Epoch 00003: val_accuracy improved from 0.65483 to 0.65983, saving model to D:\ipython
notebook\Working with callbacks\model\model_save5\weights-03-0.6598.hdf5
Epoch 4/20

Epoch 00004: LearningRateScheduler setting learning rate to 0.009499999694526196.
560/560 [==============================] - 1s 1ms/step - loss: 0.6121 - accuracy: 0.66
58 - val_loss: 0.6160 - val_accuracy: 0.6585
f1_score: 0.6585
auc_train: 0.7323 - auc_val: 0.7199

Epoch 00004: val_accuracy did not improve from 0.65983
Epoch 5/20

Epoch 00005: LearningRateScheduler setting learning rate to 0.009499999694526196.
560/560 [==============================] - 1s 1ms/step - loss: 0.6070 - accuracy: 0.66
68 - val_loss: 0.6114 - val_accuracy: 0.6627
f1_score: 0.6627
auc_train: 0.7368 - auc_val: 0.7257

Epoch 00005: val_accuracy improved from 0.65983 to 0.66267, saving model to D:\ipython
notebook\Working with callbacks\model\model_save5\weights-05-0.6627.hdf5
Epoch 6/20

Epoch 00006: LearningRateScheduler setting learning rate to 0.009024999709799886.
560/560 [==============================] - 1s 1ms/step - loss: 0.6052 - accuracy: 0.66
81 - val_loss: 0.6125 - val_accuracy: 0.6613
f1_score: 0.6613
auc_train: 0.7363 - auc_val: 0.7253

Epoch 00006: val_accuracy did not improve from 0.66267
Epoch 7/20

Epoch 00007: LearningRateScheduler setting learning rate to 0.009025000035762787.
560/560 [==============================] - 1s 1ms/step - loss: 0.6038 - accuracy: 0.66
98 - val_loss: 0.6117 - val_accuracy: 0.6640
f1_score: 0.6640
auc_train: 0.7363 - auc_val: 0.7281

Epoch 00007: val_accuracy improved from 0.66267 to 0.66400, saving model to D:\ipython
notebook\Working with callbacks\model\model_save5\weights-07-0.6640.hdf5
Epoch 8/20

Epoch 00008: LearningRateScheduler setting learning rate to 0.009025000035762787.
560/560 [==============================] - 1s 2ms/step - loss: 0.6029 - accuracy: 0.66
74 - val_loss: 0.6211 - val_accuracy: 0.6525
f1_score: 0.6525
auc_train: 0.7372 - auc_val: 0.724

Epoch 00008: val_accuracy did not improve from 0.66400
Epoch 9/20

Epoch 00009: LearningRateScheduler setting learning rate to 0.008573750033974648.
560/560 [==============================] - 1s 1ms/step - loss: 0.6023 - accuracy: 0.67
05 - val_loss: 0.6087 - val_accuracy: 0.6627
f1_score: 0.6627
auc_train: 0.7394 - auc_val: 0.7285

Epoch 00009: val_accuracy did not improve from 0.66400
Epoch 10/20

Epoch 00010: LearningRateScheduler setting learning rate to 0.008573750033974648.
560/560 [==============================] - 1s 1ms/step - loss: 0.6017 - accuracy: 0.66
99 - val_loss: 0.6116 - val_accuracy: 0.6587
f1_score: 0.6587
auc_train: 0.7379 - auc_val: 0.7239
```

```
Epoch 00010: val_accuracy did not improve from 0.66400
Epoch 00010: early stopping
```

Out[35]:
```
<keras.callbacks.History at 0x5252ba20>
```

Observations:

After training the above model with relu activation function for the hidden layers and with sigmoid function for the output layer and with he initialization of weights, we can notice the following:

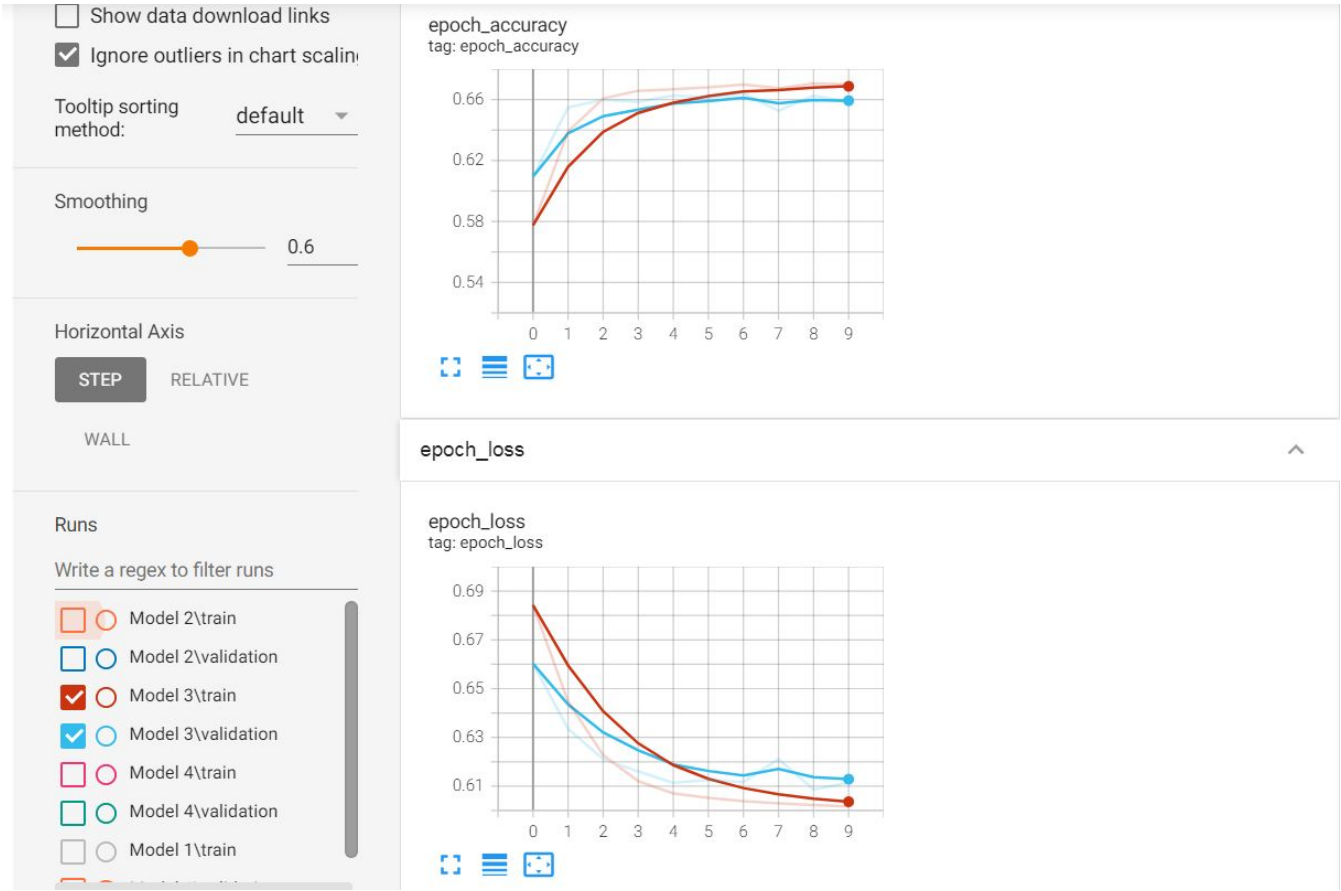
1)Maximum accuracy of 0.66400 can be observed in the 7th epoch.

2)As Epoch number increases, val_loss decreases

Tensorboard results for model 3

In [48]:
```
from IPython.display import Image
Image(filename='Model3.png',width=800, height=400)
```

Out[48]:



Model-4

In [39]:
```
#input layer
input_layer = Input(shape=(2,))

#dense layer
layer1 = Dense(5, activation='tanh', kernel_initializer= tf.keras.initializers.GlorotNor

#output layer
output = Dense(1,activation = 'sigmoid',kernel_initializer= tf.keras.initializers.Glorot

#Creating a model
model = Model(inputs=input_layer,outputs=output)

lrschedule = LearningRateScheduler(changeLearningRate, verbose= 1)

filepath = "D:\ipython notebook\Working with callbacks\model\model_save5/weights-{epoch:
checkpoint = ModelCheckpoint(filepath=filepath, monitor='val_accuracy',  verbose=1, save

earlystop = EarlyStopping(monitor='val_accuracy', min_delta=0, patience=3, verbose=1)

log_dir="D:\ipython notebook\Working with callbacks\logs/fit/" + datetime.datetime.now()
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir, histogram_freq=1,

callback_list=[metric,auc_score,checkpoint,Terminate,earlystop,lrschedule,tensorboard_ca

#optimizer = tf.keras.optimizers.Adagrad(learning_rate=0.001,initial_accumulator_value=0
optimizer = tf.keras.optimizers.SGD(learning_rate=0.01, momentum=0.9, nesterov=False, na

model.compile(optimizer=optimizer, loss='BinaryCrossentropy', metrics=['accuracy'])

model.fit(X_train,y_train, epochs = 20, validation_data= (X_test,y_test), batch_size = 2
```

```
560/560 [==============================] - 1s 1ms/step - loss: 0.6162 - accuracy: 0.
6679 - val_loss: 0.6158 - val_accuracy: 0.6615
f1_score: 0.6615
auc_train: 0.7373 - auc_val: 0.7234

Epoch 00009: val_accuracy did not improve from 0.66500
Epoch 10/20

Epoch 00010: LearningRateScheduler setting learning rate to 0.008573750033974648.
560/560 [==============================] - 1s 1ms/step - loss: 0.6077 - accuracy: 0.
6699 - val_loss: 0.6131 - val_accuracy: 0.6655
f1_score: 0.6655
auc_train: 0.737 - auc_val: 0.7265

Epoch 00010: val_accuracy improved from 0.66500 to 0.66550, saving model to D:\ipyth
on notebook\Working with callbacks\model\model_save5\weights-10-0.6655.hdf5
Epoch 11/20

Epoch 00011: LearningRateScheduler setting learning rate to 0.008573750033974648.
560/560 [==============================] - 1s 1ms/step - loss: 0.6062 - accuracy: 0.
```

Observations:

Out of all 4 models, model 4 gives the maximum accuracy of 0.6655 and F1 score of 0.6705 when tanh activation functions are used for hidden layers and sigmoid function is used for ouput layer with Glorot_Normal initializations.

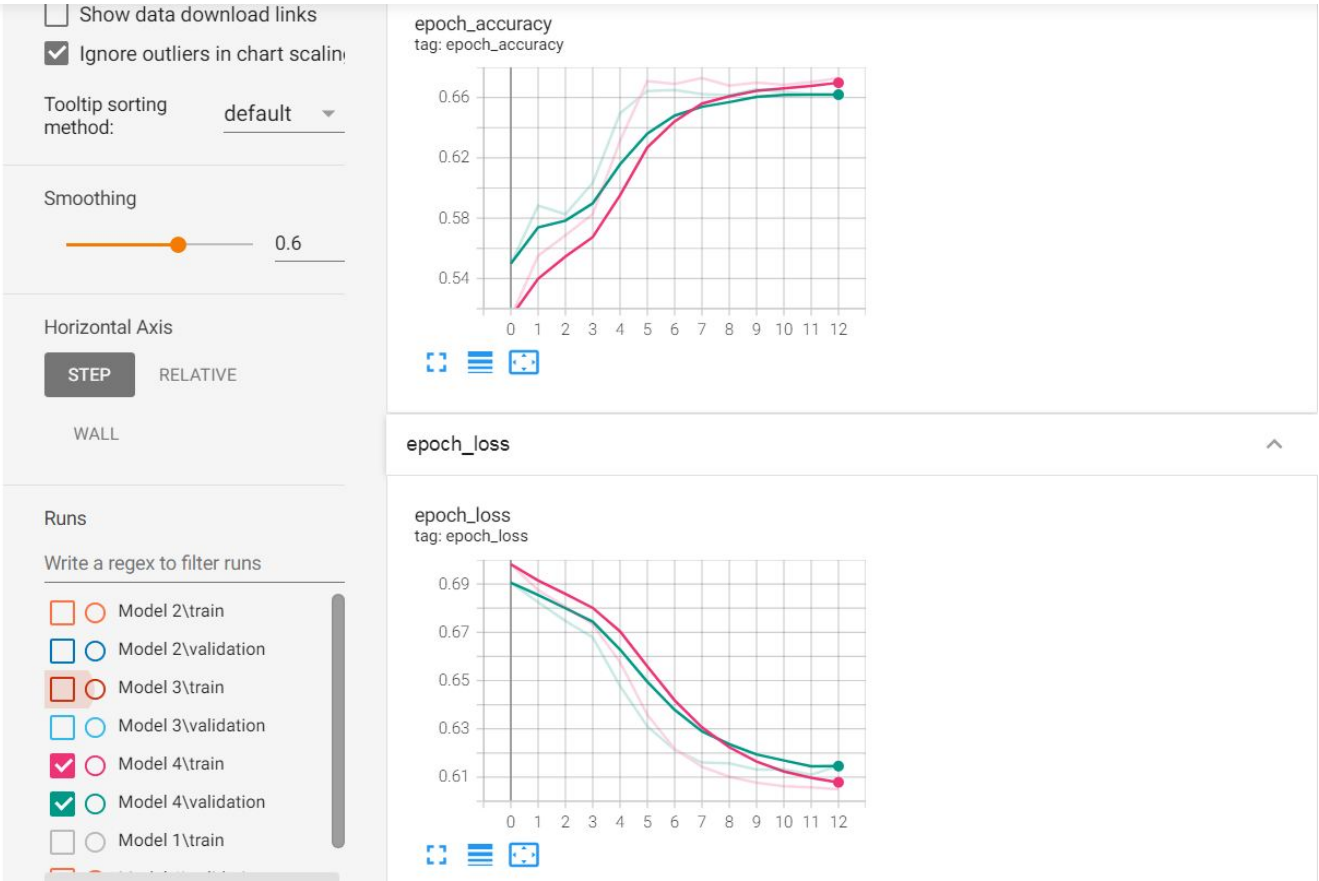
As the epoch number increases, val_loss reduces gradually therefore convergence can be observed for higher epochs.

When the learning rate decreases, a significant increase in val_accuracy can be observed as well as reduction in val_loss.

Tensorboard results for model 4

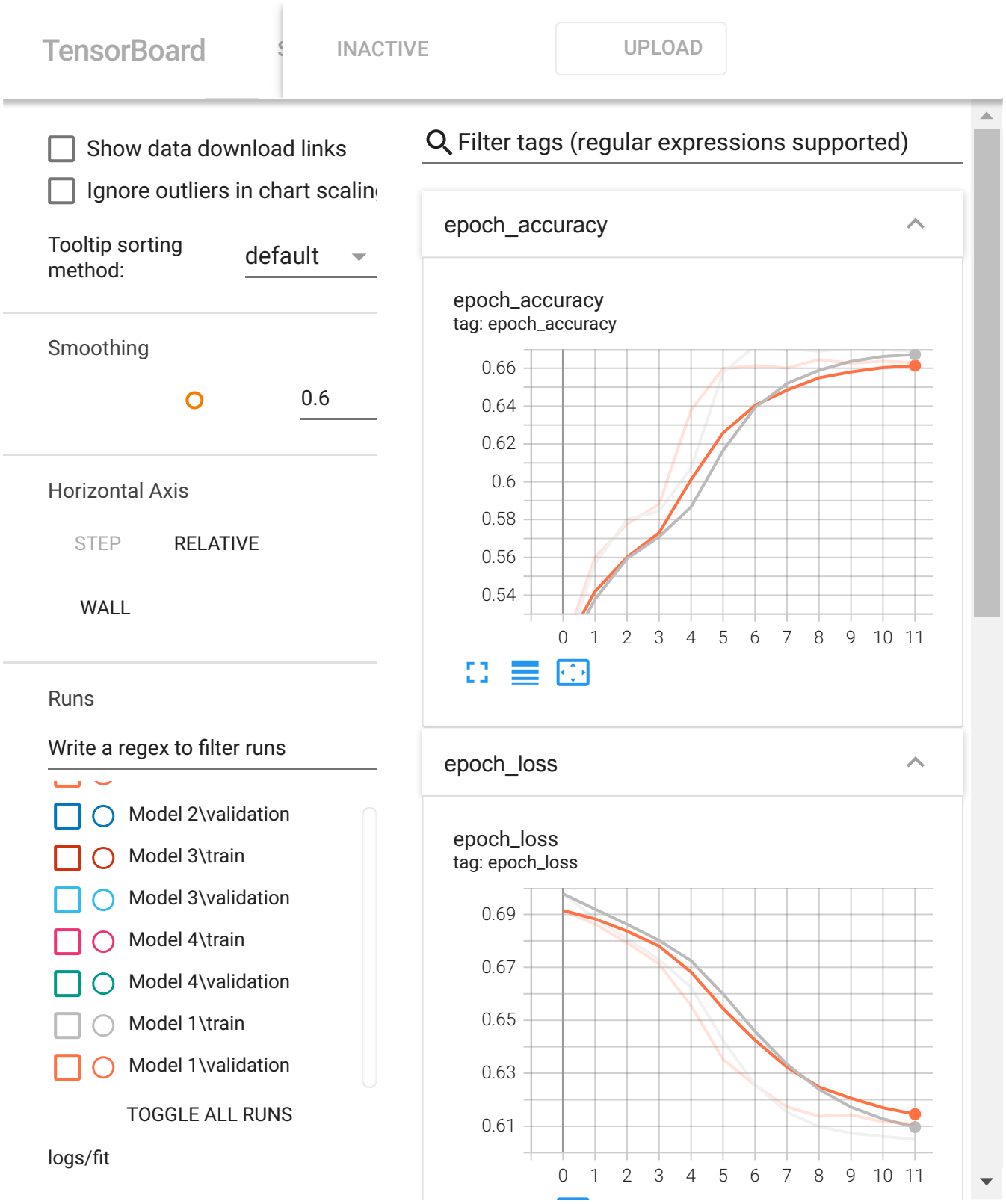
In [47]:
```
from IPython.display import Image
Image(filename='Model4.png',width=800, height=400)
```

Out[47]:



Tensorboard

In [42]:
```
%tensorboard --logdir logs/fit
```



In [ ]: