In [86]:
```
import numpy as np
from keras.models import Sequential
from keras.utils import np_utils
from keras.layers import Dense, Activation,Dropout,RNN
import pandas as pd

import matplotlib.pyplot as plt
```

In [87]:
```
df=pd.read_csv('EEGdata.csv')
df.head()
```

Out[87]:

	A	X1	X2	X3	X4	X5	X6	X7	X8	X9	...	X170	X171	X172	X173	X174	X175	X
0	X21.V1.791	135	190	229	223	192	125	55	-9	-33	...	-17	-15	-31	-77	-103	-127	-
1	X15.V1.924	386	382	356	331	320	315	307	272	244	...	164	150	146	152	157	156	
2	X8.V1.1	-32	-39	-47	-37	-32	-36	-57	-73	-85	...	57	64	48	19	-12	-30	
3	X16.V1.60	-105	-101	-96	-92	-89	-95	-102	-100	-87	...	-82	-81	-80	-77	-85	-77	
4	X20.V1.54	-9	-65	-98	-102	-78	-48	-16	0	-21	...	4	2	-12	-32	-41	-65	

5 rows × 180 columns

In [88]:
```
X=df.values
```

In [89]:
```
X=X[:,1:-1]
```

In [90]:
```
X=df.values
X=X[:,1:-1]
X = np.asarray(X).astype(np.float32)
from sklearn.model_selection import train_test_split


y=np.array(df['y'])
Y=np_utils.to_categorical(y)
Y.shape
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.20, random_state=1)
X_train = X_train.reshape(-1,178,1)
X_test = X_test.reshape(-1,178,1)


X_train.shape
X_test.shape
```

Out[90]:
```
(2300, 178, 1)
```

In [91]:
```
print(X.shape,y.shape)
```

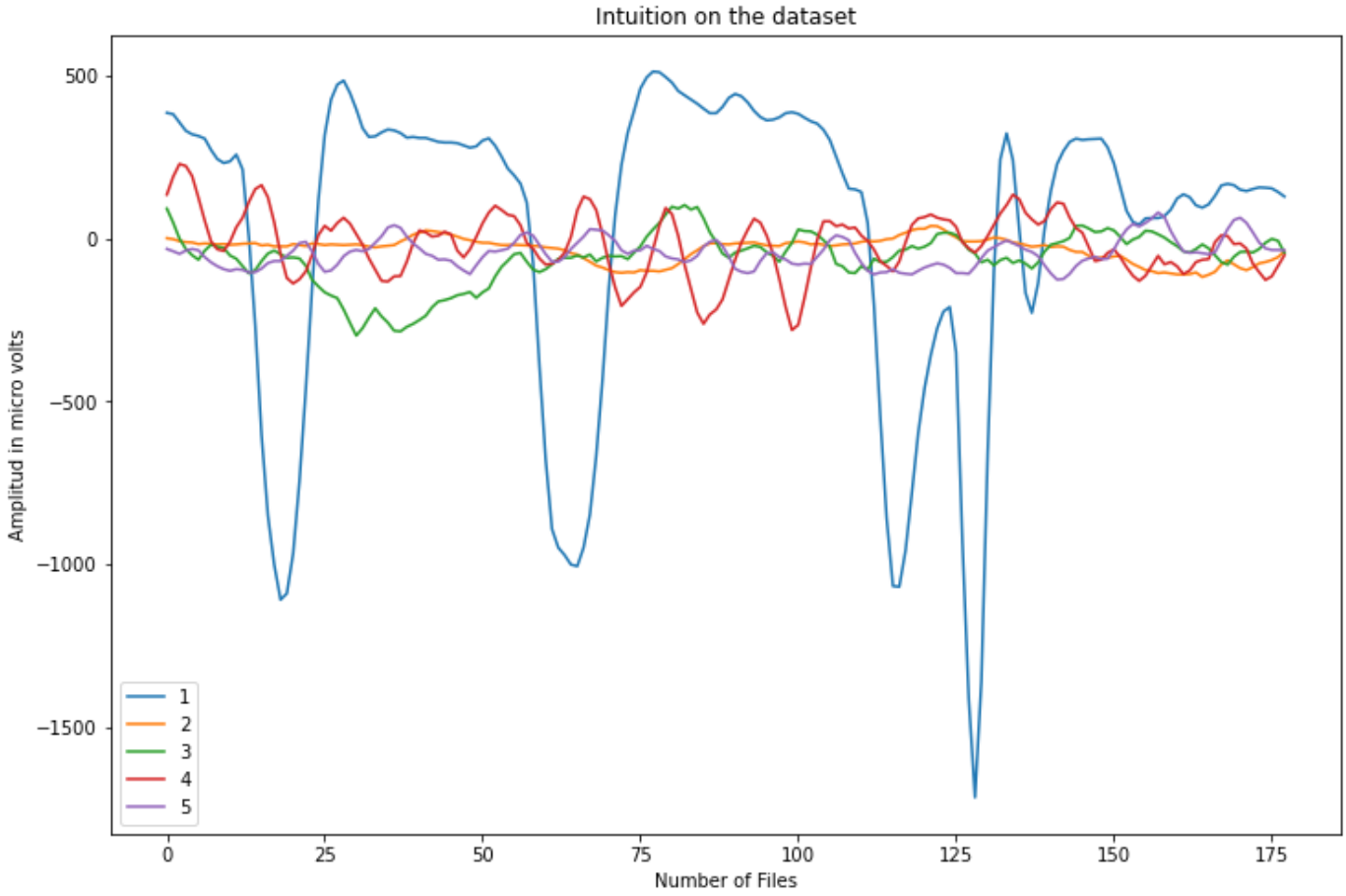
```
(11500, 178) (11500,)
```

In [137…
```
plt.figure(figsize=(12,8))
plt.plot(X[1,:],label='1')
plt.plot(X[7,:],label='2')
plt.plot(X[12,:],label='3')
plt.plot(X[0,:],label='4')
plt.plot(X[2,:],label='5')
```

```
plt.legend()
plt.xlabel("Number of Files")
plt.ylabel("Amplitud in micro volts")
plt.title("Intuition on the dataset")
plt.show()
```

Out[137…

```
Text(0.5, 1.0, 'Intuition on the dataset')
```



In [104…

```
model = Sequential()
model.add(RNN(128, input_shape=(45,1), return_sequences=True))
model.add(Dense(256,input_shape=(45,)))
model.add(Activation('tanh'))
model.add(Dense(128))
model.add(Activation('relu'))
model.add(Dropout(0.2))
model.add(Dense(16))
model.add(Activation('tanh'))
model.add(Dropout(0.2))
model.add(Dense(5))
model.add(Activation('softmax'))
model.build()
model.summary()
```

```
Model: "sequential_14"
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 dense_51 (Dense)             (None, 256)               11776

 activation_50 (Activation)   (None, 256)               0

 dense_52 (Dense)             (None, 128)               32896

 activation_51 (Activation)   (None, 128)               0

 dropout_22 (Dropout)         (None, 128)               0

 dense_53 (Dense)             (None, 16)                2064

 activation_52 (Activation)   (None, 16)                0
```

```
 dropout_23 (Dropout)        (None, 16)                0

 dense_54 (Dense)            (None, 5)                 85

 activation_53 (Activation)  (None, 5)                 0

=================================================================
Total params: 46,821
Trainable params: 46,821
Non-trainable params: 0
_________________________________________________________________
```

In [105…

```
model.compile(optimizer='adam',loss='binary_crossentropy',metrics=['accuracy', 'AUC', 'Recall',
```

