In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
from keras.models import Sequential
from keras.layers import Dense
from keras.optimizers import Adam
from keras.utils.np_utils import to_categorical
from keras.layers import Dropout, Flatten
from keras.layers.convolutional import Conv2D, MaxPooling2D
import cv2
from sklearn.model_selection import train_test_split
import pickle
import os
import pandas as pd
import random
from keras.preprocessing.image import ImageDataGenerator
import tensorflow as tf
from sklearn.metrics import precision_recall_curve
from sklearn.metrics import plot_precision_recall_curve
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score
```

In [2]:
```
from PIL import Image
import os

# path = "C:\\Users\\Ishaan\\AI project model (3)\\Dataset2\\traffic_Data\\DATA"
# path = "C:\\Users\\Ishaan\\AI project model (3)\\Dataset3\\Images"
path = "C:\\Users\\Ishaan\\AAI project model (3) - Copy\\Dataset5\\train"

i=0
# r=root, d=directories, f = files
for r, d, f in os.walk(path):
    for file in f:
#         if file.endswith('.png'):
#             pat=os.path.join(r, file)
#             with Image.open(pat) as im:
#                 if im.size!=(32, 32):
#                     im=im.resize((32, 32),Image.LANCZOS)
#                 im.save(pat.replace(".png",".jpg"))
#             os.remove(pat)
#             i+=1
#             print(i,end='\r')

        if file.endswith('.jpg'):
            pat=os.path.join(r, file)
            with Image.open(pat) as im:
                if im.size!=(32, 32):
                    im=im.resize((32, 32),Image.LANCZOS)
#                     im.save(pat)
                im.save(pat.replace(".jpg",".png"))
                os.remove(pat)
                i+=1
                print(i,end='\r')

        elif file.endswith('.ppm'):
            pat=os.path.join(r, file)
            with Image.open(pat) as im:
                im.save(pat.replace(".ppm",".png"))
            os.remove(pat)
            i+=1
            print(i,end='\r')

        elif file.endswith('.csv'):
            pat=os.path.join(r, file)
```

```
            os.remove(pat)
```

In [3]:
```
################## Parameters ######################

path = "Dataset5/train" # folder with all the class folders
labelFile = 'Dataset5/labels.csv' # file with all names of classes
batch_size_val=50  # how many to process together
steps_per_epoch_val=2000
epochs_val=20
imageDimesions = (32,32,3)
testRatio = 0.2    # if 1000 images split will 200 for testing
validationRatio = 0.2 # if 1000 images 20% of remaining 800 will be 160 for validation
####################################################
```

In [4]:
```
################################ Importing of the Images
count = 0
images = []
classNo = []
myList = os.listdir(path)
print("Total Classes Detected:",len(myList))
noOfClasses=len(myList)
print("Importing Classes.....")
for x in range (0,len(myList)):
    myPicList = os.listdir(path+"/"+str(count))
    for y in myPicList:
        curImg = cv2.imread(path+"/"+str(count)+"/"+y)
        images.append(curImg)
        classNo.append(count)
    print(count, end =" ")
    count +=1
print(" ")
images = np.array(images)
classNo = np.array(classNo)
```

```
Total Classes Detected: 85
Importing Classes.....
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76
77 78 79 80 81 82 83 84
```

In [5]:
```
############################### Split Data
X_train, X_test, y_train, y_test = train_test_split(images, classNo, test_size=testRatio)
X_train, X_validation, y_train, y_validation = train_test_split(X_train, y_train, test_size=validationRatio)

# X_train = ARRAY OF IMAGES TO TRAIN
# y_train = CORRESPONDING CLASS ID
```

In [6]:
```
############################### TO CHECK IF NUMBER OF IMAGES MATCHES TO NUMBER OF LABELS FOR EACH DATA SET
print("Data Shapes")
print("Train",end = "");print(X_train.shape,y_train.shape)
print("Validation",end = "");print(X_validation.shape,y_validation.shape)
print("Test",end = "");print(X_test.shape,y_test.shape)
assert(X_train.shape[0]==y_train.shape[0]), "The number of images in not equal to the number of lables in traini
assert(X_validation.shape[0]==y_validation.shape[0]), "The number of images in not equal to the number of lables
assert(X_test.shape[0]==y_test.shape[0]), "The number of images in not equal to the number of lables in test set
assert(X_train.shape[1:]==(imageDimesions)),' The dimesions of the Training images are wrong '
assert(X_validation.shape[1:]==(imageDimesions)),' The dimesionas of the Validation images are wrong '
assert(X_test.shape[1:]==(imageDimesions)),' The dimesionas of the Test images are wrong'
```

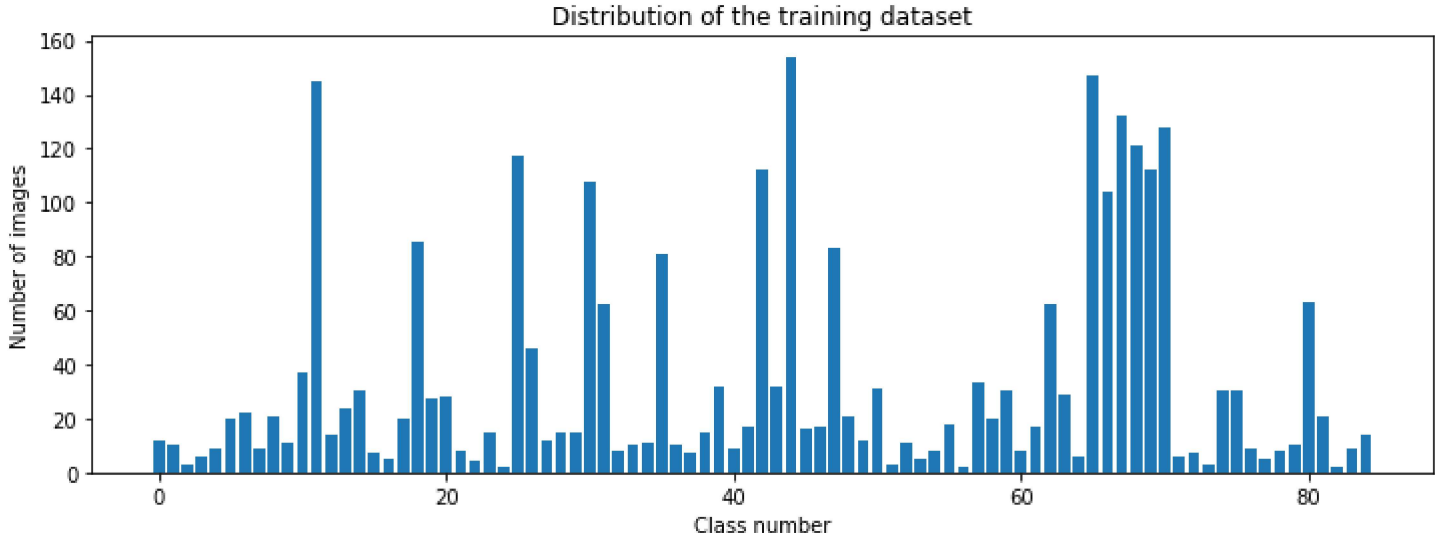
```
Data Shapes
Train(2840, 32, 32, 3) (2840,)
Validation(710, 32, 32, 3) (710,)
Test(888, 32, 32, 3) (888,)
```

In [7]:
```
############################### READ CSV FILE
data=pd.read_csv(labelFile)
print("data shape ",data.shape,type(data))

############################### DISPLAY SOME SAMPLES IMAGES  OF ALL THE CLASSES
num_of_samples = []
cols = 5
num_classes = noOfClasses
fig, axs = plt.subplots(nrows=num_classes, ncols=cols, figsize=(5, 300))
fig.tight_layout()
for i in range(cols):
    for j,row in data.iterrows():
        x_selected = X_train[y_train == j]
        axs[j][i].imshow(x_selected[random.randint(0, len(x_selected)- 1), :, :], cmap=plt.get_cmap("gray"))
        axs[j][i].axis("off")
        if i == 2:
            axs[j][i].set_title(str(j)+ "-"+row["Name"])
            num_of_samples.append(len(x_selected))
```

```
data shape  (85, 2) <class 'pandas.core.frame.DataFrame'>
```

In [8]:
```
############################## DISPLAY A BAR CHART SHOWING NO OF SAMPLES FOR EACH CATEGORY
print(num_of_samples)
plt.figure(figsize=(12, 4))
plt.bar(range(0, num_classes), num_of_samples)
plt.title("Distribution of the training dataset")
plt.xlabel("Class number")
plt.ylabel("Number of images")
plt.show()
```

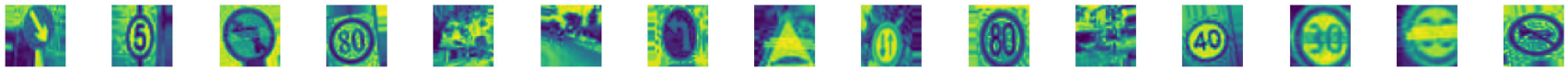
```
[12, 10, 3, 6, 9, 20, 22, 9, 21, 11, 37, 145, 14, 24, 30, 7, 5, 20, 85, 27, 28, 8, 4, 15, 2, 117, 46, 12, 15,
15, 108, 62, 8, 10, 11, 81, 10, 7, 15, 32, 9, 17, 112, 32, 154, 16, 17, 83, 21, 12, 31, 3, 11, 5, 8, 18, 2, 3
3, 20, 30, 8, 17, 62, 29, 6, 147, 104, 132, 121, 112, 128, 6, 7, 3, 30, 30, 9, 5, 8, 10, 63, 21, 2, 9, 14]
```



In [9]:
```
################################ PREPROCESSING THE IMAGES

def grayscale(img):
    img = cv2.cvtColor(img,cv2.COLOR_BGR2GRAY)
    return img
def equalize(img):
    img =cv2.equalizeHist(img)
    return img
def preprocessing(img):
    img = grayscale(img)     # CONVERT TO GRAYSCALE
    img = equalize(img)      # STANDARDIZE THE LIGHTING IN AN IMAGE
    img = img/255            # TO NORMALIZE VALUES BETWEEN 0 AND 1 INSTEAD OF 0 TO 255
    return img

X_train=np.array(list(map(preprocessing,X_train)))  # TO IRETATE AND PREPROCESS ALL IMAGES
X_validation=np.array(list(map(preprocessing,X_validation)))
X_test=np.array(list(map(preprocessing,X_test)))
cv2.imshow("GrayScale Images",X_train[random.randint(0,len(X_train)-1)]) # TO CHECK IF THE TRAINING IS DONE PROP
```

In [10]:
```
################################ ADD A DEPTH OF 1
X_train=X_train.reshape(X_train.shape[0],X_train.shape[1],X_train.shape[2],1)
X_validation=X_validation.reshape(X_validation.shape[0],X_validation.shape[1],X_validation.shape[2],1)
X_test=X_test.reshape(X_test.shape[0],X_test.shape[1],X_test.shape[2],1)
```

In [11]:
```
############################### AUGMENTATAION OF IMAGES: TO MAKEIT MORE GENERIC
dataGen= ImageDataGenerator(width_shift_range=0.1,   # 0.1 = 10%     IF MORE THAN 1 E.G 10 THEN IT REFFERS TO NO
                            height_shift_range=0.1,
                            zoom_range=0.2,  # 0.2 MEANS CAN GO FROM 0.8 TO 1.2
                            shear_range=0.1,  # MAGNITUDE OF SHEAR ANGLE
                            rotation_range=10)  # DEGREES
dataGen.fit(X_train)
batches= dataGen.flow(X_train,y_train,batch_size=20)  # REQUESTING DATA GENRATOR TO GENERATE IMAGES  BATCH SIZE
X_batch,y_batch = next(batches)

# TO SHOW AGMENTED IMAGE SAMPLES
fig,axs=plt.subplots(1,15,figsize=(20,5))
fig.tight_layout()

for i in range(15):
    axs[i].imshow(X_batch[i].reshape(imageDimesions[0],imageDimesions[1]))
    axs[i].axis('off')
plt.show()


y_train = to_categorical(y_train,noOfClasses)
y_validation = to_categorical(y_validation,noOfClasses)
y_test = to_categorical(y_test,noOfClasses)
```



In [12]:
```
############################### CONVOLUTION NEURAL NETWORK MODEL
def myModel():
    no_Of_Filters=60
    size_of_Filter=(5,5) # THIS IS THE KERNEL THAT MOVE AROUND THE IMAGE TO GET THE FEATURES.
                         # THIS WOULD REMOVE 2 PIXELS FROM EACH BORDER WHEN USING 32 32 IMAGE
    size_of_Filter2=(3,3)
    size_of_pool=(2,2)  # SCALE DOWN ALL FEATURE MAP TO GERNALIZE MORE, TO REDUCE OVERFITTING
    no_Of_Nodes = 500   # NO. OF NODES IN HIDDEN LAYERS
    model= Sequential()
    model.add((Conv2D(no_Of_Filters,size_of_Filter,input_shape=(imageDimesions[0],imageDimesions[1],1),activatic
    model.add((Conv2D(no_Of_Filters, size_of_Filter, activation='relu')))
    model.add(MaxPooling2D(pool_size=size_of_pool)) # DOES NOT EFFECT THE DEPTH/NO OF FILTERS

    model.add((Conv2D(no_Of_Filters//2, size_of_Filter2,activation='relu')))
    model.add((Conv2D(no_Of_Filters // 2, size_of_Filter2, activation='relu')))
    model.add(MaxPooling2D(pool_size=size_of_pool))
    model.add(Dropout(0.5))

    model.add(Flatten())
    model.add(Dense(no_Of_Nodes,activation='relu'))
    model.add(Dropout(0.5)) # INPUTS NODES TO DROP WITH EACH UPDATE 1 ALL 0 NONE
    model.add(Dense(noOfClasses,activation='softmax')) # OUTPUT LAYER
    # COMPILE MODEL
    model.compile(Adam(lr=0.001),loss='categorical_crossentropy',metrics=['accuracy'])
    return model
```

In [13]:
```
############################### TRAIN
model = myModel()
print(model.summary())
history=model.fit_generator(dataGen.flow(X_train,y_train,batch_size=batch_size_val),steps_per_epoch=len(X_train)
# history=model.fit_generator(dataGen.flow(X_train,y_train,batch_size=batch_size_val),steps_per_epoch=steps_per_
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 28, 28, 60)        1560

 conv2d_1 (Conv2D)           (None, 24, 24, 60)        90060

 max_pooling2d (MaxPooling2D  (None, 12, 12, 60)       0
 )

 conv2d_2 (Conv2D)           (None, 10, 10, 30)        16230

 conv2d_3 (Conv2D)           (None, 8, 8, 30)          8130

 max_pooling2d_1 (MaxPooling  (None, 4, 4, 30)         0
 2D)

 dropout (Dropout)           (None, 4, 4, 30)          0

 flatten (Flatten)           (None, 480)               0

 dense (Dense)               (None, 500)               240500

 dropout_1 (Dropout)         (None, 500)               0

 dense_1 (Dense)             (None, 85)                42585

=================================================================
Total params: 399,065
Trainable params: 399,065
Non-trainable params: 0
_________________________________________________________________
```

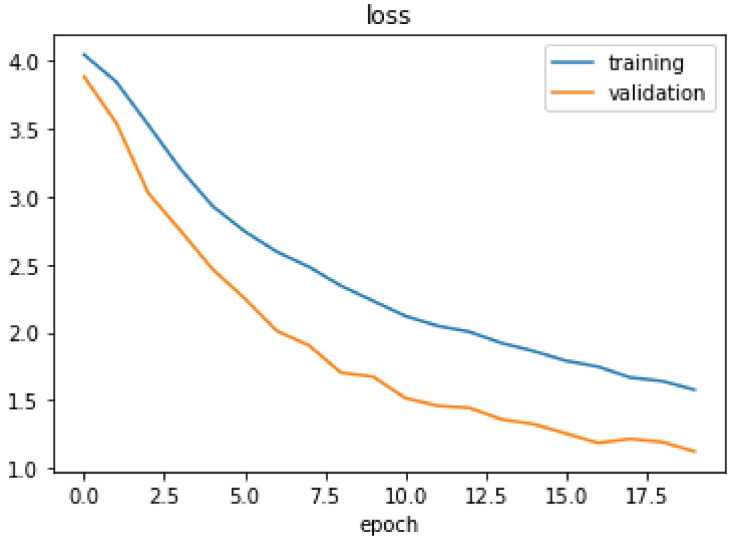
```
C:\Users\Ishaan\anaconda3\lib\site-packages\keras\optimizers\optimizer_v2\adam.py:114: UserWarning: The `lr` a
rgument is deprecated, use `learning_rate` instead.
  super().__init__(name, **kwargs)
C:\Users\Ishaan\AppData\Local\Temp\ipykernel_8552\37330348.py:4: UserWarning: `Model.fit_generator` is depreca
ted and will be removed in a future version. Please use `Model.fit`, which supports generators.
  history=model.fit_generator(dataGen.flow(X_train,y_train,batch_size=batch_size_val),steps_per_epoch=len(X_tr
ain)//batch_size_val,epochs=epochs_val,validation_data=(X_validation,y_validation),shuffle=1)

None
Epoch 1/20
56/56 [==============================] - 18s 272ms/step - loss: 4.0482 - accuracy: 0.0491 - val_loss: 3.8858 -
val_accuracy: 0.0873
Epoch 2/20
56/56 [==============================] - 13s 228ms/step - loss: 3.8486 - accuracy: 0.0846 - val_loss: 3.5463 -
val_accuracy: 0.1761
Epoch 3/20
56/56 [==============================] - 12s 214ms/step - loss: 3.5307 - accuracy: 0.1685 - val_loss: 3.0282 -
val_accuracy: 0.2662
Epoch 4/20
56/56 [==============================] - 12s 216ms/step - loss: 3.2054 - accuracy: 0.2204 - val_loss: 2.7510 -
val_accuracy: 0.3718
Epoch 5/20
56/56 [==============================] - 12s 219ms/step - loss: 2.9322 - accuracy: 0.2599 - val_loss: 2.4661 -
val_accuracy: 0.4014
Epoch 6/20
56/56 [==============================] - 12s 206ms/step - loss: 2.7456 - accuracy: 0.3014 - val_loss: 2.2515 -
val_accuracy: 0.4521
Epoch 7/20
56/56 [==============================] - 12s 213ms/step - loss: 2.5952 - accuracy: 0.3337 - val_loss: 2.0116 -
val_accuracy: 0.4930
Epoch 8/20
56/56 [==============================] - 12s 216ms/step - loss: 2.4837 - accuracy: 0.3520 - val_loss: 1.9046 -
val_accuracy: 0.4986
Epoch 9/20
56/56 [==============================] - 12s 210ms/step - loss: 2.3444 - accuracy: 0.3778 - val_loss: 1.7042 -
val_accuracy: 0.5380
Epoch 10/20
56/56 [==============================] - 12s 216ms/step - loss: 2.2326 - accuracy: 0.4022 - val_loss: 1.6744 -
val_accuracy: 0.5408
Epoch 11/20
56/56 [==============================] - 12s 218ms/step - loss: 2.1214 - accuracy: 0.4237 - val_loss: 1.5159 -
val_accuracy: 0.6225
Epoch 12/20
```

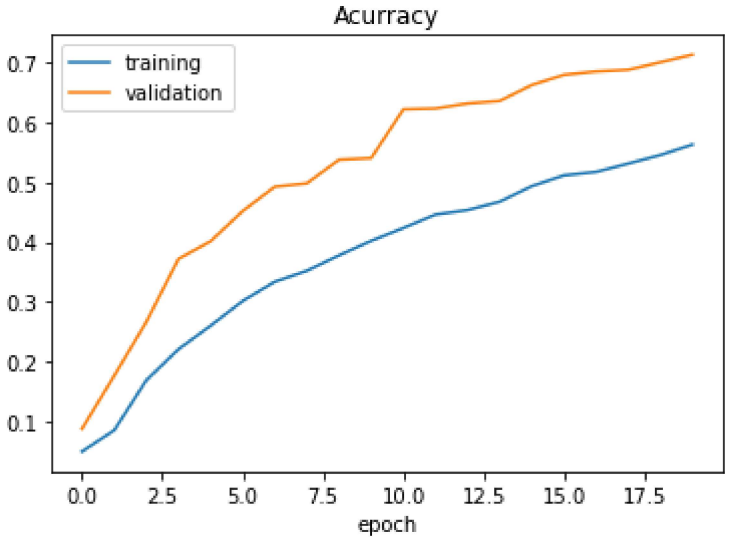
```
56/56 [==============================] - 12s 205ms/step - loss: 2.0490 - accuracy: 0.4462 - val_loss: 1.4599 -
val_accuracy: 0.6239
Epoch 13/20
56/56 [==============================] - 12s 216ms/step - loss: 2.0047 - accuracy: 0.4538 - val_loss: 1.4438 -
val_accuracy: 0.6324
Epoch 14/20
56/56 [==============================] - 12s 217ms/step - loss: 1.9219 - accuracy: 0.4677 - val_loss: 1.3591 -
val_accuracy: 0.6366
Epoch 15/20
56/56 [==============================] - 11s 204ms/step - loss: 1.8623 - accuracy: 0.4939 - val_loss: 1.3238 -
val_accuracy: 0.6634
Epoch 16/20
56/56 [==============================] - 12s 216ms/step - loss: 1.7915 - accuracy: 0.5118 - val_loss: 1.2546 -
val_accuracy: 0.6803
Epoch 17/20
56/56 [==============================] - 12s 214ms/step - loss: 1.7482 - accuracy: 0.5176 - val_loss: 1.1849 -
val_accuracy: 0.6859
Epoch 18/20
56/56 [==============================] - 11s 203ms/step - loss: 1.6683 - accuracy: 0.5315 - val_loss: 1.2147 -
val_accuracy: 0.6887
Epoch 19/20
56/56 [==============================] - 12s 212ms/step - loss: 1.6417 - accuracy: 0.5459 - val_loss: 1.1922 -
val_accuracy: 0.7014
Epoch 20/20
56/56 [==============================] - 12s 215ms/step - loss: 1.5780 - accuracy: 0.5634 - val_loss: 1.1223 -
val_accuracy: 0.7141
```

In [15]:
```
pred = model.predict(X_test)
pred=np.argmax(pred, axis=1)

y_test1=np.argmax(y_test, axis=1)

precision = precision_score(y_test1, pred, pos_label='positive', average='macro')
recall = recall_score(y_test1, pred, pos_label='positive', average='macro')
```

```
28/28 [==============================] - 0s 11ms/step

C:\Users\Ishaan\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1370: UserWarning: Note that po
s_label (set to 'positive') is ignored when average != 'binary' (got 'macro'). You may use labels=[pos_label]
to specify a single positive class.
  warnings.warn(
C:\Users\Ishaan\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1318: UndefinedMetricWarning: P
recision is ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` paramete
r to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Ishaan\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1370: UserWarning: Note that po
s_label (set to 'positive') is ignored when average != 'binary' (got 'macro'). You may use labels=[pos_label]
to specify a single positive class.
  warnings.warn(
C:\Users\Ishaan\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1318: UndefinedMetricWarning: R
ecall is ill-defined and being set to 0.0 in labels with no true samples. Use `zero_division` parameter to con
trol this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [16]:
```
############################## PLOT
plt.figure(1)
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.legend(['training','validation'])
plt.title('loss')
plt.xlabel('epoch')
plt.figure(2)
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.legend(['training','validation'])
plt.title('Acurracy')
plt.xlabel('epoch')
plt.show()
score =model.evaluate(X_test,y_test,verbose=0)
print('Test Score:',score[0])
print('Test Accuracy:',score[1])

print('\nPrecision: ',precision)
print('Recall: ',recall)
```




Acurracy
training
validation
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
epoch

```
Test Score: 1.136437177658081
Test Accuracy: 0.6970720887184143

Precision:  0.5190307982798127
Recall:  0.48540798428422616
```

In [17]:
```
# STORE THE MODEL AS A PICKLE OBJECT
# pickle_out= open("model_trained.sav","wb")  # wb = WRITE BYTE
# pickle.dump(model,pickle_out)
# pickle_out.close()
# import joblib
# # save the model to disk
# filename = './finalized_model.sav'
# joblib.dump(model, filename)

from keras.models import load_model
model.save('model_d5_3.h5')
```

In [ ]:
```

```