In [106…

```
fits=model.fit(((X_train[:,::4]-X_train.mean())/X_train.std()),Y_train[:,1:],10,100,verbose=2,v
```

```
Epoch 1/100
920/920 - 4s - loss: 0.4194 - accuracy: 0.4474 - auc: 0.7818 - recall: 0.2052 - precision: 0.77
31 - val_loss: 0.3379 - val_accuracy: 0.5661 - val_auc: 0.8859 - val_recall: 0.2874 - val_preci
sion: 0.8551 - 4s/epoch - 4ms/step
Epoch 2/100
920/920 - 2s - loss: 0.3366 - accuracy: 0.5672 - auc: 0.8795 - recall: 0.3854 - precision: 0.73
34 - val_loss: 0.3001 - val_accuracy: 0.6252 - val_auc: 0.9069 - val_recall: 0.3839 - val_preci
sion: 0.7787 - 2s/epoch - 2ms/step
Epoch 3/100
920/920 - 2s - loss: 0.3094 - accuracy: 0.6089 - auc: 0.9027 - recall: 0.4588 - precision: 0.72
63 - val_loss: 0.2882 - val_accuracy: 0.6274 - val_auc: 0.9127 - val_recall: 0.4504 - val_preci
sion: 0.7296 - 2s/epoch - 2ms/step
Epoch 4/100
920/920 - 2s - loss: 0.2963 - accuracy: 0.6321 - auc: 0.9133 - recall: 0.5050 - precision: 0.73
07 - val_loss: 0.2816 - val_accuracy: 0.6474 - val_auc: 0.9173 - val_recall: 0.4900 - val_preci
sion: 0.7478 - 2s/epoch - 2ms/step
Epoch 5/100
920/920 - 2s - loss: 0.2893 - accuracy: 0.6455 - auc: 0.9171 - recall: 0.5268 - precision: 0.73
57 - val_loss: 0.2794 - val_accuracy: 0.6513 - val_auc: 0.9177 - val_recall: 0.5178 - val_preci
sion: 0.7472 - 2s/epoch - 2ms/step
Epoch 6/100
920/920 - 2s - loss: 0.2827 - accuracy: 0.6523 - auc: 0.9212 - recall: 0.5434 - precision: 0.73
30 - val_loss: 0.2739 - val_accuracy: 0.6465 - val_auc: 0.9201 - val_recall: 0.5409 - val_preci
sion: 0.7266 - 2s/epoch - 2ms/step
Epoch 7/100
920/920 - 2s - loss: 0.2775 - accuracy: 0.6645 - auc: 0.9245 - recall: 0.5661 - precision: 0.74
23 - val_loss: 0.2666 - val_accuracy: 0.6657 - val_auc: 0.9258 - val_recall: 0.5543 - val_preci
sion: 0.7244 - 2s/epoch - 2ms/step
Epoch 8/100
920/920 - 2s - loss: 0.2705 - accuracy: 0.6746 - auc: 0.9289 - recall: 0.5845 - precision: 0.74
24 - val_loss: 0.2667 - val_accuracy: 0.6543 - val_auc: 0.9227 - val_recall: 0.5678 - val_preci
sion: 0.7188 - 2s/epoch - 2ms/step
Epoch 9/100
920/920 - 2s - loss: 0.2612 - accuracy: 0.6998 - auc: 0.9349 - recall: 0.6196 - precision: 0.75
83 - val_loss: 0.2684 - val_accuracy: 0.6609 - val_auc: 0.9221 - val_recall: 0.5952 - val_preci
sion: 0.7164 - 2s/epoch - 2ms/step
Epoch 10/100
920/920 - 2s - loss: 0.2628 - accuracy: 0.6871 - auc: 0.9322 - recall: 0.6164 - precision: 0.73
98 - val_loss: 0.2678 - val_accuracy: 0.6613 - val_auc: 0.9218 - val_recall: 0.5887 - val_preci
sion: 0.7070 - 2s/epoch - 2ms/step
Epoch 11/100
920/920 - 2s - loss: 0.2557 - accuracy: 0.6999 - auc: 0.9371 - recall: 0.6352 - precision: 0.74
93 - val_loss: 0.2641 - val_accuracy: 0.6674 - val_auc: 0.9240 - val_recall: 0.5961 - val_preci
sion: 0.7115 - 2s/epoch - 2ms/step
Epoch 12/100
920/920 - 2s - loss: 0.2524 - accuracy: 0.7057 - auc: 0.9383 - recall: 0.6409 - precision: 0.75
21 - val_loss: 0.2700 - val_accuracy: 0.6674 - val_auc: 0.9193 - val_recall: 0.5909 - val_preci
sion: 0.7023 - 2s/epoch - 3ms/step
Epoch 13/100
920/920 - 2s - loss: 0.2466 - accuracy: 0.7139 - auc: 0.9415 - recall: 0.6512 - precision: 0.75
93 - val_loss: 0.2684 - val_accuracy: 0.6617 - val_auc: 0.9199 - val_recall: 0.6152 - val_preci
sion: 0.6943 - 2s/epoch - 2ms/step
Epoch 14/100
920/920 - 2s - loss: 0.2431 - accuracy: 0.7155 - auc: 0.9431 - recall: 0.6637 - precision: 0.76
30 - val_loss: 0.2696 - val_accuracy: 0.6604 - val_auc: 0.9191 - val_recall: 0.6143 - val_preci
```

```
sion: 0.6903 - 2s/epoch - 2ms/step
Epoch 15/100
920/920 - 2s - loss: 0.2411 - accuracy: 0.7207 - auc: 0.9442 - recall: 0.6745 - precision: 0.76
19 - val_loss: 0.2678 - val_accuracy: 0.6678 - val_auc: 0.9200 - val_recall: 0.6157 - val_preci
sion: 0.6880 - 2s/epoch - 2ms/step
Epoch 16/100
920/920 - 2s - loss: 0.2370 - accuracy: 0.7317 - auc: 0.9457 - recall: 0.6797 - precision: 0.76
96 - val_loss: 0.2621 - val_accuracy: 0.6696 - val_auc: 0.9244 - val_recall: 0.6222 - val_preci
sion: 0.7001 - 2s/epoch - 2ms/step
Epoch 17/100
920/920 - 2s - loss: 0.2321 - accuracy: 0.7335 - auc: 0.9481 - recall: 0.6862 - precision: 0.77
13 - val_loss: 0.2650 - val_accuracy: 0.6735 - val_auc: 0.9226 - val_recall: 0.6283 - val_preci
sion: 0.7073 - 2s/epoch - 2ms/step
Epoch 18/100
920/920 - 2s - loss: 0.2301 - accuracy: 0.7411 - auc: 0.9489 - recall: 0.6953 - precision: 0.77
32 - val_loss: 0.2613 - val_accuracy: 0.6743 - val_auc: 0.9251 - val_recall: 0.6430 - val_preci
sion: 0.7073 - 2s/epoch - 2ms/step
Epoch 19/100
920/920 - 2s - loss: 0.2258 - accuracy: 0.7526 - auc: 0.9515 - recall: 0.7104 - precision: 0.78
46 - val_loss: 0.2601 - val_accuracy: 0.6891 - val_auc: 0.9254 - val_recall: 0.6387 - val_preci
sion: 0.7190 - 2s/epoch - 2ms/step
Epoch 20/100
920/920 - 2s - loss: 0.2243 - accuracy: 0.7467 - auc: 0.9517 - recall: 0.7068 - precision: 0.78
05 - val_loss: 0.2621 - val_accuracy: 0.6809 - val_auc: 0.9238 - val_recall: 0.6461 - val_preci
sion: 0.7019 - 2s/epoch - 2ms/step
Epoch 21/100
920/920 - 2s - loss: 0.2216 - accuracy: 0.7591 - auc: 0.9528 - recall: 0.7159 - precision: 0.78
87 - val_loss: 0.2681 - val_accuracy: 0.6761 - val_auc: 0.9206 - val_recall: 0.6365 - val_preci
sion: 0.7055 - 2s/epoch - 2ms/step
Epoch 22/100
920/920 - 2s - loss: 0.2213 - accuracy: 0.7586 - auc: 0.9526 - recall: 0.7197 - precision: 0.78
54 - val_loss: 0.2683 - val_accuracy: 0.6748 - val_auc: 0.9195 - val_recall: 0.6291 - val_preci
sion: 0.6997 - 2s/epoch - 2ms/step
Epoch 23/100
920/920 - 2s - loss: 0.2169 - accuracy: 0.7610 - auc: 0.9547 - recall: 0.7242 - precision: 0.78
92 - val_loss: 0.2646 - val_accuracy: 0.6817 - val_auc: 0.9222 - val_recall: 0.6465 - val_preci
sion: 0.6998 - 2s/epoch - 2ms/step
Epoch 24/100
920/920 - 3s - loss: 0.2117 - accuracy: 0.7702 - auc: 0.9570 - recall: 0.7396 - precision: 0.79
90 - val_loss: 0.2669 - val_accuracy: 0.6891 - val_auc: 0.9222 - val_recall: 0.6648 - val_preci
sion: 0.7053 - 3s/epoch - 3ms/step
Epoch 25/100
920/920 - 3s - loss: 0.2107 - accuracy: 0.7704 - auc: 0.9565 - recall: 0.7379 - precision: 0.80
11 - val_loss: 0.2657 - val_accuracy: 0.6935 - val_auc: 0.9209 - val_recall: 0.6600 - val_preci
sion: 0.7130 - 3s/epoch - 3ms/step
Epoch 26/100
920/920 - 2s - loss: 0.2072 - accuracy: 0.7716 - auc: 0.9587 - recall: 0.7376 - precision: 0.79
92 - val_loss: 0.2718 - val_accuracy: 0.6826 - val_auc: 0.9183 - val_recall: 0.6548 - val_preci
sion: 0.7001 - 2s/epoch - 2ms/step
Epoch 27/100
920/920 - 2s - loss: 0.2074 - accuracy: 0.7782 - auc: 0.9580 - recall: 0.7488 - precision: 0.80
32 - val_loss: 0.2640 - val_accuracy: 0.7030 - val_auc: 0.9240 - val_recall: 0.6748 - val_preci
sion: 0.7249 - 2s/epoch - 2ms/step
Epoch 28/100
920/920 - 2s - loss: 0.2057 - accuracy: 0.7776 - auc: 0.9586 - recall: 0.7463 - precision: 0.80
42 - val_loss: 0.2640 - val_accuracy: 0.6922 - val_auc: 0.9222 - val_recall: 0.6626 - val_preci
sion: 0.7105 - 2s/epoch - 2ms/step
Epoch 29/100
920/920 - 2s - loss: 0.2032 - accuracy: 0.7847 - auc: 0.9595 - recall: 0.7537 - precision: 0.80
77 - val_loss: 0.2655 - val_accuracy: 0.6900 - val_auc: 0.9227 - val_recall: 0.6691 - val_preci
sion: 0.7095 - 2s/epoch - 2ms/step
Epoch 30/100
920/920 - 2s - loss: 0.1975 - accuracy: 0.7897 - auc: 0.9623 - recall: 0.7638 - precision: 0.81
48 - val_loss: 0.2707 - val_accuracy: 0.6909 - val_auc: 0.9194 - val_recall: 0.6657 - val_preci
sion: 0.7068 - 2s/epoch - 2ms/step
Epoch 31/100
920/920 - 2s - loss: 0.1981 - accuracy: 0.7884 - auc: 0.9617 - recall: 0.7605 - precision: 0.81
17 - val_loss: 0.2725 - val_accuracy: 0.6909 - val_auc: 0.9182 - val_recall: 0.6626 - val_preci
sion: 0.7062 - 2s/epoch - 2ms/step
Epoch 32/100
920/920 - 2s - loss: 0.1951 - accuracy: 0.7940 - auc: 0.9631 - recall: 0.7682 - precision: 0.81
66 - val_loss: 0.2683 - val_accuracy: 0.6952 - val_auc: 0.9201 - val_recall: 0.6743 - val_preci
sion: 0.7082 - 2s/epoch - 2ms/step
Epoch 33/100
```

```
920/920 - 2s - loss: 0.1922 - accuracy: 0.8003 - auc: 0.9642 - recall: 0.7796 - precision: 0.82
22 - val_loss: 0.2735 - val_accuracy: 0.6974 - val_auc: 0.9178 - val_recall: 0.6704 - val_preci
sion: 0.7169 - 2s/epoch - 2ms/step
Epoch 34/100
920/920 - 2s - loss: 0.1911 - accuracy: 0.7989 - auc: 0.9647 - recall: 0.7699 - precision: 0.82
05 - val_loss: 0.2691 - val_accuracy: 0.7043 - val_auc: 0.9207 - val_recall: 0.6822 - val_preci
sion: 0.7250 - 2s/epoch - 2ms/step
Epoch 35/100
920/920 - 2s - loss: 0.1895 - accuracy: 0.8030 - auc: 0.9643 - recall: 0.7775 - precision: 0.82
34 - val_loss: 0.2735 - val_accuracy: 0.6839 - val_auc: 0.9174 - val_recall: 0.6670 - val_preci
sion: 0.7040 - 2s/epoch - 2ms/step
Epoch 36/100
920/920 - 2s - loss: 0.1848 - accuracy: 0.8064 - auc: 0.9666 - recall: 0.7823 - precision: 0.82
56 - val_loss: 0.2748 - val_accuracy: 0.6835 - val_auc: 0.9184 - val_recall: 0.6643 - val_preci
sion: 0.6987 - 2s/epoch - 2ms/step
Epoch 37/100
920/920 - 2s - loss: 0.1825 - accuracy: 0.8090 - auc: 0.9674 - recall: 0.7879 - precision: 0.82
71 - val_loss: 0.2746 - val_accuracy: 0.7017 - val_auc: 0.9175 - val_recall: 0.6857 - val_preci
sion: 0.7145 - 2s/epoch - 2ms/step
Epoch 38/100
920/920 - 2s - loss: 0.1810 - accuracy: 0.8100 - auc: 0.9679 - recall: 0.7891 - precision: 0.82
70 - val_loss: 0.2788 - val_accuracy: 0.6943 - val_auc: 0.9153 - val_recall: 0.6791 - val_preci
sion: 0.7087 - 2s/epoch - 3ms/step
Epoch 39/100
920/920 - 3s - loss: 0.1797 - accuracy: 0.8203 - auc: 0.9681 - recall: 0.7977 - precision: 0.83
78 - val_loss: 0.2743 - val_accuracy: 0.7061 - val_auc: 0.9183 - val_recall: 0.6891 - val_preci
sion: 0.7195 - 3s/epoch - 3ms/step
Epoch 40/100
920/920 - 2s - loss: 0.1792 - accuracy: 0.8130 - auc: 0.9685 - recall: 0.7927 - precision: 0.83
08 - val_loss: 0.2744 - val_accuracy: 0.7083 - val_auc: 0.9170 - val_recall: 0.6917 - val_preci
sion: 0.7238 - 2s/epoch - 2ms/step
Epoch 41/100
920/920 - 2s - loss: 0.1779 - accuracy: 0.8177 - auc: 0.9691 - recall: 0.7954 - precision: 0.83
72 - val_loss: 0.2737 - val_accuracy: 0.7022 - val_auc: 0.9168 - val_recall: 0.6848 - val_preci
sion: 0.7172 - 2s/epoch - 2ms/step
Epoch 42/100
920/920 - 2s - loss: 0.1748 - accuracy: 0.8233 - auc: 0.9695 - recall: 0.8024 - precision: 0.83
77 - val_loss: 0.2789 - val_accuracy: 0.7048 - val_auc: 0.9146 - val_recall: 0.6926 - val_preci
sion: 0.7195 - 2s/epoch - 2ms/step
Epoch 43/100
920/920 - 2s - loss: 0.1715 - accuracy: 0.8273 - auc: 0.9705 - recall: 0.8082 - precision: 0.84
28 - val_loss: 0.2782 - val_accuracy: 0.7026 - val_auc: 0.9156 - val_recall: 0.6883 - val_preci
sion: 0.7121 - 2s/epoch - 2ms/step
Epoch 44/100
920/920 - 2s - loss: 0.1752 - accuracy: 0.8234 - auc: 0.9688 - recall: 0.8063 - precision: 0.84
15 - val_loss: 0.2856 - val_accuracy: 0.6900 - val_auc: 0.9103 - val_recall: 0.6743 - val_preci
sion: 0.7018 - 2s/epoch - 2ms/step
Epoch 45/100
920/920 - 2s - loss: 0.1684 - accuracy: 0.8286 - auc: 0.9720 - recall: 0.8103 - precision: 0.84
44 - val_loss: 0.2785 - val_accuracy: 0.6974 - val_auc: 0.9164 - val_recall: 0.6870 - val_preci
sion: 0.7136 - 2s/epoch - 2ms/step
Epoch 46/100
920/920 - 2s - loss: 0.1705 - accuracy: 0.8252 - auc: 0.9708 - recall: 0.8078 - precision: 0.84
20 - val_loss: 0.2863 - val_accuracy: 0.7048 - val_auc: 0.9106 - val_recall: 0.6870 - val_preci
sion: 0.7172 - 2s/epoch - 2ms/step
Epoch 47/100
920/920 - 2s - loss: 0.1641 - accuracy: 0.8317 - auc: 0.9729 - recall: 0.8170 - precision: 0.84
93 - val_loss: 0.2869 - val_accuracy: 0.7035 - val_auc: 0.9121 - val_recall: 0.6917 - val_preci
sion: 0.7119 - 2s/epoch - 2ms/step
Epoch 48/100
920/920 - 2s - loss: 0.1673 - accuracy: 0.8348 - auc: 0.9717 - recall: 0.8173 - precision: 0.84
92 - val_loss: 0.2897 - val_accuracy: 0.7026 - val_auc: 0.9112 - val_recall: 0.6874 - val_preci
sion: 0.7125 - 2s/epoch - 2ms/step
Epoch 49/100
920/920 - 2s - loss: 0.1646 - accuracy: 0.8346 - auc: 0.9728 - recall: 0.8188 - precision: 0.85
39 - val_loss: 0.2856 - val_accuracy: 0.6996 - val_auc: 0.9123 - val_recall: 0.6865 - val_preci
sion: 0.7074 - 2s/epoch - 2ms/step
Epoch 50/100
920/920 - 2s - loss: 0.1596 - accuracy: 0.8374 - auc: 0.9750 - recall: 0.8233 - precision: 0.85
51 - val_loss: 0.2978 - val_accuracy: 0.6887 - val_auc: 0.9070 - val_recall: 0.6730 - val_preci
sion: 0.6998 - 2s/epoch - 2ms/step
Epoch 51/100
920/920 - 2s - loss: 0.1596 - accuracy: 0.8383 - auc: 0.9738 - recall: 0.8216 - precision: 0.85
25 - val_loss: 0.2877 - val_accuracy: 0.7061 - val_auc: 0.9111 - val_recall: 0.6904 - val_preci
```

```
sion: 0.7140 - 2s/epoch - 2ms/step
Epoch 52/100
920/920 - 2s - loss: 0.1598 - accuracy: 0.8386 - auc: 0.9741 - recall: 0.8232 - precision: 0.85
07 - val_loss: 0.3031 - val_accuracy: 0.6909 - val_auc: 0.9040 - val_recall: 0.6717 - val_preci
sion: 0.7010 - 2s/epoch - 2ms/step
Epoch 53/100
920/920 - 2s - loss: 0.1529 - accuracy: 0.8472 - auc: 0.9766 - recall: 0.8314 - precision: 0.85
99 - val_loss: 0.2967 - val_accuracy: 0.6991 - val_auc: 0.9051 - val_recall: 0.6726 - val_preci
sion: 0.7100 - 2s/epoch - 2ms/step
Epoch 54/100
920/920 - 2s - loss: 0.1566 - accuracy: 0.8432 - auc: 0.9740 - recall: 0.8286 - precision: 0.85
80 - val_loss: 0.2964 - val_accuracy: 0.7022 - val_auc: 0.9086 - val_recall: 0.6917 - val_preci
sion: 0.7115 - 2s/epoch - 2ms/step
Epoch 55/100
920/920 - 2s - loss: 0.1546 - accuracy: 0.8453 - auc: 0.9754 - recall: 0.8307 - precision: 0.85
90 - val_loss: 0.3005 - val_accuracy: 0.6961 - val_auc: 0.9065 - val_recall: 0.6765 - val_preci
sion: 0.7057 - 2s/epoch - 2ms/step
Epoch 56/100
920/920 - 2s - loss: 0.1550 - accuracy: 0.8470 - auc: 0.9747 - recall: 0.8318 - precision: 0.85
80 - val_loss: 0.2886 - val_accuracy: 0.7048 - val_auc: 0.9117 - val_recall: 0.6922 - val_preci
sion: 0.7107 - 2s/epoch - 2ms/step
Epoch 57/100
920/920 - 2s - loss: 0.1515 - accuracy: 0.8471 - auc: 0.9768 - recall: 0.8334 - precision: 0.85
93 - val_loss: 0.2951 - val_accuracy: 0.7009 - val_auc: 0.9103 - val_recall: 0.6922 - val_preci
sion: 0.7076 - 2s/epoch - 2ms/step
Epoch 58/100
920/920 - 2s - loss: 0.1497 - accuracy: 0.8491 - auc: 0.9774 - recall: 0.8347 - precision: 0.86
18 - val_loss: 0.2965 - val_accuracy: 0.7052 - val_auc: 0.9093 - val_recall: 0.6948 - val_preci
sion: 0.7134 - 2s/epoch - 3ms/step
Epoch 59/100
920/920 - 2s - loss: 0.1506 - accuracy: 0.8489 - auc: 0.9762 - recall: 0.8371 - precision: 0.86
17 - val_loss: 0.3040 - val_accuracy: 0.6957 - val_auc: 0.9050 - val_recall: 0.6835 - val_preci
sion: 0.7043 - 2s/epoch - 2ms/step
Epoch 60/100
920/920 - 2s - loss: 0.1527 - accuracy: 0.8485 - auc: 0.9749 - recall: 0.8353 - precision: 0.86
08 - val_loss: 0.2990 - val_accuracy: 0.6996 - val_auc: 0.9067 - val_recall: 0.6909 - val_preci
sion: 0.7069 - 2s/epoch - 2ms/step
Epoch 61/100
920/920 - 2s - loss: 0.1422 - accuracy: 0.8611 - auc: 0.9793 - recall: 0.8477 - precision: 0.87
30 - val_loss: 0.2976 - val_accuracy: 0.7100 - val_auc: 0.9057 - val_recall: 0.6952 - val_preci
sion: 0.7151 - 2s/epoch - 3ms/step
Epoch 62/100
920/920 - 2s - loss: 0.1482 - accuracy: 0.8512 - auc: 0.9766 - recall: 0.8388 - precision: 0.86
50 - val_loss: 0.2968 - val_accuracy: 0.7074 - val_auc: 0.9052 - val_recall: 0.6878 - val_preci
sion: 0.7178 - 2s/epoch - 2ms/step
Epoch 63/100
920/920 - 2s - loss: 0.1455 - accuracy: 0.8541 - auc: 0.9775 - recall: 0.8415 - precision: 0.86
63 - val_loss: 0.2997 - val_accuracy: 0.7052 - val_auc: 0.9060 - val_recall: 0.6935 - val_preci
sion: 0.7127 - 2s/epoch - 3ms/step
Epoch 64/100
920/920 - 2s - loss: 0.1463 - accuracy: 0.8584 - auc: 0.9769 - recall: 0.8447 - precision: 0.87
19 - val_loss: 0.3054 - val_accuracy: 0.6987 - val_auc: 0.9030 - val_recall: 0.6883 - val_preci
sion: 0.7073 - 2s/epoch - 2ms/step
Epoch 65/100
920/920 - 2s - loss: 0.1427 - accuracy: 0.8633 - auc: 0.9780 - recall: 0.8504 - precision: 0.87
42 - val_loss: 0.3134 - val_accuracy: 0.6909 - val_auc: 0.9005 - val_recall: 0.6774 - val_preci
sion: 0.6993 - 2s/epoch - 2ms/step
Epoch 66/100
920/920 - 2s - loss: 0.1409 - accuracy: 0.8625 - auc: 0.9780 - recall: 0.8505 - precision: 0.87
28 - val_loss: 0.3029 - val_accuracy: 0.7161 - val_auc: 0.9035 - val_recall: 0.7104 - val_preci
sion: 0.7224 - 2s/epoch - 2ms/step
Epoch 67/100
920/920 - 2s - loss: 0.1430 - accuracy: 0.8608 - auc: 0.9785 - recall: 0.8479 - precision: 0.87
05 - val_loss: 0.2989 - val_accuracy: 0.7113 - val_auc: 0.9068 - val_recall: 0.7000 - val_preci
sion: 0.7200 - 2s/epoch - 2ms/step
Epoch 68/100
920/920 - 2s - loss: 0.1392 - accuracy: 0.8607 - auc: 0.9790 - recall: 0.8495 - precision: 0.87
27 - val_loss: 0.3077 - val_accuracy: 0.7026 - val_auc: 0.9037 - val_recall: 0.6957 - val_preci
sion: 0.7121 - 2s/epoch - 2ms/step
Epoch 69/100
920/920 - 2s - loss: 0.1412 - accuracy: 0.8646 - auc: 0.9781 - recall: 0.8528 - precision: 0.87
25 - val_loss: 0.3052 - val_accuracy: 0.7017 - val_auc: 0.9044 - val_recall: 0.6943 - val_preci
sion: 0.7117 - 2s/epoch - 2ms/step
Epoch 70/100
```

```
920/920 - 2s - loss: 0.1375 - accuracy: 0.8638 - auc: 0.9792 - recall: 0.8532 - precision: 0.87
44 - val_loss: 0.3109 - val_accuracy: 0.7039 - val_auc: 0.9019 - val_recall: 0.6878 - val_preci
sion: 0.7145 - 2s/epoch - 2ms/step
Epoch 71/100
920/920 - 3s - loss: 0.1358 - accuracy: 0.8668 - auc: 0.9807 - recall: 0.8538 - precision: 0.87
72 - val_loss: 0.3074 - val_accuracy: 0.6991 - val_auc: 0.9032 - val_recall: 0.6817 - val_preci
sion: 0.7098 - 3s/epoch - 3ms/step
Epoch 72/100
920/920 - 3s - loss: 0.1338 - accuracy: 0.8701 - auc: 0.9802 - recall: 0.8596 - precision: 0.88
21 - val_loss: 0.3096 - val_accuracy: 0.7065 - val_auc: 0.9026 - val_recall: 0.6891 - val_preci
sion: 0.7178 - 3s/epoch - 3ms/step
Epoch 73/100
920/920 - 3s - loss: 0.1344 - accuracy: 0.8707 - auc: 0.9809 - recall: 0.8600 - precision: 0.87
94 - val_loss: 0.3112 - val_accuracy: 0.7096 - val_auc: 0.8994 - val_recall: 0.7009 - val_preci
sion: 0.7209 - 3s/epoch - 3ms/step
Epoch 74/100
920/920 - 3s - loss: 0.1311 - accuracy: 0.8704 - auc: 0.9809 - recall: 0.8632 - precision: 0.87
92 - val_loss: 0.3210 - val_accuracy: 0.6991 - val_auc: 0.8992 - val_recall: 0.6809 - val_preci
sion: 0.7115 - 3s/epoch - 3ms/step
Epoch 75/100
920/920 - 3s - loss: 0.1325 - accuracy: 0.8730 - auc: 0.9799 - recall: 0.8655 - precision: 0.88
22 - val_loss: 0.3149 - val_accuracy: 0.7052 - val_auc: 0.9014 - val_recall: 0.6978 - val_preci
sion: 0.7114 - 3s/epoch - 3ms/step
Epoch 76/100
920/920 - 3s - loss: 0.1317 - accuracy: 0.8697 - auc: 0.9810 - recall: 0.8595 - precision: 0.87
79 - val_loss: 0.3195 - val_accuracy: 0.7043 - val_auc: 0.8998 - val_recall: 0.6952 - val_preci
sion: 0.7116 - 3s/epoch - 3ms/step
Epoch 77/100
920/920 - 3s - loss: 0.1319 - accuracy: 0.8700 - auc: 0.9812 - recall: 0.8621 - precision: 0.87
82 - val_loss: 0.3196 - val_accuracy: 0.7022 - val_auc: 0.8989 - val_recall: 0.6930 - val_preci
sion: 0.7100 - 3s/epoch - 3ms/step
Epoch 78/100
920/920 - 3s - loss: 0.1307 - accuracy: 0.8740 - auc: 0.9810 - recall: 0.8661 - precision: 0.88
32 - val_loss: 0.3190 - val_accuracy: 0.6991 - val_auc: 0.9015 - val_recall: 0.6804 - val_preci
sion: 0.7120 - 3s/epoch - 3ms/step
Epoch 79/100
920/920 - 3s - loss: 0.1250 - accuracy: 0.8795 - auc: 0.9830 - recall: 0.8712 - precision: 0.88
79 - val_loss: 0.3176 - val_accuracy: 0.7100 - val_auc: 0.8985 - val_recall: 0.7048 - val_preci
sion: 0.7182 - 3s/epoch - 3ms/step
Epoch 80/100
920/920 - 3s - loss: 0.1222 - accuracy: 0.8829 - auc: 0.9833 - recall: 0.8757 - precision: 0.89
12 - val_loss: 0.3189 - val_accuracy: 0.7078 - val_auc: 0.8991 - val_recall: 0.6961 - val_preci
sion: 0.7173 - 3s/epoch - 3ms/step
Epoch 81/100
920/920 - 3s - loss: 0.1262 - accuracy: 0.8808 - auc: 0.9819 - recall: 0.8736 - precision: 0.88
90 - val_loss: 0.3146 - val_accuracy: 0.7139 - val_auc: 0.8998 - val_recall: 0.7026 - val_preci
sion: 0.7195 - 3s/epoch - 4ms/step
Epoch 82/100
920/920 - 3s - loss: 0.1238 - accuracy: 0.8834 - auc: 0.9823 - recall: 0.8766 - precision: 0.89
03 - val_loss: 0.3141 - val_accuracy: 0.7087 - val_auc: 0.9006 - val_recall: 0.7030 - val_preci
sion: 0.7161 - 3s/epoch - 3ms/step
Epoch 83/100
920/920 - 3s - loss: 0.1236 - accuracy: 0.8827 - auc: 0.9823 - recall: 0.8753 - precision: 0.89
21 - val_loss: 0.3211 - val_accuracy: 0.7083 - val_auc: 0.8985 - val_recall: 0.6935 - val_preci
sion: 0.7159 - 3s/epoch - 3ms/step
Epoch 84/100
920/920 - 3s - loss: 0.1216 - accuracy: 0.8801 - auc: 0.9829 - recall: 0.8746 - precision: 0.88
84 - val_loss: 0.3121 - val_accuracy: 0.7152 - val_auc: 0.9037 - val_recall: 0.7074 - val_preci
sion: 0.7199 - 3s/epoch - 3ms/step
Epoch 85/100
920/920 - 2s - loss: 0.1218 - accuracy: 0.8821 - auc: 0.9830 - recall: 0.8739 - precision: 0.88
87 - val_loss: 0.3292 - val_accuracy: 0.6991 - val_auc: 0.8946 - val_recall: 0.6939 - val_preci
sion: 0.7062 - 2s/epoch - 3ms/step
Epoch 86/100
920/920 - 2s - loss: 0.1238 - accuracy: 0.8790 - auc: 0.9824 - recall: 0.8732 - precision: 0.88
59 - val_loss: 0.3214 - val_accuracy: 0.7043 - val_auc: 0.8971 - val_recall: 0.6996 - val_preci
sion: 0.7101 - 2s/epoch - 2ms/step
Epoch 87/100
920/920 - 2s - loss: 0.1211 - accuracy: 0.8807 - auc: 0.9833 - recall: 0.8755 - precision: 0.88
81 - val_loss: 0.3117 - val_accuracy: 0.7161 - val_auc: 0.9024 - val_recall: 0.7087 - val_preci
sion: 0.7248 - 2s/epoch - 2ms/step
Epoch 88/100
920/920 - 2s - loss: 0.1179 - accuracy: 0.8838 - auc: 0.9844 - recall: 0.8777 - precision: 0.89
31 - val_loss: 0.3250 - val_accuracy: 0.7109 - val_auc: 0.8971 - val_recall: 0.7057 - val_preci
```

```
sion: 0.7150 - 2s/epoch - 3ms/step
Epoch 89/100
920/920 - 2s - loss: 0.1146 - accuracy: 0.8892 - auc: 0.9849 - recall: 0.8824 - precision: 0.89
82 - val_loss: 0.3252 - val_accuracy: 0.7143 - val_auc: 0.8972 - val_recall: 0.6952 - val_preci
sion: 0.7235 - 2s/epoch - 2ms/step
Epoch 90/100
920/920 - 2s - loss: 0.1166 - accuracy: 0.8918 - auc: 0.9834 - recall: 0.8860 - precision: 0.89
90 - val_loss: 0.3334 - val_accuracy: 0.7004 - val_auc: 0.8938 - val_recall: 0.6952 - val_preci
sion: 0.7094 - 2s/epoch - 2ms/step
Epoch 91/100
920/920 - 2s - loss: 0.1146 - accuracy: 0.8898 - auc: 0.9845 - recall: 0.8837 - precision: 0.89
56 - val_loss: 0.3271 - val_accuracy: 0.7065 - val_auc: 0.8959 - val_recall: 0.7009 - val_preci
sion: 0.7117 - 2s/epoch - 3ms/step
Epoch 92/100
920/920 - 2s - loss: 0.1167 - accuracy: 0.8926 - auc: 0.9838 - recall: 0.8859 - precision: 0.90
04 - val_loss: 0.3305 - val_accuracy: 0.7017 - val_auc: 0.8947 - val_recall: 0.6857 - val_preci
sion: 0.7133 - 2s/epoch - 3ms/step
Epoch 93/100
920/920 - 2s - loss: 0.1126 - accuracy: 0.8912 - auc: 0.9853 - recall: 0.8860 - precision: 0.89
80 - val_loss: 0.3302 - val_accuracy: 0.7087 - val_auc: 0.8943 - val_recall: 0.7017 - val_preci
sion: 0.7132 - 2s/epoch - 2ms/step
Epoch 94/100
920/920 - 2s - loss: 0.1138 - accuracy: 0.8920 - auc: 0.9844 - recall: 0.8867 - precision: 0.89
72 - val_loss: 0.3270 - val_accuracy: 0.7178 - val_auc: 0.8958 - val_recall: 0.7104 - val_preci
sion: 0.7240 - 2s/epoch - 2ms/step
Epoch 95/100
920/920 - 2s - loss: 0.1158 - accuracy: 0.8879 - auc: 0.9835 - recall: 0.8817 - precision: 0.89
42 - val_loss: 0.3290 - val_accuracy: 0.7148 - val_auc: 0.8968 - val_recall: 0.7096 - val_preci
sion: 0.7215 - 2s/epoch - 3ms/step
Epoch 96/100
920/920 - 2s - loss: 0.1138 - accuracy: 0.8893 - auc: 0.9843 - recall: 0.8837 - precision: 0.89
48 - val_loss: 0.3278 - val_accuracy: 0.7087 - val_auc: 0.8974 - val_recall: 0.6943 - val_preci
sion: 0.7197 - 2s/epoch - 2ms/step
Epoch 97/100
920/920 - 2s - loss: 0.1129 - accuracy: 0.8915 - auc: 0.9847 - recall: 0.8849 - precision: 0.89
78 - val_loss: 0.3340 - val_accuracy: 0.7083 - val_auc: 0.8930 - val_recall: 0.7048 - val_preci
sion: 0.7154 - 2s/epoch - 2ms/step
Epoch 98/100
920/920 - 2s - loss: 0.1129 - accuracy: 0.8948 - auc: 0.9842 - recall: 0.8889 - precision: 0.90
09 - val_loss: 0.3294 - val_accuracy: 0.7096 - val_auc: 0.8962 - val_recall: 0.7043 - val_preci
sion: 0.7165 - 2s/epoch - 2ms/step
Epoch 99/100
920/920 - 2s - loss: 0.1083 - accuracy: 0.9005 - auc: 0.9858 - recall: 0.8947 - precision: 0.90
72 - val_loss: 0.3402 - val_accuracy: 0.7109 - val_auc: 0.8925 - val_recall: 0.6948 - val_preci
sion: 0.7185 - 2s/epoch - 2ms/step
Epoch 100/100
920/920 - 2s - loss: 0.1095 - accuracy: 0.8971 - auc: 0.9850 - recall: 0.8929 - precision: 0.90
37 - val_loss: 0.3385 - val_accuracy: 0.7078 - val_auc: 0.8957 - val_recall: 0.7039 - val_preci
sion: 0.7138 - 2s/epoch - 2ms/step
```

In [107…

```
ypred=model.predict((X_test[:,::4]-X_test.mean())/X_test.std())
ypred.shape
```

Out[107… (2300, 5)

In [108…

```
yp=np.zeros((Y_test.shape[0]))
yo=np.ones((Y_test.shape[0]))
```

In [109…

```
for i in range(Y_test.shape[0]):
    yp[i]=np.argmax(ypred[i])+1
    yo[i]=np.argmax(Y_test[i])
```

In [110…

```
yp.shape
```

Out[110… (2300,)

In [111…

```
np.unique(yo)
```

Out[111…
```
array([1., 2., 3., 4., 5.])
```

In [112…
```
np.unique(Y_test)
```

Out[112…
```
array([0., 1.], dtype=float32)
```

In [113…
```
#conversion of classes
for i in range(Y_test.shape[0]):
    if yo[i]!=1:
        yo[i]=0
    if yp[i]!=1:
        yp[i]=0
```

In [114…
```
np.unique(yo)
```

Out[114…
```
array([0., 1.])
```

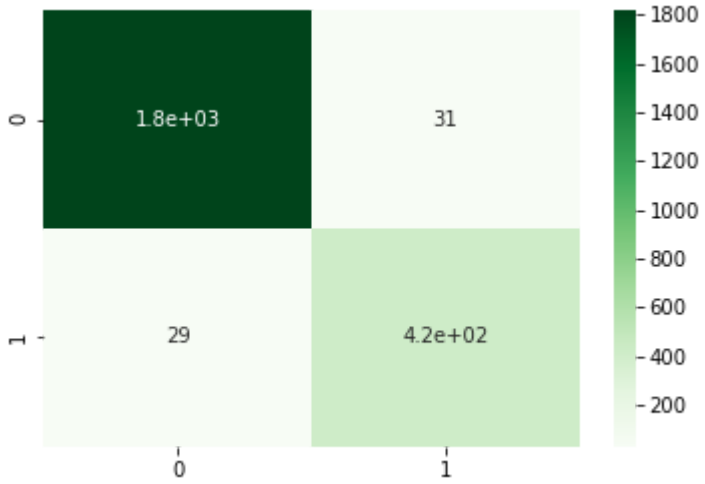
In [115…
```
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score
from sklearn.metrics import f1_score
#from sklearn.metrics import sensitivity
#from sklearn.metrics import specificity
accuracy = accuracy_score(yo,yp)
print("Accuracy: %f" % accuracy)
precision = precision_score(yo,yp)
print("Precision: %f" % precision)
recall = recall_score(yo,yp)
print("Recall: %f" % recall)
f1 = f1_score(yo,yp)
print("F1_score: %f" % f1)
#sensitivity = sensitivity(yo,yp)
#print("F1_score: %f" % f1)
#specificity = specificity(yo,yp)
#print("F1_score: %f" % f1)
```

```
Accuracy: 0.973913
Precision: 0.932018
Recall: 0.936123
F1_score: 0.934066
```

In [116…
```
cm=confusion_matrix(yo,yp)
cm
```

Out[116…
```
array([[1815,   31],
       [  29,  425]], dtype=int64)
```

In [117…
```
import seaborn as sns
#sns.heatmap(cm)
sns.heatmap(cm,cmap="Greens",annot=True)
plt.show()
```

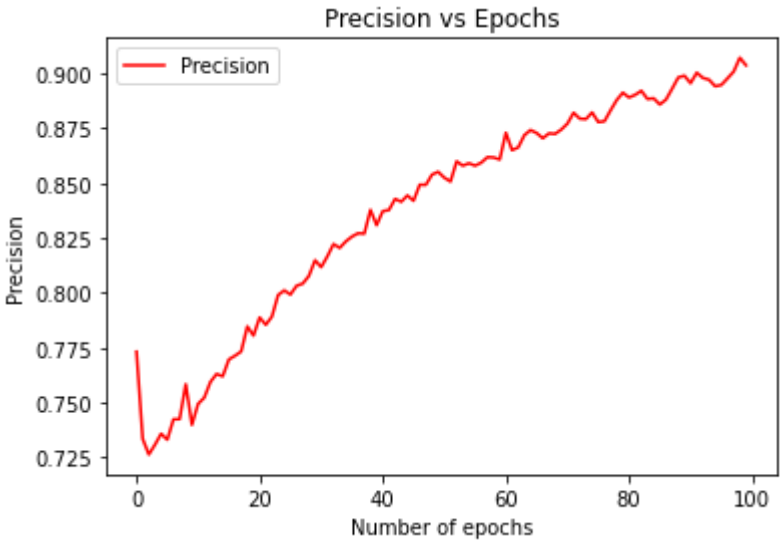


In [118…

```
plt.figure(0)
plt.plot(fits.history['loss'],'g',label='Training Loss')
plt.plot(fits.history['accuracy'],'r',label='Training accuracy')
plt.xlabel("Number of epochs")
plt.ylabel("Accuracy")
plt.title("Training accuracy vs Training Loss")
plt.legend()
plt.show()
```

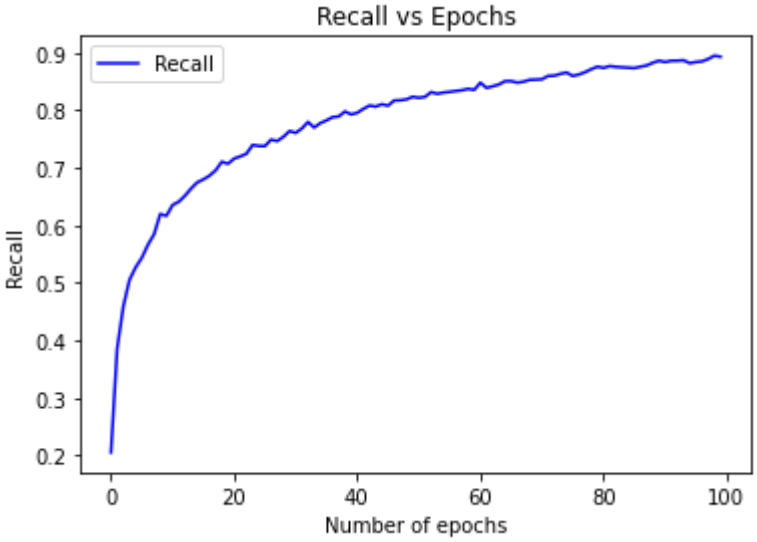
In [119…

```
plt.plot(fits.history['precision'],'r',label='Precision')
plt.xlabel("Number of epochs")
plt.ylabel("Precision")
plt.title("Precision vs Epochs")
plt.legend()
plt.show()
```



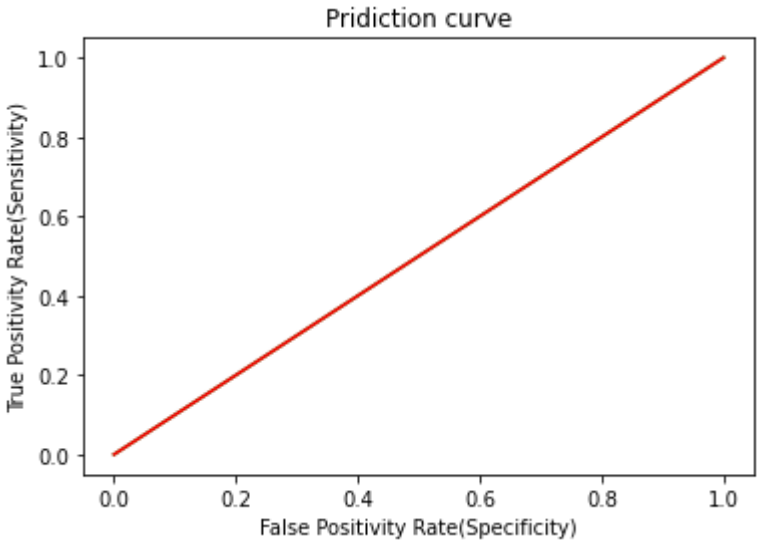
In [120…

```
plt.plot(fits.history['recall'],'b',label='Recall')
plt.xlabel("Number of epochs")
plt.ylabel("Recall")
plt.title("Recall vs Epochs")
plt.legend()
plt.show()
```



In [121…

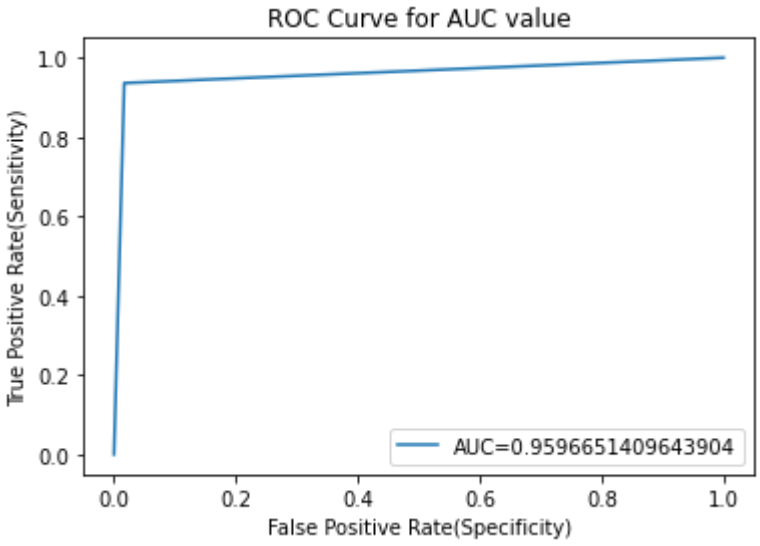
```
plt.plot(np.unique(yo),'g')
plt.plot(np.unique(yp), 'red')
plt.xlabel('False Positivity Rate(Specificity)')
plt.ylabel('True Positivity Rate(Sensitivity)')
plt.title("Pridiction curve")
plt.show()
```



In [122…

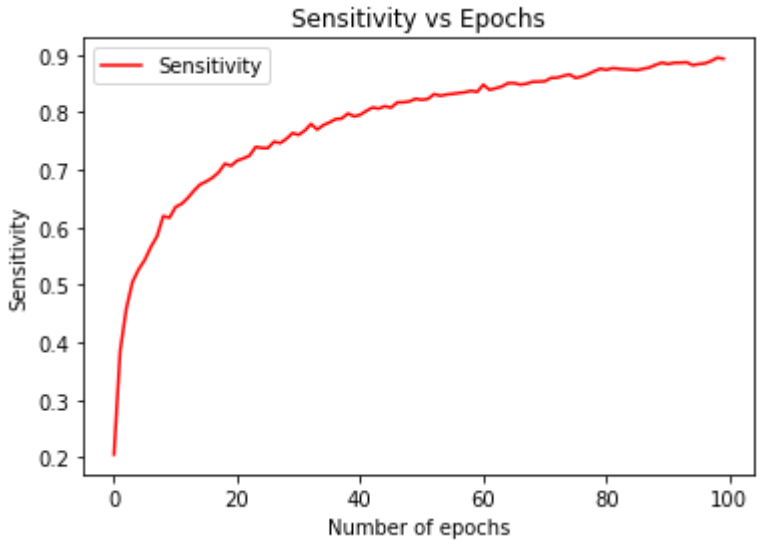
```
from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import train_test_split
from sklearn.metrics import roc_auc_score
import sklearn.metrics as metrics
fpr,tpr,thresholds=roc_curve(yo,yp)
fpr, tpr, _ = metrics.roc_curve(yo,yp)
auc = metrics.roc_auc_score(yo, yp)

#create ROC curve
plt.plot(fpr,tpr,label="AUC="+str(auc))
plt.ylabel('True Positive Rate(Sensitivity)')
plt.xlabel('False Positive Rate(Specificity)')
plt.legend(loc=4)
plt.title("ROC Curve for AUC value")
plt.show()
```



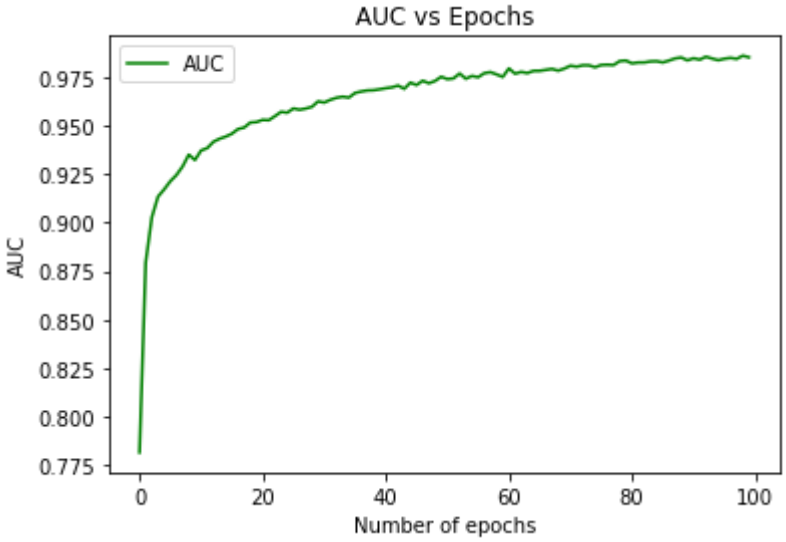
In [123…

```
plt.plot(fits.history['recall'],'r',label='Sensitivity')
plt.xlabel("Number of epochs")
plt.ylabel("Sensitivity")
plt.title("Sensitivity vs Epochs")
plt.legend()
plt.show()
```



In [124…

```
plt.plot(fits.history['auc'],'g',label='AUC')
plt.xlabel("Number of epochs")
plt.ylabel("AUC")
plt.title("AUC vs Epochs")
plt.legend()
plt.show()
```



In [125…

```
#Training Dataset Acuracy
ypred1=model.predict((X_train[:,::4]-X_train.mean())/X_train.std())
ypred1.shape
```

Out[125… (9200, 5)

In [126…

```
yp1=np.zeros((Y_train.shape[0]))
yo1=np.ones((Y_train.shape[0]))
```

In [127…

```
for i in range(Y_train.shape[0]):
    yp1[i]=np.argmax(ypred1[i])+1
    yo1[i]=np.argmax(Y_train[i])
```

In [128…

```
yp1.shape
```

Out[128… (9200,)

In [129…

```
yo1.shape
```

Out[129… (9200,)

In [130…
```
np.unique(yo1)
```

Out[130… array([1., 2., 3., 4., 5.])

In [131…
```
np.unique(yp1)
```

Out[131… array([1., 2., 3., 4., 5.])

In [132…
```
#conversion of classes
for i in range(Y_train.shape[0]):
    if yo1[i]!=1:
        yo1[i]=0
    if yp1[i]!=1:
        yp1[i]=0
```

In [133…
```
np.unique(yo1)
```

Out[133… array([0., 1.])

In [134…
```
np.unique(yp1)
```

Out[134… array([0., 1.])

In [135…
```
accuracy_score(yo1,yp1)
```

Out[135… 0.9997826086956522

In [ ]: