Homework 3
CSCE 633 – Machine Learning
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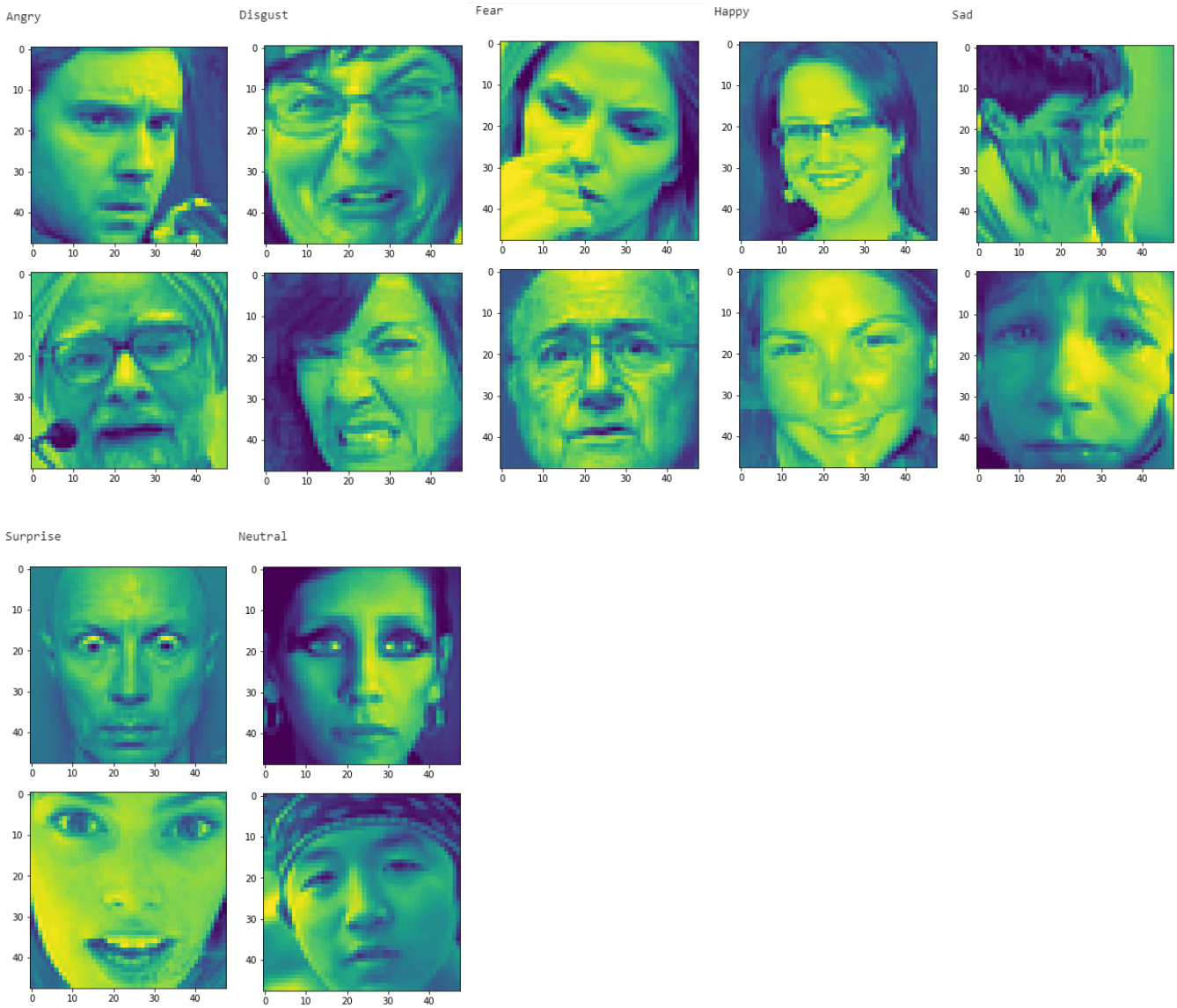
(a)



(b)

(0=Angry, 1=Disgust, 2=Fear, 3=Happy, 4=Sad, 5=Surprise, 6=Neutral)
Number of different emotions in Training Data
Angry: 3995
Disgust: 436
Fear: 4097
Happy: 7215
Sad: 4830
Surprise: 3171
Neutral: 4965

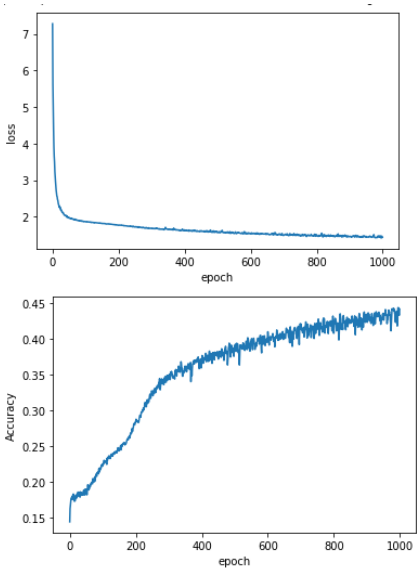
(c)
<Code is attached to this pdf in the end>

(c.i)
Emotion classification with FNN

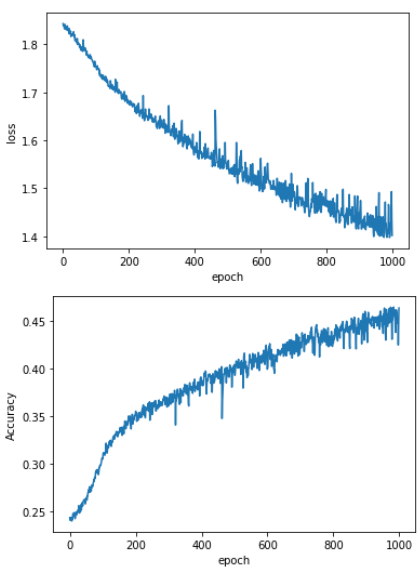
Model	#Layers	#Nodes per layer	Activation function	Dropout	#Parameters	Running time	Train Accuracy	Validation Accuracy	Test Accuracy
1	6	50	relu	0.3	125,807	4min 42s	44.2	39.7	39.5
2	4	50	relu	0.3	120,707	4min 36s	46.3	41.8	42
3	5	100	relu	0	261,507	4min 43s	45.9	39.7	39.3

Loss and Accuracy Graphs –

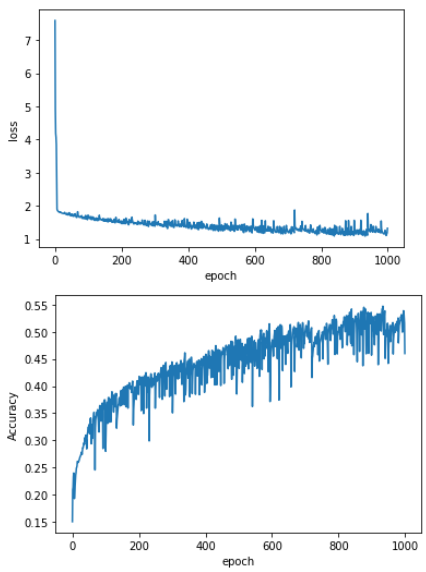
Model 1



Model 2



Model 3



Best Model based on validation set accuracy: Model 2
Best Model accuracy on testing data: Model 2.

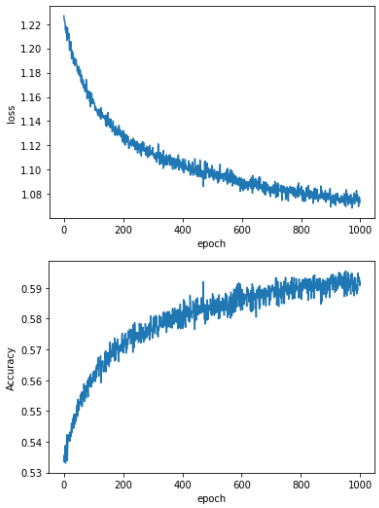
(d)
<Code is attached to this pdf in the end>

(d.i)

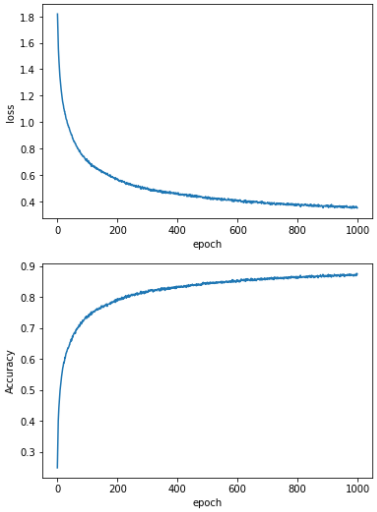
Model	#Layers	#Filters per layer	Activation function	Dropout	#Parameters	Running time	Train Accuracy	Validation Accuracy	Test Accuracy
1	Conv- 3 Dense-1	10	relu	0.1,0.2,0.3	19,529	11min 20s	9.2	56.7	57.8
2	Conv- 3 Dense-1	50	relu	0.1,0.2,0.3	199,347	30min 19s	87.5	60.4	60.1
3	Conv- 4 Dense-1	50	relu	0.1,0.2,0.3	111,057	27min 53s	76.5	59.9	61.0

Loss and Accuracy Graphs –

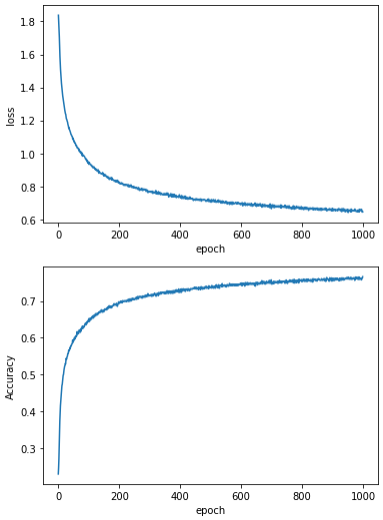
Model 1



Model 2



Model 3



(d.ii)

Best model on validation set – Model 2, accuracy in test set 60.1%

(d) Fine Tuning

VGG model was fine tuned to classify the data.

Model	#Layers	Activation function	Dropout	#Parameters	Running time	Train Accuracy	Validation Accuracy	Test Accuracy
1	VGG + 1	Relu	0.5	Total params: 14,766,695 Trainable params: 2,411,815	9min 12s	25.1	24.9	24.4
2	VGG + 4	Relu	0.5	Total params: 14,796,995 Trainable params: 82,307	49.1 s	31.4	37	36.1
3	VGG + 3	Sigmoid	0.5	Total params: 15,475,695 Trainable params: 761,007	2min 57s	42.4	42.9	42.2

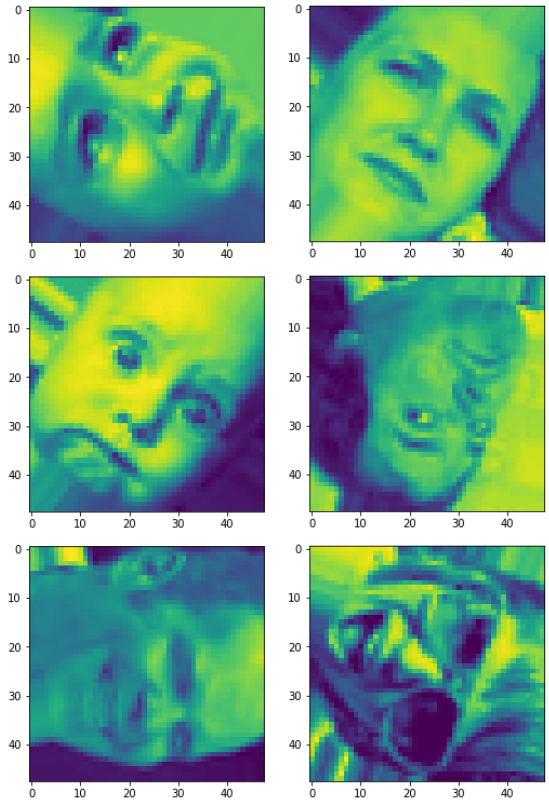
Best model according to validation accuracy – Model 3
Accuracy of model 3 in test set = 42.2%

(e) Bayesian optimization for hyper-parameter tuning:
<Code is attached in the end>

Model	#Layers	#Filters per layer	#Neurons in Dense	Activation function	Dropout	Validation Accuracy	Test Accuracy
1	Conv- 4 Dense-1	30	1024	relu	0.22	39	38
2	Conv- 3 Dense-1	10	50	sigmoid	0.24	24.9	24.4
3	Conv- 4 Dense-1	20	100	sigmoid	0.36	24.9	24.4
4	Conv- 4 Dense-1	30	500	sigmoid	0.56	24.9	24.4
5	Conv- 3 Dense-1	10	50	sigmoid	0.24	24.9	24.4

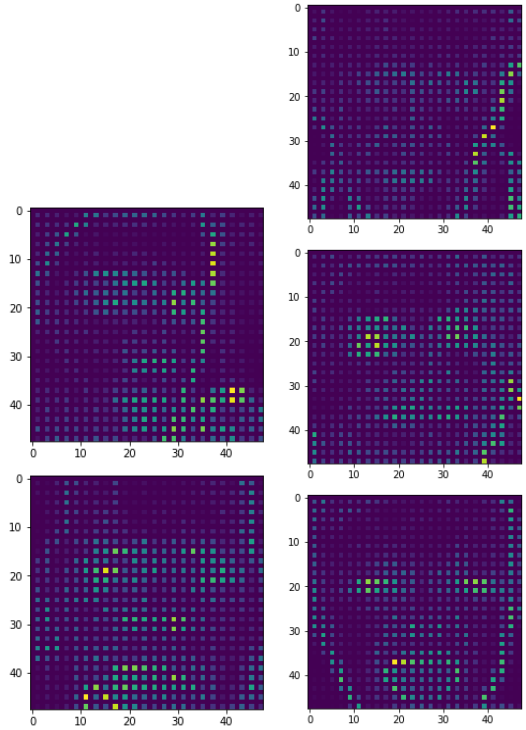
(f) Data augmentation

Some Output Images –



(g) Feature design

HOG feature images



Trained model 2 FNN
Accuracy in test set – 30%
Accuracy in validation set – 29%

In [1]:
```
from keras import models
from keras import layers
from keras.utils import to_categorical
import numpy as np
from google.colab import files
import matplotlib.pyplot as plt
import io

import warnings
warnings.filterwarnings('ignore')
```

```
Using TensorFlow backend.
```

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade (https://www.tensorflow.org/guide/migrate) now or ensure your notebook will continue to use TensorFlow 1.x via the `%tensorflow_version 1.x` magic: more info (https://colab.research.google.com/notebooks/tensorflow_version.ipynb).

In [0]:
```
# Code to read csv file into Colaboratory:
!pip install -U -q PyDrive
from pydrive.auth import GoogleAuth
from pydrive.drive import GoogleDrive
from google.colab import auth
from oauth2client.client import GoogleCredentials
# Authenticate and create the PyDrive client.
auth.authenticate_user()
gauth = GoogleAuth()
gauth.credentials = GoogleCredentials.get_application_default()
drive = GoogleDrive(gauth)
```

In [0]:
```
# https://drive.google.com/open?id=1mypSe66DjS1NEXdcN3b4NJw8WjQIP39z
downloaded = drive.CreateFile({'id':'1mypSe66DjS1NEXdcN3b4NJw8WjQIP39z'})
downloaded.GetContentFile('Test_Data.csv')

# https://drive.google.com/open?id=1zXJ4i_byS4XezWo-TdCjlvalwJy2Pb64
downloaded = drive.CreateFile({'id':'1zXJ4i_byS4XezWo-TdCjlvalwJy2Pb64'})
downloaded.GetContentFile('Train_Data.csv')

#https://drive.google.com/open?id=1TZH_sw6we5GB1n0E4v2kBQhkxFg8Edku
downloaded = drive.CreateFile({'id':'1TZH_sw6we5GB1n0E4v2kBQhkxFg8Edku'})
downloaded.GetContentFile('Validation_Data.csv')
```

In [4]:
```
!ls
```

```
adc.json  sample_data  Test_Data.csv  Train_Data.csv  Validation_Data.csv
```

In [0]:
```
with open('Train_Data.csv', 'r') as f:
  f.readline()
  clean_lines = (line.replace(' ',',') for line in f)
  train_data = np.genfromtxt(clean_lines, dtype=int, delimiter=',')

with open('Test_Data.csv', 'r') as f:
  f.readline()
  clean_lines = (line.replace(' ',',') for line in f)
  test_data = np.genfromtxt(clean_lines, dtype=int, delimiter=',')

with open('Validation_Data.csv', 'r') as f:
  f.readline()
  clean_lines = (line.replace(' ',',') for line in f)
  val_data = np.genfromtxt(clean_lines, dtype=int, delimiter=',')
```

In [6]:
```
train_data_y_original = train_data[:,0]
train_data_X = ( train_data[:,1:] / 255.0 ) - 0.5
test_data_y_original = test_data[:,0]
test_data_X = ( test_data[:,1:] / 255.0 ) - 0.5
val_data_y_original = val_data[:,0]
val_data_X = ( val_data[:,1:] / 255.0 ) - 0.5

train_data_y = to_categorical(train_data_y_original)
test_data_y = to_categorical(test_data_y_original)
val_data_y = to_categorical(val_data_y_original)

train_data_X_2D = np.zeros(shape=(train_data_X.shape[0],48,48,))
test_data_X_2D = np.zeros(shape=(test_data_X.shape[0],48,48))
val_data_X_2D = np.zeros(shape=(val_data_X.shape[0],48,48))

for i in range(train_data_X.shape[0]):
  img = train_data_X[i].reshape(48,48)
  train_data_X_2D[i,:,:] = img

for i in range(test_data_X.shape[0]):
  img = test_data_X[i].reshape(48,48)
  test_data_X_2D[i,:,:] = img

for i in range(val_data_X.shape[0]):
  img = val_data_X[i].reshape(48,48)
  val_data_X_2D[i,:,:] = img

train_data_X_2D = train_data_X_2D.reshape((train_data_X_2D.shape[0],train_data
_X_2D.shape[1],train_data_X_2D.shape[2],1))
test_data_X_2D = test_data_X_2D.reshape((test_data_X_2D.shape[0],test_data_X_2
D.shape[1],test_data_X_2D.shape[2],1))
val_data_X_2D = val_data_X_2D.reshape((val_data_X_2D.shape[0],val_data_X_2D.sh
ape[1],val_data_X_2D.shape[2],1))

print(train_data_X.shape)
print(test_data_X.shape)
print(val_data_X.shape)
print(train_data_X_2D.shape)
print(train_data_y.shape)
print(test_data_X_2D.shape)
print(test_data_y.shape)
print(val_data_X_2D.shape)
print(val_data_y.shape)
```

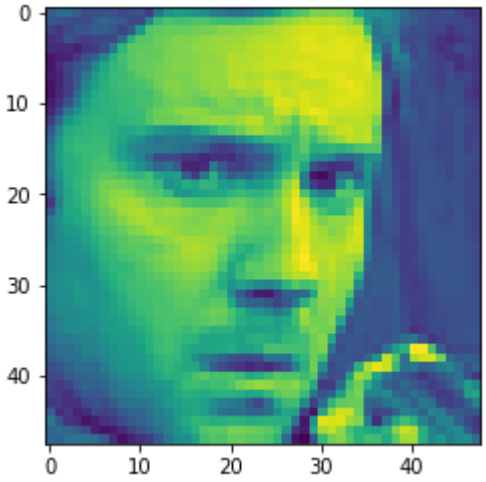
```
(28709, 2304)
(3589, 2304)
(3589, 2304)
(28709, 48, 48, 1)
(28709, 7)
(3589, 48, 48, 1)
(3589, 7)
(3589, 48, 48, 1)
(3589, 7)
```

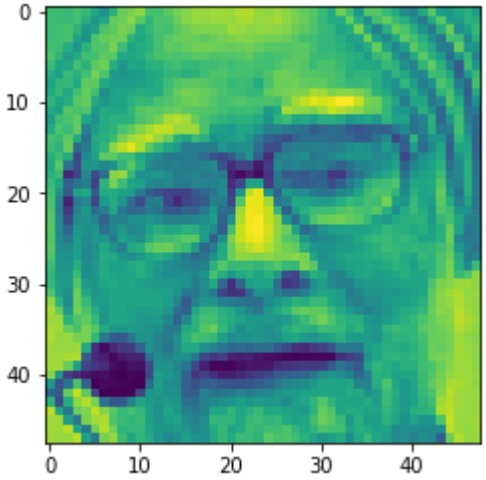
Question (a)

In [15]:
```
emotionList = ['Angry', 'Disgust', 'Fear', 'Happy', 'Sad', 'Surprise', 'Neutra
l']
for emotionVal in range(len(emotionList)):

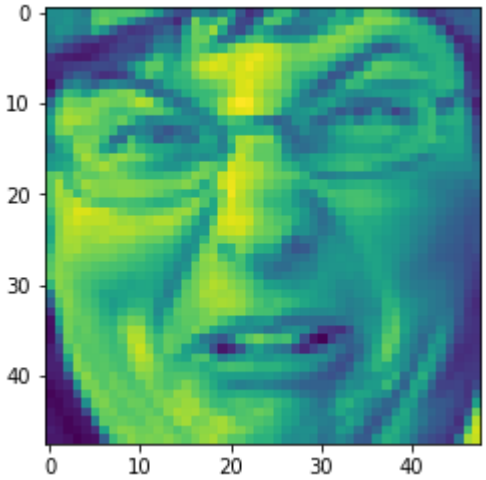
  num = 0
  plt.figure()
  print(emotionList[emotionVal], '\n')
  for i in range(train_data_X.shape[0]):
    if train_data_y_original[i] == emotionVal:
      num += 1
      plt.imshow(train_data_X[i].reshape(48,48))
      plt.show()
      if num == 2:
        break
```

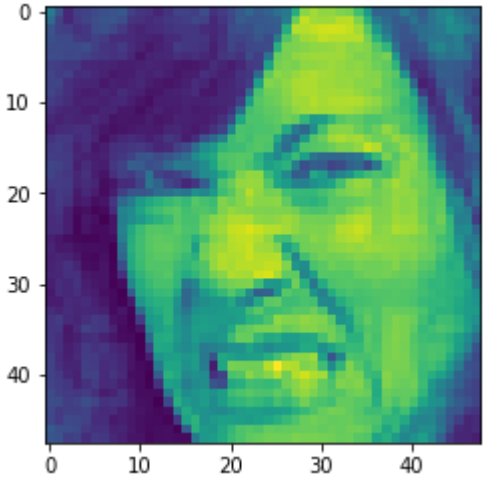
```
Angry
```



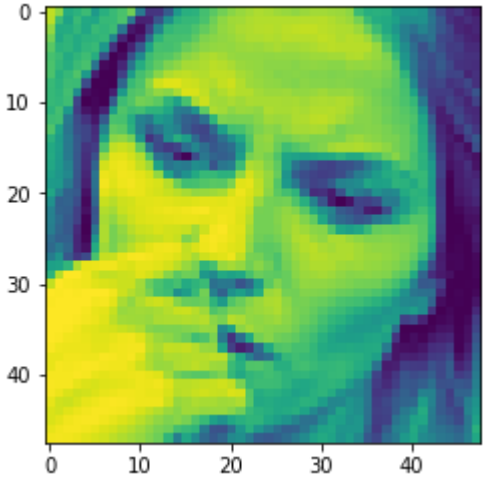


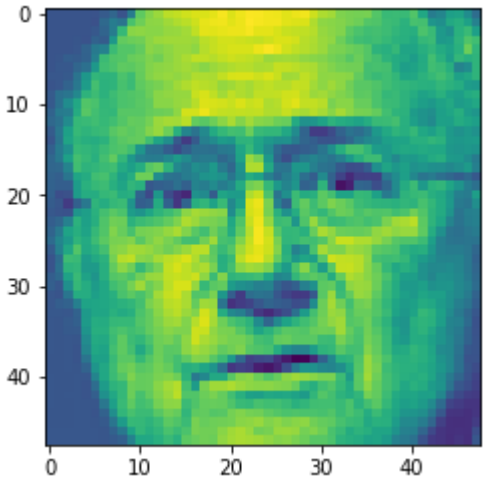

```
Disgust
```



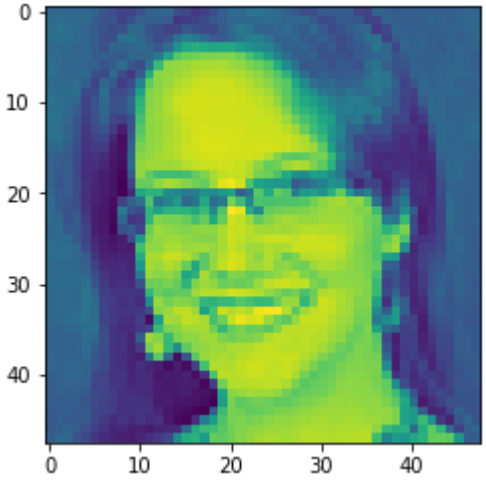

0
10
20
30
40
0
10
20
30
40

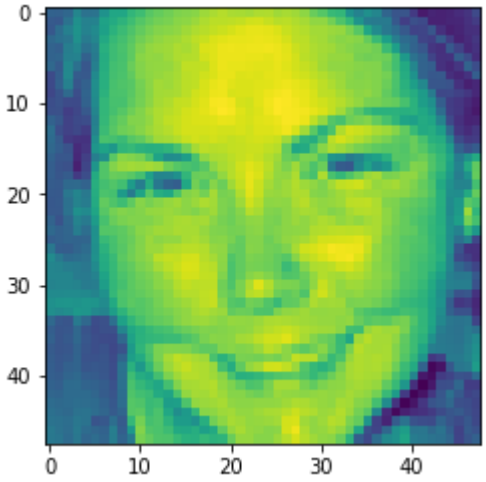
```
Fear
```


0
10
20
30
40
0
10
20
30
40

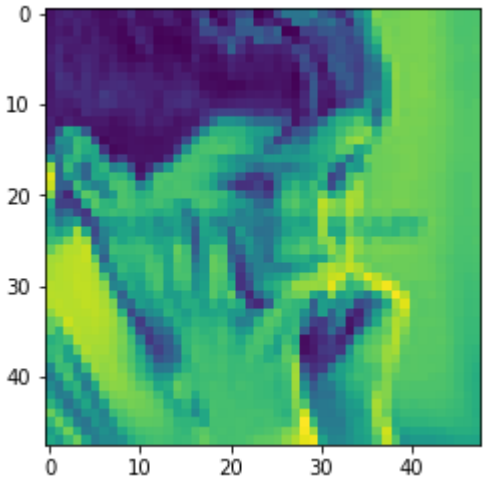

0
10
20
30
40
0
10
20
30
40

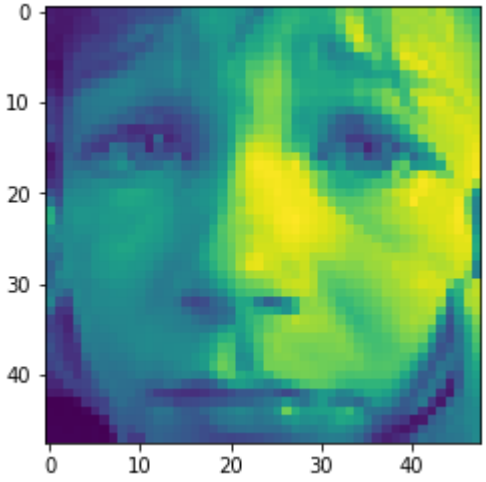
```
Happy
```


0
10
20
30
40
0
10
20
30
40

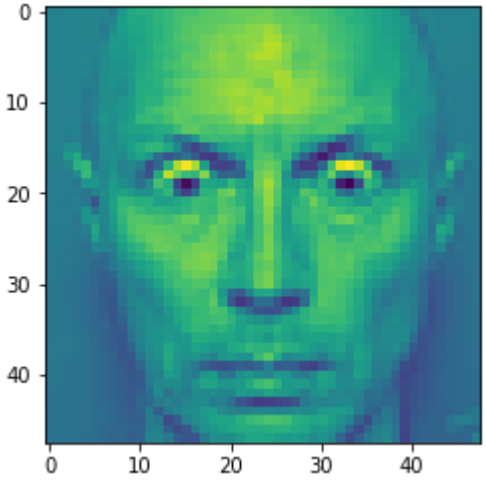

0
10
20
30
40
0
10
20
30
40

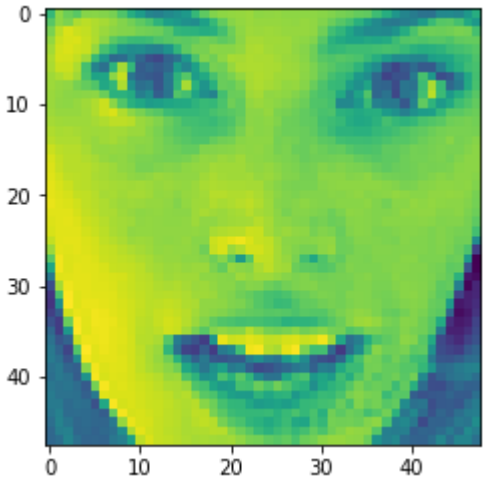
Sad


0
10
20
30
40
0
10
20
30
40

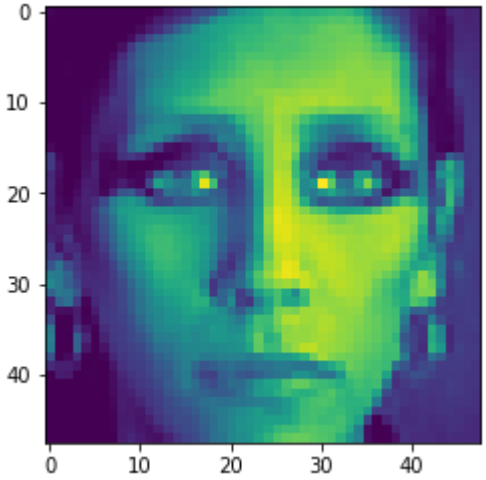


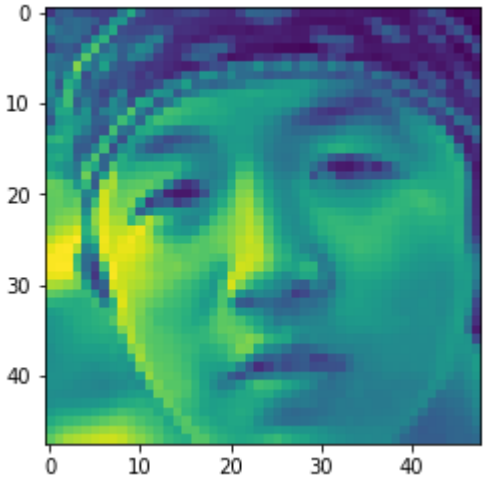

```
Surprise
```






```
Neutral
```





Question (b)

In [16]:
```
print('\nNumber of emotions in Training Data')
for i in range(len(emotionList)):
  print(emotionList[i] , ' : ' , np.sum(train_data_y_original == i))
```

```
Number of emotions in Training Data
Angry  :  3995
Disgust  :  436
Fear  :  4097
Happy  :  7215
Sad  :  4830
Surprise  :  3171
Neutral  :  4965
```

In [0]:
```
def generate_FNN_model_1():

  m = models.Sequential()
  m.add(layers.Dense( 50 , input_shape = (2304,), activation='relu'))
  m.add(layers.Dropout(0.3))
  m.add(layers.Dense( 50 , activation='relu'))
  m.add(layers.Dropout(0.3))
  m.add(layers.Dense( 50 , activation='relu'))
  m.add(layers.Dropout(0.3))
  m.add(layers.Dense( 50 , activation='relu'))
  m.add(layers.Dropout(0.3))
  m.add(layers.Dense( 50 , activation='relu'))
  m.add(layers.Dropout(0.3))
  m.add(layers.Dense( 7 , activation='relu'))

  m.compile(optimizer='rmsprop', loss='categorical_crossentropy', metrics=['ac
curacy'])

  return m
```

In [26]:
```
FNN_network = generate_FNN_model_1()
FNN_network.summary()
```

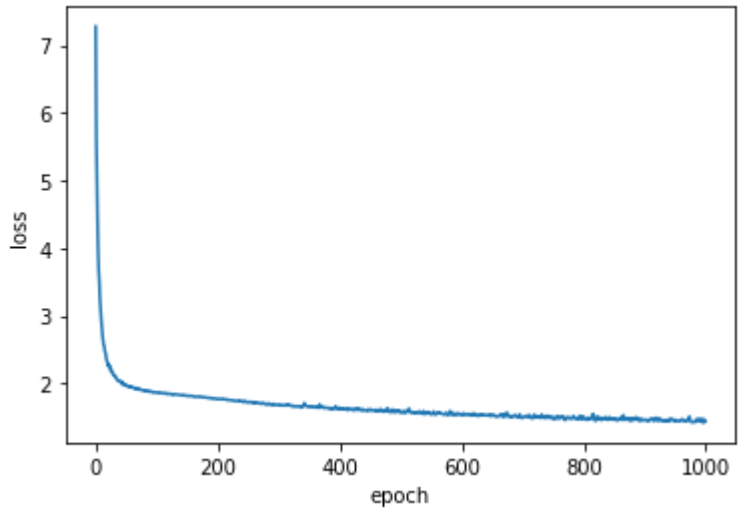
```
Model: "sequential_49"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_289 (Dense)            (None, 50)                115250
_________________________________________________________________
dropout_193 (Dropout)        (None, 50)                0
_________________________________________________________________
dense_290 (Dense)            (None, 50)                2550
_________________________________________________________________
dropout_194 (Dropout)        (None, 50)                0
_________________________________________________________________
dense_291 (Dense)            (None, 50)                2550
_________________________________________________________________
dropout_195 (Dropout)        (None, 50)                0
_________________________________________________________________
dense_292 (Dense)            (None, 50)                2550
_________________________________________________________________
dropout_196 (Dropout)        (None, 50)                0
_________________________________________________________________
dense_293 (Dense)            (None, 50)                2550
_________________________________________________________________
dropout_197 (Dropout)        (None, 50)                0
_________________________________________________________________
dense_294 (Dense)            (None, 7)                 357
=================================================================
Total params: 125,807
Trainable params: 125,807
Non-trainable params: 0
_________________________________________________________________
```

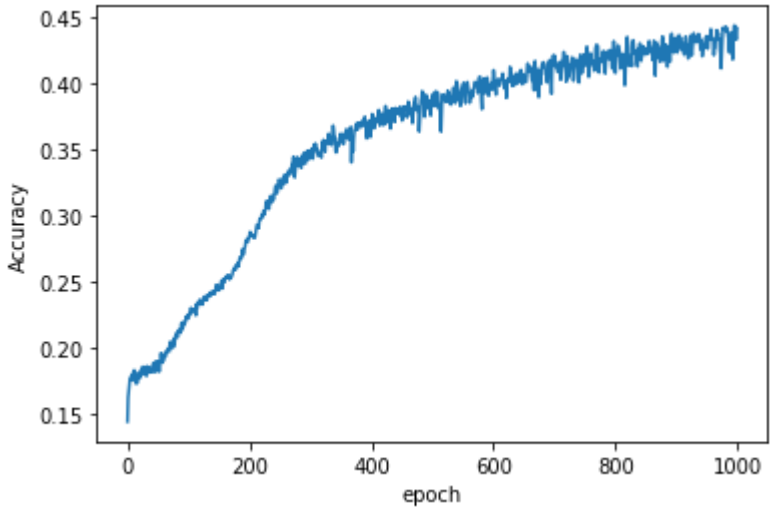
In [0]:
```
%%time
history = FNN_network.fit(train_data_X, train_data_y, epochs=1000, batch_size=
60000)
```

In [29]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[29]:
```
[<matplotlib.lines.Line2D at 0x7fc29e9d9160>]
```





In [30]:
```
loss, test_acc = FNN_network.evaluate(test_data_X, test_data_y)
print('test_acc: ', test_acc)

loss, val_acc = FNN_network.evaluate(val_data_X, val_data_y)
print('test_acc: ', val_acc)
```

```
3589/3589 [==============================] - 1s 188us/step
test_acc:  0.39509612705488995
3589/3589 [==============================] - 0s 67us/step
test_acc:  0.3970465310837572
```

In [0]:
```
def generate_FNN_model_2():

  m = models.Sequential()
  m.add(layers.Dense( 50 , input_shape = (2304,), activation='relu'))
  m.add(layers.Dropout(0.3))
  m.add(layers.Dense( 50 , activation='relu'))
  m.add(layers.Dropout(0.3))
  m.add(layers.Dense( 50 , activation='relu'))
  m.add(layers.Dropout(0.3))
  m.add(layers.Dense( 7 , activation='relu'))

  m.compile(optimizer='rmsprop', loss='categorical_crossentropy', metrics=['ac
curacy'])

  return m
```

In [32]:
```
FNN_network2 = generate_FNN_model_2()
FNN_network2.summary()
```

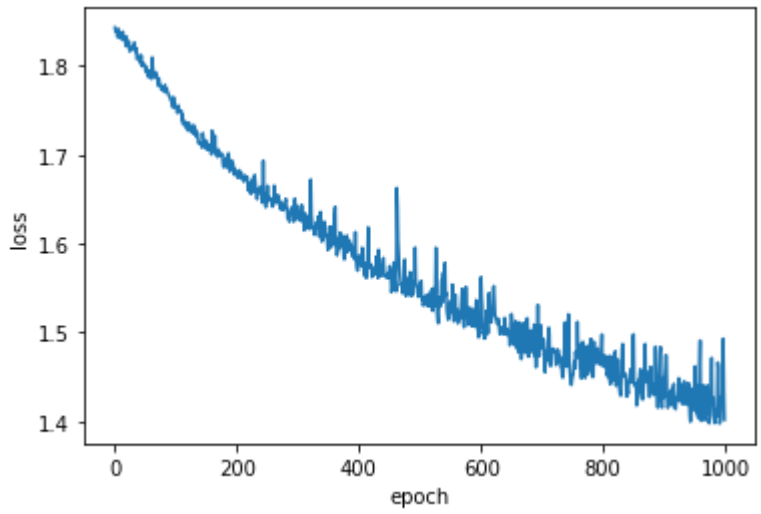
```
Model: "sequential_50"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_295 (Dense)            (None, 50)                115250
_________________________________________________________________
dropout_198 (Dropout)        (None, 50)                0
_________________________________________________________________
dense_296 (Dense)            (None, 50)                2550
_________________________________________________________________
dropout_199 (Dropout)        (None, 50)                0
_________________________________________________________________
dense_297 (Dense)            (None, 50)                2550
_________________________________________________________________
dropout_200 (Dropout)        (None, 50)                0
_________________________________________________________________
dense_298 (Dense)            (None, 7)                 357
=================================================================
Total params: 120,707
Trainable params: 120,707
Non-trainable params: 0
_________________________________________________________________
```

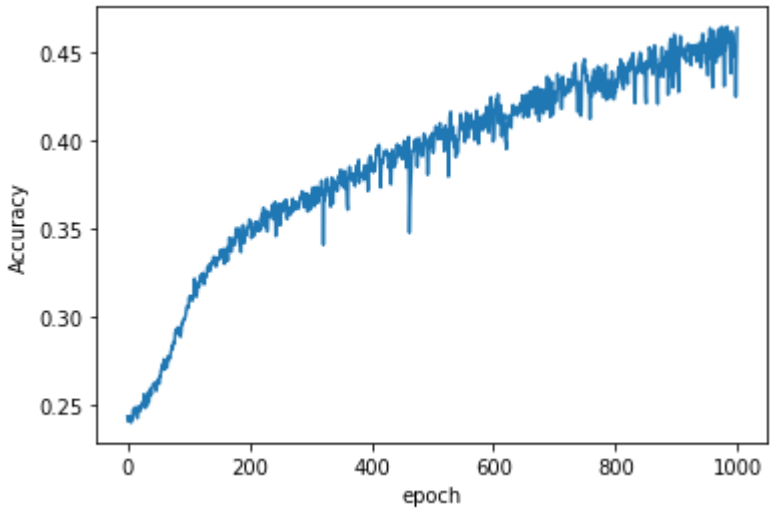
In [0]:
```
%%time
history = FNN_network2.fit(train_data_X, train_data_y, epochs=1000, batch_size
=60000)
```

In [35]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[35]:
```
[<matplotlib.lines.Line2D at 0x7fc29e588b38>]
```





In [36]:
```
test_loss, test_acc = FNN_network2.evaluate(test_data_X, test_data_y)
print('test_acc: ', test_acc)

val_loss, val_acc = FNN_network2.evaluate(val_data_X, val_data_y)
print('test_acc: ', val_acc)
```

```
3589/3589 [==============================] - 1s 184us/step
test_acc:  0.4204513792184177
3589/3589 [==============================] - 0s 64us/step
test_acc:  0.41877960435491846
```

In [0]:
```
def generate_FNN_model_3():

  m = models.Sequential()
  m.add(layers.Dense( 100 , input_shape = (2304,), activation='relu'))
  m.add(layers.Dense( 100 , activation='relu'))
  m.add(layers.Dense( 100 , activation='relu'))
  m.add(layers.Dense( 100 , activation='relu'))
  m.add(layers.Dense( 7 , activation='relu'))

  m.compile(optimizer='rmsprop', loss='categorical_crossentropy', metrics=['ac
curacy'])

  return m
```

In [38]:
```
FNN_network3 = generate_FNN_model_3()
FNN_network3.summary()
```

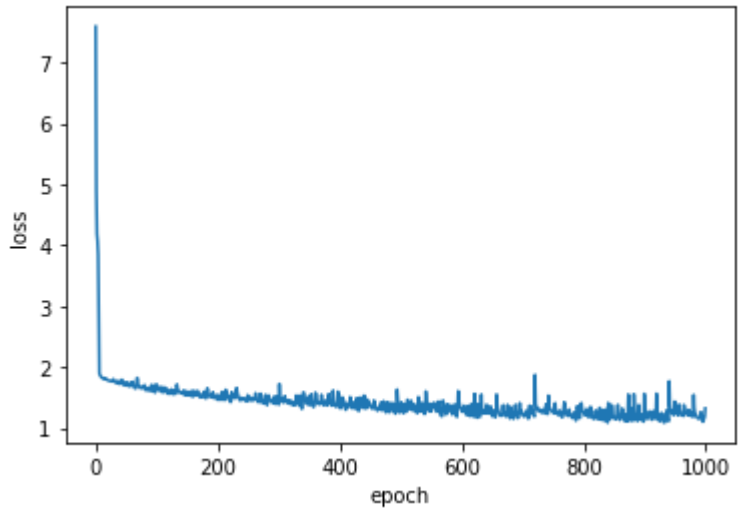
```
Model: "sequential_51"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_299 (Dense)            (None, 100)               230500
_________________________________________________________________
dense_300 (Dense)            (None, 100)               10100
_________________________________________________________________
dense_301 (Dense)            (None, 100)               10100
_________________________________________________________________
dense_302 (Dense)            (None, 100)               10100
_________________________________________________________________
dense_303 (Dense)            (None, 7)                 707
=================================================================
Total params: 261,507
Trainable params: 261,507
Non-trainable params: 0
_________________________________________________________________
```

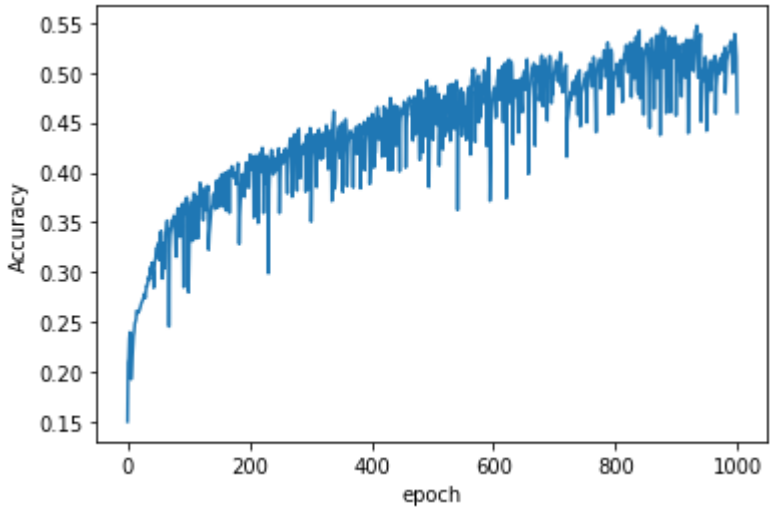
In [0]:
```
%%time
history = FNN_network3.fit(train_data_X, train_data_y, epochs=1000, batch_size
=60000)
```

In [40]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[40]:
```
[<matplotlib.lines.Line2D at 0x7fc29e321710>]
```





In [41]:
```
test_loss, test_acc = FNN_network3.evaluate(test_data_X, test_data_y)
print('test_acc: ', test_acc)

val_loss, val_acc = FNN_network3.evaluate(val_data_X, val_data_y)
print('test_acc: ', val_acc)
```

```
3589/3589 [==============================] - 1s 199us/step
test_acc:  0.39398161047645586
3589/3589 [==============================] - 0s 66us/step
test_acc:  0.39732516024497333
```

In [0]:
```
def generate_CNN_model():

  m = models.Sequential()

  m.add(layers.Conv2D( 10, kernel_size=3 , strides=(1,1), activation='relu' ,
input_shape = (48,48,1) ))
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.1))

  m.add(layers.Conv2D( 10, kernel_size=3 , strides=(1,1), activation='relu') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.2))

  m.add(layers.Conv2D( 32, kernel_size=3 , strides=(1,1), activation='relu') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.3))

  m.add(layers.Flatten())
  m.add(layers.Dense( 30 , activation='relu'))
  m.add(layers.Dense( 7 , activation='softmax'))

  m.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accur
acy'])
  return m
```

In [44]:
```
CNN_network = generate_CNN_model()
CNN_network.summary()
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:4267: The name tf.nn.max_pool is deprecated. Please use
tf.nn.max_pool2d instead.

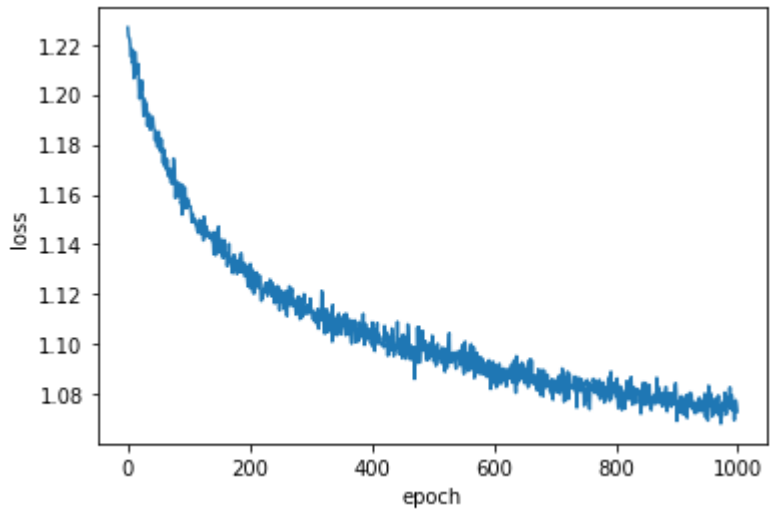
Model: "sequential_52"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 46, 46, 10)        100
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 23, 23, 10)        0
_________________________________________________________________
dropout_201 (Dropout)        (None, 23, 23, 10)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 21, 21, 10)        910
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 10, 10, 10)        0
_________________________________________________________________
dropout_202 (Dropout)        (None, 10, 10, 10)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 8, 8, 32)          2912
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 4, 4, 32)          0
_________________________________________________________________
dropout_203 (Dropout)        (None, 4, 4, 32)          0
_________________________________________________________________
flatten_1 (Flatten)          (None, 512)               0
_________________________________________________________________
dense_304 (Dense)            (None, 30)                15390
_________________________________________________________________
dense_305 (Dense)            (None, 7)                 217
=================================================================
Total params: 19,529
Trainable params: 19,529
Non-trainable params: 0
_________________________________________________________________
```

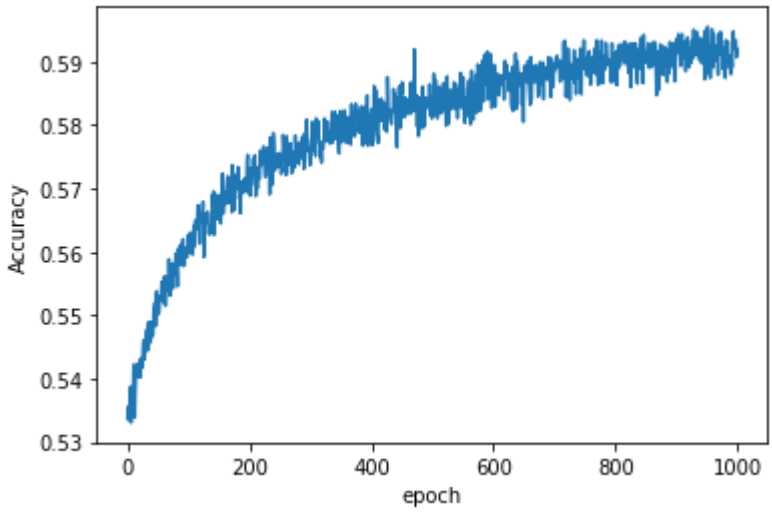
In [0]:
```
%%time
history = CNN_network.fit(train_data_X_2D, train_data_y, epochs=1000, batch_si
ze=1000)
```

In [47]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[47]:
```
[<matplotlib.lines.Line2D at 0x7fc29df7acf8>]
```





In [48]:
```
loss, test_acc = CNN_network.evaluate(test_data_X_2D, test_data_y)
print('test_acc: ', test_acc)

loss, val_acc = CNN_network.evaluate(val_data_X_2D, val_data_y)
print('val_acc: ', val_acc)
```

```
3589/3589 [==============================] - 1s 257us/step
test_acc:  0.578991362504821
3589/3589 [==============================] - 0s 81us/step
val_acc:  0.5675675675758713
```

In [0]:
```
def generate_CNN_model2():

  m = models.Sequential()

  m.add(layers.Conv2D( 70, kernel_size=3 , strides=(1,1), activation='relu' ,
input_shape = (48,48,1) )) #padding = 'same'
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.1))

  m.add(layers.Conv2D( 70, kernel_size=3 , strides=(1,1), activation='relu') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.2))

  m.add(layers.Conv2D( 70, kernel_size=5 , strides=(1,1), activation='relu') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.3))

  m.add(layers.Flatten())
  m.add(layers.Dense( 50 , activation='relu'))
  m.add(layers.Dense( 7 , activation='softmax'))

  m.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accur
acy'])
  return m
```

In [52]:
```
CNN_network2 = generate_CNN_model2()
CNN_network2.summary()
```

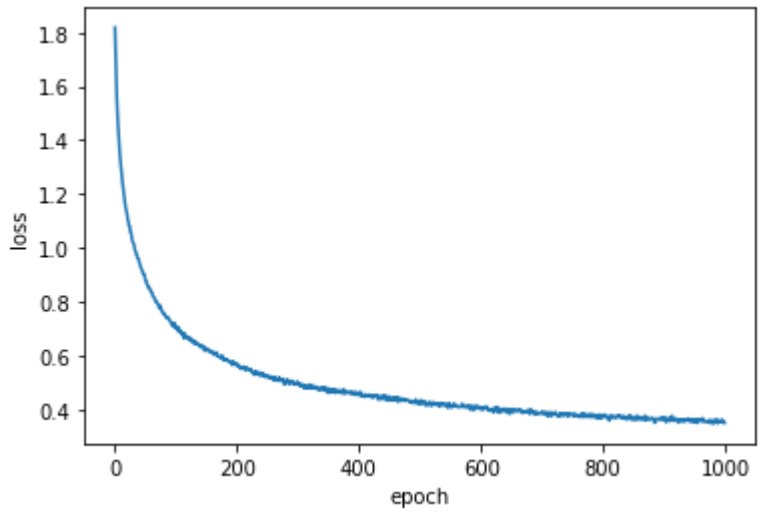
```
Model: "sequential_54"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_7 (Conv2D)            (None, 46, 46, 70)        700
_________________________________________________________________
max_pooling2d_7 (MaxPooling2 (None, 23, 23, 70)        0
_________________________________________________________________
dropout_207 (Dropout)        (None, 23, 23, 70)        0
_________________________________________________________________
conv2d_8 (Conv2D)            (None, 21, 21, 70)        44170
_________________________________________________________________
max_pooling2d_8 (MaxPooling2 (None, 10, 10, 70)        0
_________________________________________________________________
dropout_208 (Dropout)        (None, 10, 10, 70)        0
_________________________________________________________________
conv2d_9 (Conv2D)            (None, 6, 6, 70)          122570
_________________________________________________________________
max_pooling2d_9 (MaxPooling2 (None, 3, 3, 70)          0
_________________________________________________________________
dropout_209 (Dropout)        (None, 3, 3, 70)          0
_________________________________________________________________
flatten_3 (Flatten)          (None, 630)               0
_________________________________________________________________
dense_308 (Dense)            (None, 50)                31550
_________________________________________________________________
dense_309 (Dense)            (None, 7)                 357
=================================================================
Total params: 199,347
Trainable params: 199,347
Non-trainable params: 0
_________________________________________________________________
```

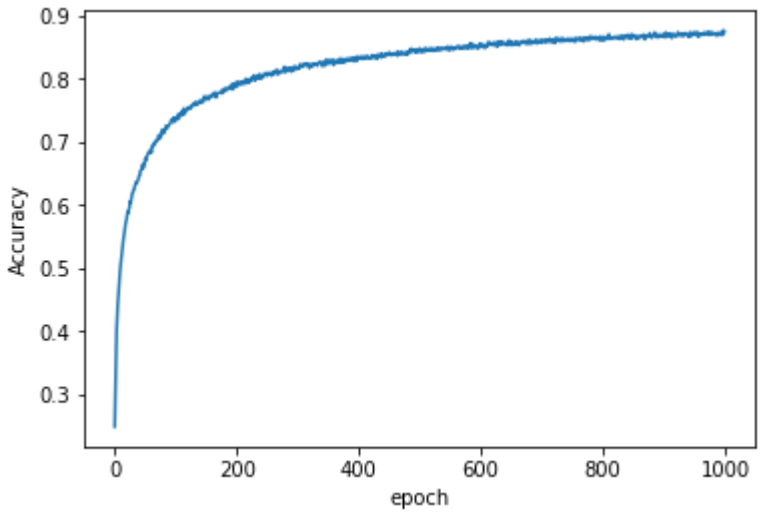
In [0]:
```
%%time
history = CNN_network2.fit(train_data_X_2D, train_data_y, epochs=1000, batch_s
ize=1000)
```

In [54]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[54]: [<matplotlib.lines.Line2D at 0x7fc29dde9668>]





In [55]:
```
loss, test_acc = CNN_network2.evaluate(test_data_X_2D, test_data_y)
print('test_acc: ', test_acc)

loss, val_acc = CNN_network2.evaluate(val_data_X_2D, val_data_y)
print('val_acc: ', val_acc)
```

```
3589/3589 [==============================] - 1s 286us/step
test_acc:  0.6010030649538058
3589/3589 [==============================] - 0s 96us/step
val_acc:  0.6043466146891082
```

In [0]:
```
def generate_CNN_model3():

  m = models.Sequential()

  m.add(layers.Conv2D( 50, kernel_size=3 , strides=(1,1), activation='relu' , input_shape = (48,48,1) )) #padding = 'same'
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.1))

  m.add(layers.Conv2D( 50, kernel_size=3 , strides=(1,1), activation='relu') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.2))

  m.add(layers.Conv2D( 50, kernel_size=5 , strides=(1,1), activation='relu') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.3))

  m.add(layers.Conv2D( 50, kernel_size=3 , strides=(1,1), activation='relu', padding = 'same') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.4))

  m.add(layers.Flatten())
  m.add(layers.Dense( 50 , activation='relu'))
  m.add(layers.Dense( 7 , activation='softmax'))

  m.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
  return m
```

In [57]:
```
CNN_network3 = generate_CNN_model3()
CNN_network3.summary()
```

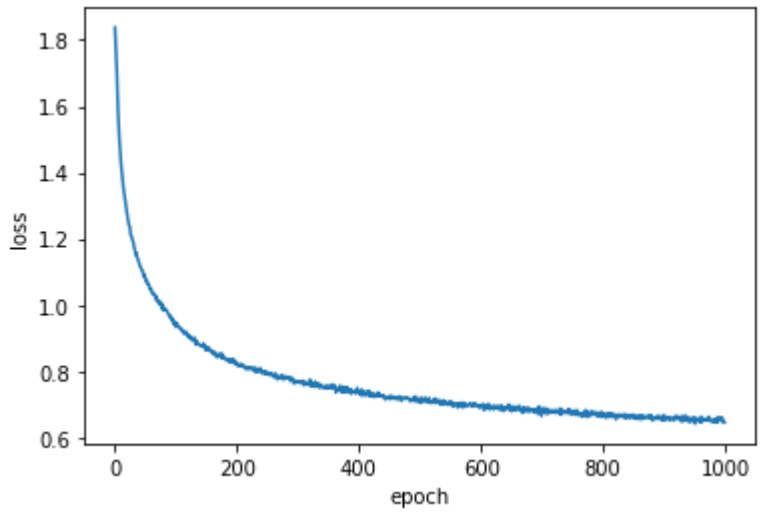
```
Model: "sequential_55"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_10 (Conv2D)           (None, 46, 46, 50)        500
_________________________________________________________________
max_pooling2d_10 (MaxPooling (None, 23, 23, 50)        0
_________________________________________________________________
dropout_210 (Dropout)        (None, 23, 23, 50)        0
_________________________________________________________________
conv2d_11 (Conv2D)           (None, 21, 21, 50)        22550
_________________________________________________________________
max_pooling2d_11 (MaxPooling (None, 10, 10, 50)        0
_________________________________________________________________
dropout_211 (Dropout)        (None, 10, 10, 50)        0
_________________________________________________________________
conv2d_12 (Conv2D)           (None, 6, 6, 50)          62550
_________________________________________________________________
max_pooling2d_12 (MaxPooling (None, 3, 3, 50)          0
_________________________________________________________________
dropout_212 (Dropout)        (None, 3, 3, 50)          0
_________________________________________________________________
conv2d_13 (Conv2D)           (None, 3, 3, 50)          22550
_________________________________________________________________
max_pooling2d_13 (MaxPooling (None, 1, 1, 50)          0
_________________________________________________________________
dropout_213 (Dropout)        (None, 1, 1, 50)          0
_________________________________________________________________
flatten_4 (Flatten)          (None, 50)                0
_________________________________________________________________
dense_310 (Dense)            (None, 50)                2550
_________________________________________________________________
dense_311 (Dense)            (None, 7)                 357
=================================================================
Total params: 111,057
Trainable params: 111,057
Non-trainable params: 0
_________________________________________________________________
```

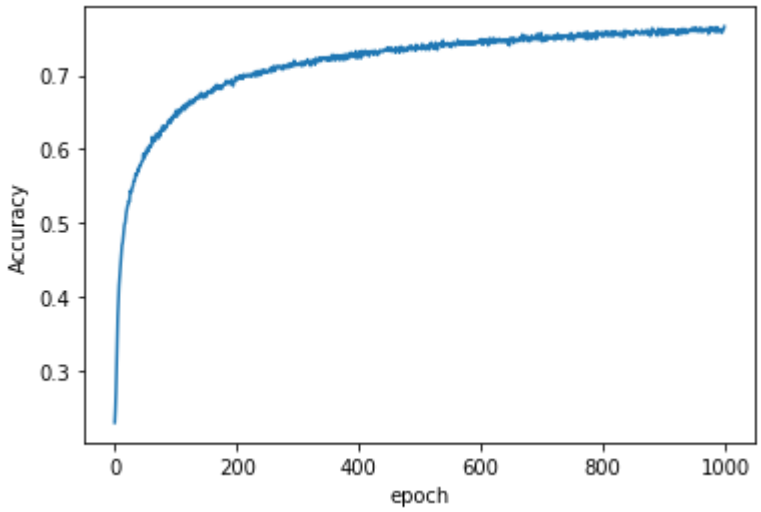
In [0]:
```
%%time
history = CNN_network3.fit(train_data_X_2D, train_data_y, epochs=1000, batch_s
ize=1000)
```

In [59]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[59]: [<matplotlib.lines.Line2D at 0x7fc29dc6d128>]





In [60]:
```
test_loss, test_acc = CNN_network3.evaluate(test_data_X_2D, test_data_y)
print('test_acc: ', test_acc)

test_loss, val_acc = CNN_network3.evaluate(val_data_X_2D, val_data_y)
print('val_acc: ', val_acc)
```

```
3589/3589 [==============================] - 1s 289us/step
test_acc:  0.6101978267092797
3589/3589 [==============================] - 0s 92us/step
val_acc:  0.5904151574337705
```

In [0]:
```
def generate_CNN_model4():

  m = models.Sequential()

  m.add(layers.Conv2D( 100, kernel_size=3 , strides=(1,1), activation='relu' , input_shape = (48,48,1) )) #padding = 'same'
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.1))

  m.add(layers.Conv2D( 100, kernel_size=3 , strides=(1,1), activation='relu') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.2))

  m.add(layers.Conv2D( 100, kernel_size=5 , strides=(1,1), activation='relu') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.3))

  m.add(layers.Conv2D( 100, kernel_size=3 , strides=(1,1), activation='relu', padding = 'same') )
  m.add(layers.MaxPooling2D(pool_size=(2,2)))
  m.add(layers.Dropout(0.4))

  m.add(layers.Flatten())
  m.add(layers.Dense( 1000 , activation='relu'))
  m.add(layers.Dense( 7 , activation='softmax'))

  m.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
  return m
```

In [0]:
```
print(train_data_X_2D.shape)
print(train_data_y.shape)
CNN_network4 = generate_CNN_model4()
CNN_network4.fit(train_data_X_2D, train_data_y, epochs=1000, batch_size=1000)
```

In [0]:
```
plt.plot(CNN_network4.history.history['loss'])
plt.figure()
plt.plot(CNN_network4.history.history['acc'])
```

In [0]:
```
test_loss, test_acc = CNN_network4.evaluate(test_data_X_2D, test_data_y)
print('test_acc: ', test_acc)

test_loss, val_acc = CNN_network4.evaluate(val_data_X_2D, val_data_y)
print('val_acc: ', val_acc)
```

```
3589/3589 [==============================] - 1s 178us/step
test_acc:  0.6082474227136275
3589/3589 [==============================] - 0s 90us/step
val_acc:  0.5998885483504603
```

Fine Tuning

In [61]:
```
from keras.applications.vgg16 import VGG16
vggModel = VGG16(include_top=False, weights='imagenet', input_shape=(48,48,3))
```

```
Downloading data from https://github.com/fchollet/deep-learning-models/releas
es/download/v0.1/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58892288/58889256 [==============================] - 2s 0us/step
```

In [65]:
```
for layer in vggModel.layers[:-2]:
  layer.trainable = False


model = models.Sequential()
model.add(vggModel)
model.add(layers.Flatten())
model.add(layers.Dense(100, activation='relu'))
model.add(layers.Dropout(0.5))
model.add(layers.Dense(7, activation='softmax'))

model.summary()
```

```
Model: "sequential_57"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Model)                (None, 1, 1, 512)         14714688
_________________________________________________________________
flatten_6 (Flatten)          (None, 512)               0
_________________________________________________________________
dense_314 (Dense)            (None, 100)               51300
_________________________________________________________________
dropout_215 (Dropout)        (None, 100)               0
_________________________________________________________________
dense_315 (Dense)            (None, 7)                 707
=================================================================
Total params: 14,766,695
Trainable params: 2,411,815
Non-trainable params: 12,354,880
_________________________________________________________________
```

In [71]:
```
train_data_X_2D_VGG = np.zeros(shape=(train_data_X.shape[0],48,48,3))
test_data_X_2D_VGG = np.zeros(shape=(test_data_X.shape[0],48,48,3))
val_data_X_2D_VGG = np.zeros(shape=(val_data_X.shape[0],48,48,3))

for i in range(train_data_X.shape[0]):
  img = train_data_X[i].reshape(48,48)
  train_data_X_2D_VGG[i,:,:,0] = img
  train_data_X_2D_VGG[i,:,:,1] = img
  train_data_X_2D_VGG[i,:,:,2] = img

for i in range(test_data_X.shape[0]):
  img = test_data_X[i].reshape(48,48)
  test_data_X_2D_VGG[i,:,:,0] = img
  test_data_X_2D_VGG[i,:,:,1] = img
  test_data_X_2D_VGG[i,:,:,2] = img

for i in range(val_data_X.shape[0]):
  img = val_data_X[i].reshape(48,48)
  val_data_X_2D_VGG[i,:,:,0] = img
  val_data_X_2D_VGG[i,:,:,1] = img
  val_data_X_2D_VGG[i,:,:,2] = img

model.summary()
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['acc
uracy'])
```

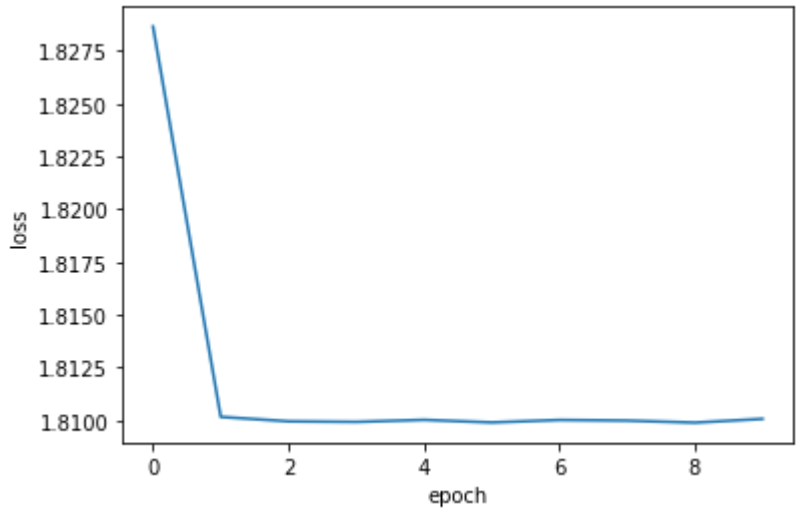
```
Model: "sequential_57"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Model)                (None, 1, 1, 512)         14714688
_________________________________________________________________
flatten_6 (Flatten)          (None, 512)               0
_________________________________________________________________
dense_314 (Dense)            (None, 100)               51300
_________________________________________________________________
dropout_215 (Dropout)        (None, 100)               0
_________________________________________________________________
dense_315 (Dense)            (None, 7)                 707
=================================================================
Total params: 14,766,695
Trainable params: 2,411,815
Non-trainable params: 12,354,880
_________________________________________________________________
```

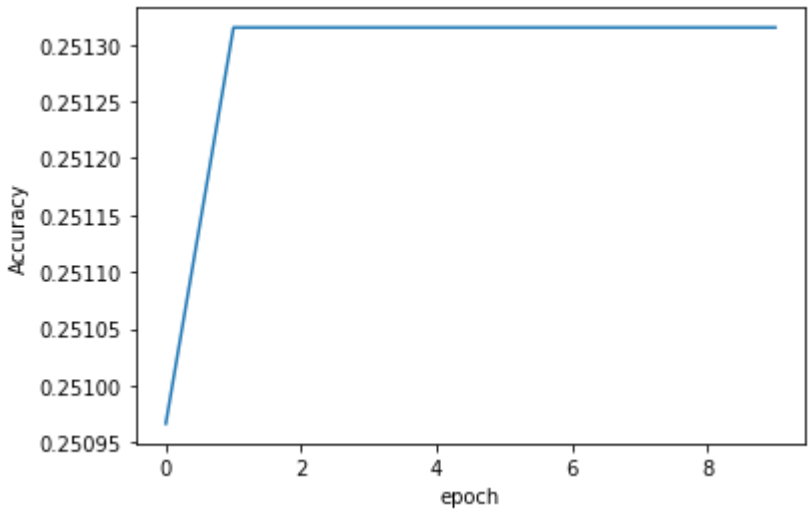
In [0]:
```
%%time
history = model.fit(train_data_X_2D_VGG, train_data_y, epochs=10, batch_size=5
)
```

In [69]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[69]: [<matplotlib.lines.Line2D at 0x7fc292e5d7f0>]





In [70]:
```
test_loss, test_acc = model.evaluate(test_data_X_2D_VGG, test_data_y)
print('test_acc: ', test_acc)

test_loss, val_acc = model.evaluate(val_data_X_2D_VGG, val_data_y)
print('val_acc: ', val_acc)
```

```
3589/3589 [==============================] - 2s 543us/step
test_acc:  0.2449150181191982
3589/3589 [==============================] - 1s 302us/step
val_acc:  0.24937308442878273
```

Fine Tuning - model 2

In [76]:
```
vggModel = VGG16(include_top=False, weights='imagenet', input_shape=(48,48,3))

for layer in vggModel.layers:
  layer.trainable = False


model = models.Sequential()
model.add(vggModel)
model.add(layers.Flatten())
model.add(layers.Dense(100, activation='relu'))
model.add(layers.Dropout(0.5))
model.add(layers.Dense(100, activation='relu'))
model.add(layers.Dropout(0.5))
model.add(layers.Dense(100, activation='relu'))
model.add(layers.Dropout(0.5))
model.add(layers.Dense(100, activation='relu'))
model.add(layers.Dropout(0.5))
model.add(layers.Dense(7, activation='softmax'))

model.summary()
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['acc
uracy'])
```

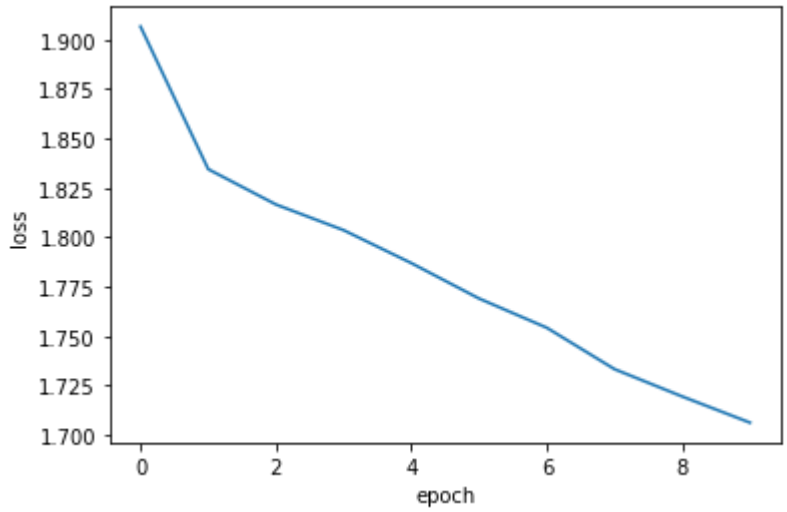
```
Model: "sequential_61"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Model)                (None, 1, 1, 512)         14714688
_________________________________________________________________
flatten_10 (Flatten)         (None, 512)               0
_________________________________________________________________
dense_331 (Dense)            (None, 100)               51300
_________________________________________________________________
dropout_228 (Dropout)        (None, 100)               0
_________________________________________________________________
dense_332 (Dense)            (None, 100)               10100
_________________________________________________________________
dropout_229 (Dropout)        (None, 100)               0
_________________________________________________________________
dense_333 (Dense)            (None, 100)               10100
_________________________________________________________________
dropout_230 (Dropout)        (None, 100)               0
_________________________________________________________________
dense_334 (Dense)            (None, 100)               10100
_________________________________________________________________
dropout_231 (Dropout)        (None, 100)               0
_________________________________________________________________
dense_335 (Dense)            (None, 7)                 707
=================================================================
Total params: 14,796,995
Trainable params: 82,307
Non-trainable params: 14,714,688
_________________________________________________________________
```

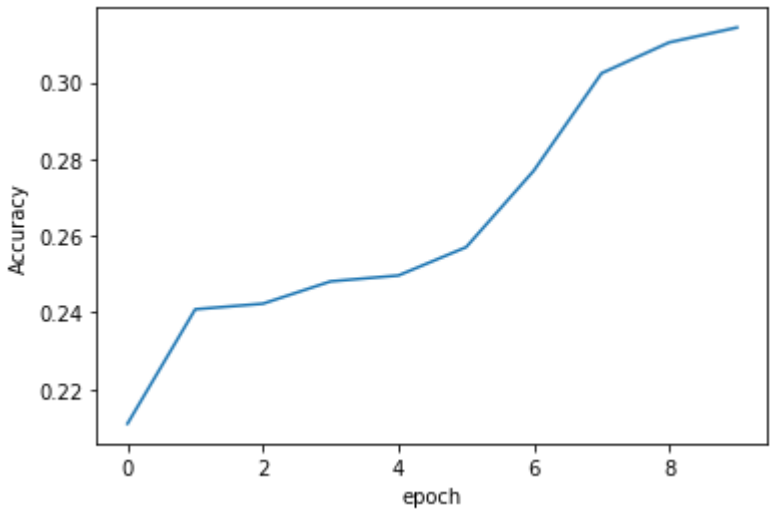
In [0]:
```
%%time
history = model.fit(train_data_X_2D_VGG, train_data_y, epochs=10, batch_size=1
000)
```

In [78]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[78]:
```
[<matplotlib.lines.Line2D at 0x7fc29263aba8>]
```





In [79]:
```
test_loss, test_acc = model.evaluate(test_data_X_2D_VGG, test_data_y)
print('test_acc: ', test_acc)

test_loss, val_acc = model.evaluate(val_data_X_2D_VGG, val_data_y)
print('val_acc: ', val_acc)
```

```
3589/3589 [==============================] - 2s 546us/step
test_acc:  0.36110337142095356
3589/3589 [==============================] - 1s 307us/step
val_acc:  0.37057676233349157
```

Fine Tuning - Model 3

In [80]:
```
vggModel = VGG16(include_top=False, weights='imagenet', input_shape=(48,48,3))

for layer in vggModel.layers:
  layer.trainable = False


model = models.Sequential()
model.add(vggModel)
model.add(layers.Flatten())
model.add(layers.Dense(500, activation='sigmoid'))
model.add(layers.Dropout(0.5))
model.add(layers.Dense(500, activation='sigmoid'))
model.add(layers.Dropout(0.5))
model.add(layers.Dense(500, activation='sigmoid'))
model.add(layers.Dropout(0.5))
model.add(layers.Dense(7, activation='softmax'))

model.summary()
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['acc
uracy'])
```

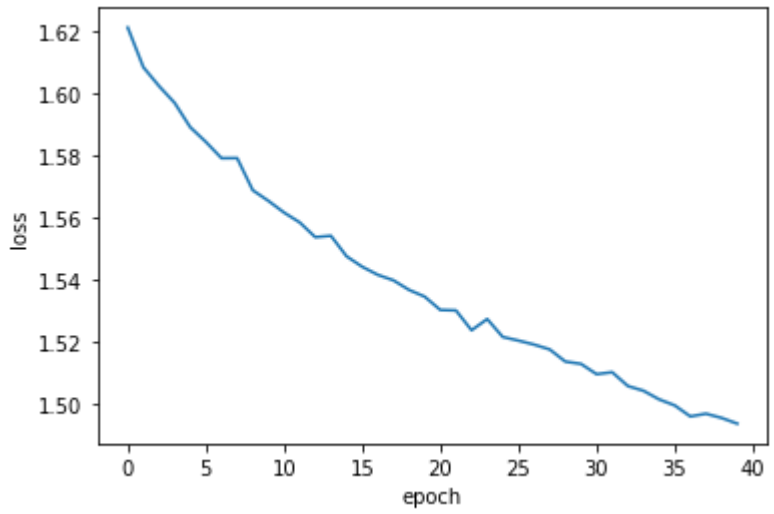
```
Model: "sequential_62"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Model)                (None, 1, 1, 512)         14714688
_________________________________________________________________
flatten_11 (Flatten)         (None, 512)               0
_________________________________________________________________
dense_336 (Dense)            (None, 500)               256500
_________________________________________________________________
dropout_232 (Dropout)        (None, 500)               0
_________________________________________________________________
dense_337 (Dense)            (None, 500)               250500
_________________________________________________________________
dropout_233 (Dropout)        (None, 500)               0
_________________________________________________________________
dense_338 (Dense)            (None, 500)               250500
_________________________________________________________________
dropout_234 (Dropout)        (None, 500)               0
_________________________________________________________________
dense_339 (Dense)            (None, 7)                 3507
=================================================================
Total params: 15,475,695
Trainable params: 761,007
Non-trainable params: 14,714,688
_________________________________________________________________
```

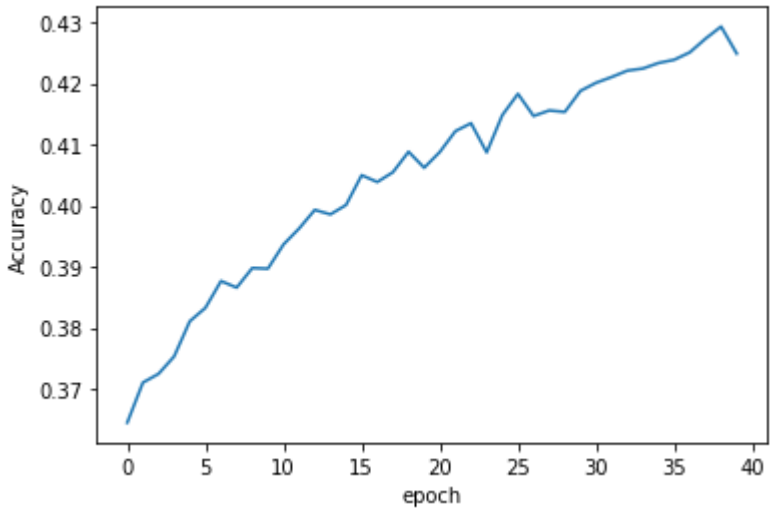
In [0]:
```
%%time
history = model.fit(train_data_X_2D_VGG, train_data_y, epochs=40, batch_size=1
000)
```

In [85]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[85]: [<matplotlib.lines.Line2D at 0x7fc292413fd0>]





In [86]:
```
test_loss, test_acc = model.evaluate(test_data_X_2D_VGG, test_data_y)
print('test_acc: ', test_acc)

test_loss, val_acc = model.evaluate(val_data_X_2D_VGG, val_data_y)
print('val_acc: ', val_acc)
```

```
3589/3589 [==============================] - 1s 304us/step
test_acc:  0.4221231540860689
3589/3589 [==============================] - 1s 306us/step
val_acc:  0.4290888827303453
```

Bayesian Optimization

In [0]:
```
from hyperopt import fmin, tpe, hp, STATUS_OK, Trials
from sklearn.metrics import roc_auc_score
import sys
```

In [0]:
```
space = {
            'NumFilters': hp.choice('NumFilters', [5,10,20,30]),
            'NumNeurons': hp.choice('NumNeurons', [50,100,500,1024]),
            'activation': hp.choice('activation', ['relu', 'sigmoid']),
            'DropOut_p': hp.uniform('DropOut_p', 0.2,0.75),
            'NumConvLayers': hp.choice('NumConvLayers', [2,3,4])
        }

def CNN_Optimization(params):

    print ('Params testing: ', params)
    model = models.Sequential()

    model.add(layers.Conv2D(filters = params['NumFilters'], kernel_size = 3, i
nput_shape = (48,48,1), activation = params['activation']))
    model.add(layers.Dropout(params['DropOut_p']))
    model.add(layers.MaxPooling2D(pool_size=(2,2)))
    model.add(layers.Conv2D(filters = params['NumFilters'], kernel_size = 3, a
ctivation = params['activation']))
    model.add(layers.Dropout(params['DropOut_p']))
    model.add(layers.MaxPooling2D(pool_size=(2,2)))

    if params['NumConvLayers'] >= 3:
      model.add(layers.Conv2D(filters = params['NumFilters'], kernel_size = 3,
activation = params['activation']))
      model.add(layers.Dropout(params['DropOut_p']))
      model.add(layers.MaxPooling2D(pool_size=(2,2)))

    if params['NumConvLayers'] >= 4:
      model.add(layers.Conv2D(filters = params['NumFilters'], kernel_size = 3,
activation = params['activation']))
      model.add(layers.Dropout(params['DropOut_p']))
      model.add(layers.MaxPooling2D(pool_size=(2,2)))

    model.add(layers.Flatten())
    model.add(layers.Dense(params['NumNeurons'], activation = params['activati
on']))
    model.add(layers.Dense(7, activation='softmax'))
    model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=[
'accuracy'])

    model.fit(train_data_X_2D, train_data_y, epochs=100, batch_size=1000, verb
ose = 0)

    val_loss, val_acc = model.evaluate(val_data_X_2D, val_data_y)
    test_loss, test_acc = model.evaluate(test_data_X_2D, test_data_y)
    print('Accuracy in validation set:', val_acc)
    print('Accuracy in test set:', test_acc)
    sys.stdout.flush()
    return {'loss': -val_acc, 'status': STATUS_OK}


trials = Trials()
best = fmin(CNN_Optimization, space, algo=tpe.suggest, max_evals=5, trials=tri
als)
print('best: ', best)
```

```
Params testing:
{'DropOut_p': 0.22697443952894894, 'NumConvLayers': 4, 'NumFilters': 30, 'Num
Neurons': 1024, 'activation': 'relu'}
  0%|          | 0/5 [00:00<?, ?it/s, best loss: ?]WARNING:tensorflow:From /u
sr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:426
7: The name tf.nn.max_pool is deprecated. Please use tf.nn.max_pool2d instea
d.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/optimize
rs.py:793: The name tf.train.Optimizer is deprecated. Please use tf.compat.v
1.train.Optimizer instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:3576: The name tf.log is deprecated. Please use tf.mat
h.log instead.

WARNING:tensorflow:From /tensorflow-1.15.0/python3.6/tensorflow_core/python/o
ps/math_grad.py:1424: where (from tensorflow.python.ops.array_ops) is depreca
ted and will be removed in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:1033: The name tf.assign_add is deprecated. Please use
tf.compat.v1.assign_add instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:1020: The name tf.assign is deprecated. Please use tf.c
ompat.v1.assign instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:3005: The name tf.Session is deprecated. Please use tf.
compat.v1.Session instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:190: The name tf.get_default_session is deprecated. Ple
ase use tf.compat.v1.get_default_session instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:197: The name tf.ConfigProto is deprecated. Please use
tf.compat.v1.ConfigProto instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:207: The name tf.global_variables is deprecated. Please
use tf.compat.v1.global_variables instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:216: The name tf.is_variable_initialized is deprecated.
Please use tf.compat.v1.is_variable_initialized instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/
tensorflow_backend.py:223: The name tf.variables_initializer is deprecated. P
lease use tf.compat.v1.variables_initializer instead.

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3589/3589 [==============================]
 - 0s 138us/step

Accuracy in validation set:
0.3978824185051271
Accuracy in test set:
0.3861799944606323
Params testing:
{'DropOut_p': 0.24515597976552447, 'NumConvLayers': 4, 'NumFilters': 10, 'Num
Neurons': 50, 'activation': 'sigmoid'}
  32/3589 [..............................]
 - ETA: 18s
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Accuracy in validation set:
0.24937308442878273
Accuracy in test set:
0.2449150181191982
Params testing:
{'DropOut_p': 0.36310857429365884, 'NumConvLayers': 4, 'NumFilters': 20, 'Num
Neurons': 100, 'activation': 'sigmoid'}
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Accuracy in validation set:
0.24937308442878273
Accuracy in test set:
0.2449150181191982
Params testing:
{'DropOut_p': 0.5647380480048461, 'NumConvLayers': 4, 'NumFilters': 30, 'NumN
eurons': 500, 'activation': 'sigmoid'}
 60%|██████    | 3/5 [01:06<00:51, 25.63s/it, best loss: -0.3978824185051271]
WARNING:tensorflow:Large dropout rate: 0.564738 (>0.5). In TensorFlow 2.x, dr
opout() uses dropout rate instead of keep_prob. Please ensure that this is in
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WARNING:tensorflow:Large dropout rate: 0.564738 (>0.5). In TensorFlow 2.x, dr
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WARNING:tensorflow:Large dropout rate: 0.564738 (>0.5). In TensorFlow 2.x, dr
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1856/3589 [==============>...............]
 - ETA: 0s
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2208/3589 [=================>............]
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2528/3589 [====================>.........]
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2912/3589 [========================>......]
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3296/3589 [===========================>...]
 - ETA: 0s
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3589/3589 [==============================]
 - 1s 144us/step

Accuracy in validation set:
0.24937308442878273
Accuracy in test set:
```

```
0.2449150181191982
Params testing:
{'DropOut_p': 0.24874105980713773, 'NumConvLayers': 3, 'NumFilters': 10, 'Num
Neurons': 50, 'activation': 'sigmoid'}
  32/3589 [..............................]
 - ETA: 24s
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 480/3589 [===>..........................]
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 992/3589 [=======>......................]
 - ETA: 0s
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1504/3589 [===========>..................]
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1984/3589 [===============>..............]
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2496/3589 [===================>..........]
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2944/3589 [=======================>......]
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3392/3589 [===========================>..]
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3589/3589 [==============================]
 - 1s 170us/step

  32/3589 [..............................]
 - ETA: 0s
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 544/3589 [===>..........................]
 - ETA: 0s
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 928/3589 [======>.......................]
 - ETA: 0s
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1344/3589 [==========>...................]
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1760/3589 [=============>................]
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2240/3589 [================>.............]
 - ETA: 0s
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2688/3589 [====================>.........]
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3104/3589 [========================>.....]
 - ETA: 0s
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3424/3589 [===========================>..]
 - ETA: 0s
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3589/3589 [==============================]
 - 0s 125us/step

Accuracy in validation set:
0.24937308442878273
Accuracy in test set:
0.2449150181191982
100%|██████████| 5/5 [01:41<00:00, 20.32s/it, best loss: -0.3978824185051271]
best:  {'DropOut_p': 0.22697443952894894, 'NumConvLayers': 2, 'NumFilters':
3, 'NumNeurons': 3, 'activation': 0}
```

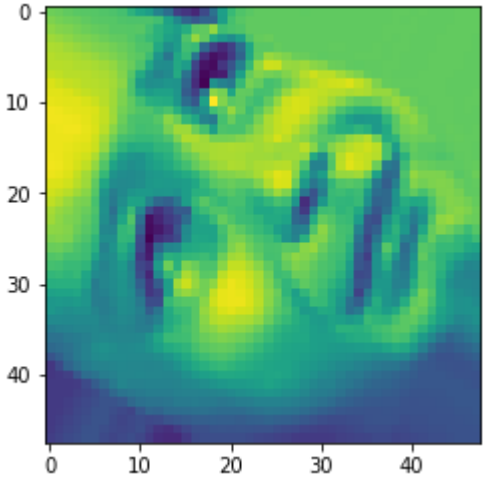
Data augmentation

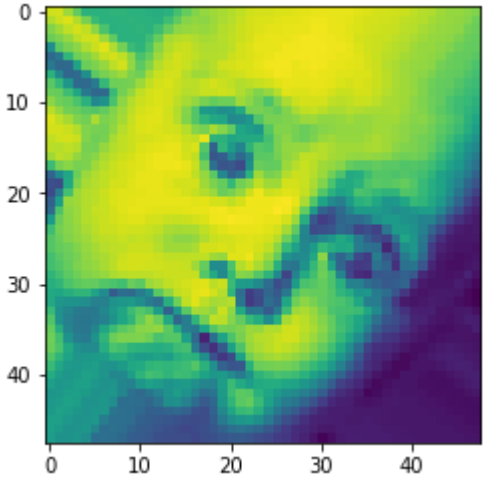
In [0]:
```
from keras.preprocessing.image import ImageDataGenerator
```

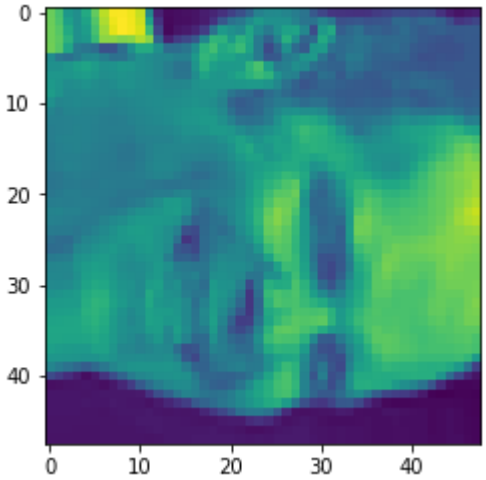
In [0]:
```
#dataGenObj = ImageDataGenerator(brightness_range=[0.2,1.0], rotation_range=9
0, horizontal_flip=True, height_shift_range=0.5, width_shift_range=[-200,200])
dataGenObj = ImageDataGenerator(brightness_range=[0.2,1.0], rotation_range=90,
horizontal_flip=True, vertical_flip=True)
New_Augmented_data_X_y = dataGenObj.flow( (train_data_X_2D, train_data_y) ,bat
ch_size=1)
```

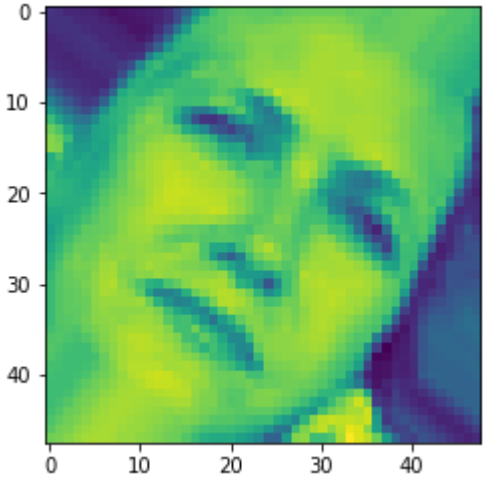
In [0]:
```
for i,img in enumerate(New_Augmented_data_X_y):
  plt.figure()
  plt.imshow(np.squeeze(img[0]))
  if i == 5:
    break
```

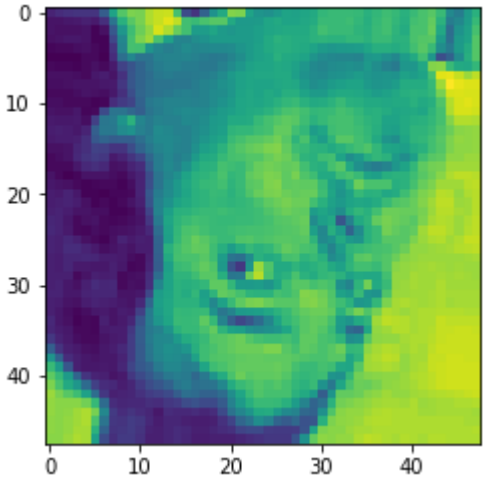
```
(1, 48, 48, 1)
(1, 48, 48, 1)
(1, 48, 48, 1)
(1, 48, 48, 1)
(1, 48, 48, 1)
(1, 48, 48, 1)
```

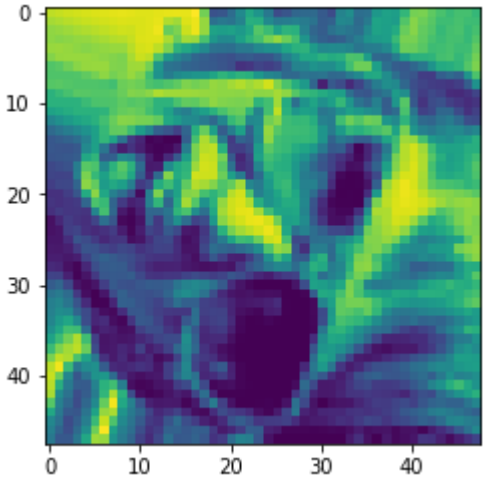












Features

In [0]:
```
from skimage.feature import hog
```

In [0]:
```
train_data_X_2D_HOG = np.zeros( (1000, 48*48) )
val_data_X_2D_HOG = np.zeros( (100, 48*48) )
test_data_X_2D_HOG = np.zeros( (100, 48*48) )

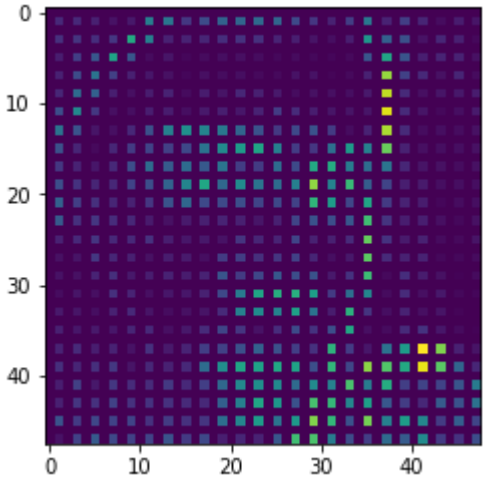
for i in range(1000):
  fd, hog_image = hog(np.squeeze(train_data_X_2D[i,:,:]), orientations=8, pixe
ls_per_cell=(2, 2), cells_per_block=(1, 1), visualize=True, multichannel=False
)
  train_data_X_2D_HOG[i,:] = hog_image.reshape(1,48*48)

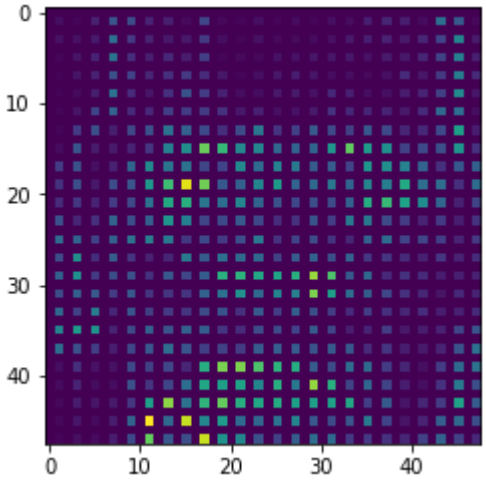
for i in range(100):
  fd, hog_image = hog(np.squeeze(val_data_X_2D[i,:,:]), orientations=8, pixels
_per_cell=(2, 2), cells_per_block=(1, 1), visualize=True, multichannel=False)
  val_data_X_2D_HOG[i,:] = hog_image.reshape(1,48*48)

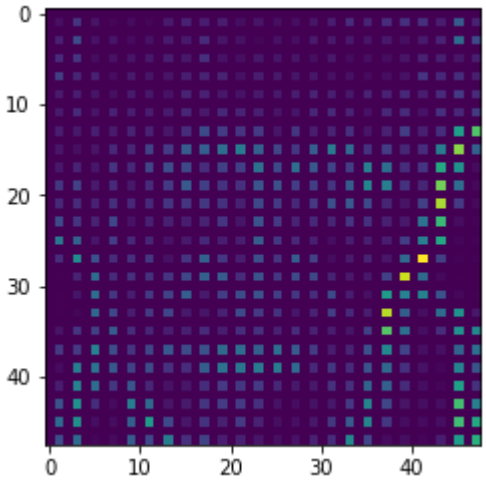
for i in range(100):
  fd, hog_image = hog(np.squeeze(test_data_X_2D[i,:,:]), orientations=8, pixel
s_per_cell=(2, 2), cells_per_block=(1, 1), visualize=True, multichannel=False)
  test_data_X_2D_HOG[i,:] = hog_image.reshape(1,48*48)
```

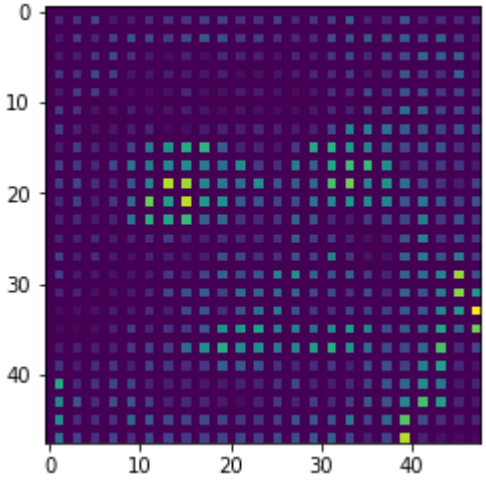
In [108]:
```
plt.figure()
plt.imshow(train_data_X_2D_HOG[0,:].reshape(48,48))
plt.figure()
plt.imshow(train_data_X_2D_HOG[10,:].reshape(48,48))
plt.figure()
plt.imshow(train_data_X_2D_HOG[50,:].reshape(48,48))
plt.figure()
plt.imshow(train_data_X_2D_HOG[100,:].reshape(48,48))
plt.figure()
plt.imshow(train_data_X_2D_HOG[110,:].reshape(48,48))
```

Out[108]: <matplotlib.image.AxesImage at 0x7fc20c3a5f28>








0
10
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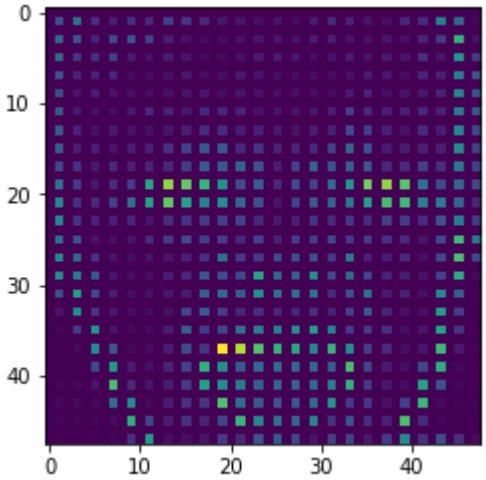
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In [102]:
```
FNN_network_featuresNetwork = generate_FNN_model_2()
history = FNN_network_featuresNetwork.fit(train_data_X_2D_HOG, train_data_y[0:
1000], epochs=1000, batch_size=60000)
```

```
Epoch 1/1000
1000/1000 [==============================] - 2s 2ms/step - loss: 10.1148 - ac
c: 0.1730
Epoch 2/1000
1000/1000 [==============================] - 0s 15us/step - loss: 8.1964 - ac
c: 0.1630
Epoch 3/1000
1000/1000 [==============================] - 0s 14us/step - loss: 7.1237 - ac
c: 0.1550
Epoch 4/1000
1000/1000 [==============================] - 0s 13us/step - loss: 6.4911 - ac
c: 0.1650
Epoch 5/1000
1000/1000 [==============================] - 0s 13us/step - loss: 6.2672 - ac
c: 0.1610
Epoch 6/1000
1000/1000 [==============================] - 0s 13us/step - loss: 5.4549 - ac
c: 0.1440
Epoch 7/1000
1000/1000 [==============================] - 0s 14us/step - loss: 5.1063 - ac
c: 0.1450
Epoch 8/1000
1000/1000 [==============================] - 0s 12us/step - loss: 4.1903 - ac
c: 0.1480
Epoch 9/1000
1000/1000 [==============================] - 0s 13us/step - loss: 3.6094 - ac
c: 0.1590
Epoch 10/1000
1000/1000 [==============================] - 0s 13us/step - loss: 3.4730 - ac
c: 0.1670
Epoch 11/1000
1000/1000 [==============================] - 0s 14us/step - loss: 3.2083 - ac
c: 0.1570
Epoch 12/1000
1000/1000 [==============================] - 0s 12us/step - loss: 2.9983 - ac
c: 0.1560
Epoch 13/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.9993 - ac
c: 0.1600
Epoch 14/1000
1000/1000 [==============================] - 0s 13us/step - loss: 3.1663 - ac
c: 0.1500
Epoch 15/1000
1000/1000 [==============================] - 0s 16us/step - loss: 3.0439 - ac
c: 0.1750
Epoch 16/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.9874 - ac
c: 0.1740
Epoch 17/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.8584 - ac
c: 0.1410
Epoch 18/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.7679 - ac
c: 0.1660
Epoch 19/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.7725 - ac
c: 0.1630
```

```
Epoch 20/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.5601 - ac
c: 0.1530
Epoch 21/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.6309 - ac
c: 0.1620
Epoch 22/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.5251 - ac
c: 0.1720
Epoch 23/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.4583 - ac
c: 0.1510
Epoch 24/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.3735 - ac
c: 0.1790
Epoch 25/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.4174 - ac
c: 0.1780
Epoch 26/1000
1000/1000 [==============================] - 0s 12us/step - loss: 2.4786 - ac
c: 0.1580
Epoch 27/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.3472 - ac
c: 0.1460
Epoch 28/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.4064 - ac
c: 0.1550
Epoch 29/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.2400 - ac
c: 0.1710
Epoch 30/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.2890 - ac
c: 0.1600
Epoch 31/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.2959 - ac
c: 0.1510
Epoch 32/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.1504 - ac
c: 0.1700
Epoch 33/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.3705 - ac
c: 0.1680
Epoch 34/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.2775 - ac
c: 0.1700
Epoch 35/1000
1000/1000 [==============================] - 0s 17us/step - loss: 2.2503 - ac
c: 0.1490
Epoch 36/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.1794 - ac
c: 0.1570
Epoch 37/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.3243 - ac
c: 0.1640
Epoch 38/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.1879 - ac
c: 0.1650
```

```
Epoch 39/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.1880 - ac
c: 0.1670
Epoch 40/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.1349 - ac
c: 0.1510
Epoch 41/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.1967 - ac
c: 0.1660
Epoch 42/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.2362 - ac
c: 0.1880
Epoch 43/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.2680 - ac
c: 0.1620
Epoch 44/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.1748 - ac
c: 0.1700
Epoch 45/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.2532 - ac
c: 0.1670
Epoch 46/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.1446 - ac
c: 0.1700
Epoch 47/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.1988 - ac
c: 0.1750
Epoch 48/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.2177 - ac
c: 0.1690
Epoch 49/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.1823 - ac
c: 0.1710
Epoch 50/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.2207 - ac
c: 0.1780
Epoch 51/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.2854 - ac
c: 0.1580
Epoch 52/1000
1000/1000 [==============================] - 0s 12us/step - loss: 2.0802 - ac
c: 0.1800
Epoch 53/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.1009 - ac
c: 0.1800
Epoch 54/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0508 - ac
c: 0.1880
Epoch 55/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.1319 - ac
c: 0.1740
Epoch 56/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.1229 - ac
c: 0.1710
Epoch 57/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.0723 - ac
c: 0.1890
```

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Epoch 58/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0870 - ac
c: 0.1670
Epoch 59/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.1018 - ac
c: 0.1930
Epoch 60/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.1179 - ac
c: 0.1830
Epoch 61/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0853 - ac
c: 0.1840
Epoch 62/1000
1000/1000 [==============================] - 0s 12us/step - loss: 2.0791 - ac
c: 0.1780
Epoch 63/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.1010 - ac
c: 0.1500
Epoch 64/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0200 - ac
c: 0.1620
Epoch 65/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.0336 - ac
c: 0.1820
Epoch 66/1000
1000/1000 [==============================] - 0s 12us/step - loss: 2.0760 - ac
c: 0.1710
Epoch 67/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0139 - ac
c: 0.1900
Epoch 68/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.0187 - ac
c: 0.1850
Epoch 69/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9977 - ac
c: 0.1720
Epoch 70/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0061 - ac
c: 0.1770
Epoch 71/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0192 - ac
c: 0.1980
Epoch 72/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0350 - ac
c: 0.1760
Epoch 73/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0414 - ac
c: 0.1860
Epoch 74/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0560 - ac
c: 0.1830
Epoch 75/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0461 - ac
c: 0.1880
Epoch 76/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0476 - ac
c: 0.1960
```

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Epoch 77/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0273 - ac
c: 0.1850
Epoch 78/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0290 - ac
c: 0.1840
Epoch 79/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9941 - ac
c: 0.1850
Epoch 80/1000
1000/1000 [==============================] - 0s 12us/step - loss: 2.0382 - ac
c: 0.1750
Epoch 81/1000
1000/1000 [==============================] - 0s 17us/step - loss: 2.0129 - ac
c: 0.1980
Epoch 82/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9599 - ac
c: 0.1850
Epoch 83/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9803 - ac
c: 0.2010
Epoch 84/1000
1000/1000 [==============================] - 0s 17us/step - loss: 2.0600 - ac
c: 0.1870
Epoch 85/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.0064 - ac
c: 0.1670
Epoch 86/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.9872 - ac
c: 0.1800
Epoch 87/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9975 - ac
c: 0.1890
Epoch 88/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9915 - ac
c: 0.1890
Epoch 89/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.9787 - ac
c: 0.1840
Epoch 90/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.0399 - ac
c: 0.1830
Epoch 91/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9729 - ac
c: 0.1930
Epoch 92/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9687 - ac
c: 0.1700
Epoch 93/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9606 - ac
c: 0.1950
Epoch 94/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.0224 - ac
c: 0.1810
Epoch 95/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9657 - ac
c: 0.1890
```

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Epoch 96/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9995 - ac
c: 0.1930
Epoch 97/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9781 - ac
c: 0.1790
Epoch 98/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.9577 - ac
c: 0.1980
Epoch 99/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.9727 - ac
c: 0.1950
Epoch 100/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0172 - ac
c: 0.1890
Epoch 101/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0135 - ac
c: 0.2030
Epoch 102/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9943 - ac
c: 0.1970
Epoch 103/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9660 - ac
c: 0.2030
Epoch 104/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9763 - ac
c: 0.1680
Epoch 105/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.9663 - ac
c: 0.1900
Epoch 106/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.9739 - ac
c: 0.2130
Epoch 107/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9657 - ac
c: 0.2040
Epoch 108/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9606 - ac
c: 0.2020
Epoch 109/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9441 - ac
c: 0.2120
Epoch 110/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.9491 - ac
c: 0.1900
Epoch 111/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9320 - ac
c: 0.2290
Epoch 112/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.9658 - ac
c: 0.2110
Epoch 113/1000
1000/1000 [==============================] - 0s 18us/step - loss: 1.9248 - ac
c: 0.2210
Epoch 114/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9463 - ac
c: 0.2130
```

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Epoch 115/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9359 - ac
c: 0.2300
Epoch 116/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9702 - ac
c: 0.2300
Epoch 117/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9362 - ac
c: 0.2280
Epoch 118/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9665 - ac
c: 0.2530
Epoch 119/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.9289 - ac
c: 0.2340
Epoch 120/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9126 - ac
c: 0.2410
Epoch 121/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9089 - ac
c: 0.2500
Epoch 122/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.9120 - ac
c: 0.2440
Epoch 123/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9358 - ac
c: 0.2520
Epoch 124/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9162 - ac
c: 0.2430
Epoch 125/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9146 - ac
c: 0.2440
Epoch 126/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9236 - ac
c: 0.2420
Epoch 127/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9082 - ac
c: 0.2510
Epoch 128/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.9041 - ac
c: 0.2620
Epoch 129/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9329 - ac
c: 0.2510
Epoch 130/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9024 - ac
c: 0.2580
Epoch 131/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.9094 - ac
c: 0.2470
Epoch 132/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.9042 - ac
c: 0.2570
Epoch 133/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8982 - ac
c: 0.2600
```

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Epoch 134/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9041 - ac
c: 0.2540
Epoch 135/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9113 - ac
c: 0.2640
Epoch 136/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8894 - ac
c: 0.2810
Epoch 137/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9088 - ac
c: 0.2680
Epoch 138/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8824 - ac
c: 0.2650
Epoch 139/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.9027 - ac
c: 0.2590
Epoch 140/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8813 - ac
c: 0.2790
Epoch 141/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8764 - ac
c: 0.2720
Epoch 142/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.8680 - ac
c: 0.2740
Epoch 143/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8551 - ac
c: 0.2840
Epoch 144/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8706 - ac
c: 0.2830
Epoch 145/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9148 - ac
c: 0.2470
Epoch 146/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8899 - ac
c: 0.2780
Epoch 147/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8750 - ac
c: 0.2900
Epoch 148/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8634 - ac
c: 0.3080
Epoch 149/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.8484 - ac
c: 0.3220
Epoch 150/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8660 - ac
c: 0.2830
Epoch 151/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8351 - ac
c: 0.2990
Epoch 152/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8559 - ac
c: 0.2910
```

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Epoch 153/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.8481 - ac
c: 0.3220
Epoch 154/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8386 - ac
c: 0.3270
Epoch 155/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8684 - ac
c: 0.3110
Epoch 156/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9046 - ac
c: 0.2540
Epoch 157/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8698 - ac
c: 0.3220
Epoch 158/1000
1000/1000 [==============================] - 0s 18us/step - loss: 1.8208 - ac
c: 0.3140
Epoch 159/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8414 - ac
c: 0.3080
Epoch 160/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.8583 - ac
c: 0.3130
Epoch 161/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8149 - ac
c: 0.3120
Epoch 162/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8384 - ac
c: 0.3370
Epoch 163/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8330 - ac
c: 0.3080
Epoch 164/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7825 - ac
c: 0.3400
Epoch 165/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8018 - ac
c: 0.3470
Epoch 166/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.0750 - ac
c: 0.2740
Epoch 167/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8596 - ac
c: 0.2980
Epoch 168/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8321 - ac
c: 0.3020
Epoch 169/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8116 - ac
c: 0.3080
Epoch 170/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8045 - ac
c: 0.3140
Epoch 171/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.8069 - ac
c: 0.3340
```

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Epoch 172/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8154 - ac
c: 0.3530
Epoch 173/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7559 - ac
c: 0.3310
Epoch 174/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.8717 - ac
c: 0.3660
Epoch 175/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.9242 - ac
c: 0.2770
Epoch 176/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8965 - ac
c: 0.2940
Epoch 177/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.7791 - ac
c: 0.3290
Epoch 178/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.7592 - ac
c: 0.3480
Epoch 179/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.7454 - ac
c: 0.3750
Epoch 180/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7355 - ac
c: 0.3840
Epoch 181/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7628 - ac
c: 0.3380
Epoch 182/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7514 - ac
c: 0.3550
Epoch 183/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7604 - ac
c: 0.3680
Epoch 184/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.7139 - ac
c: 0.3670
Epoch 185/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7336 - ac
c: 0.3770
Epoch 186/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.7440 - ac
c: 0.3710
Epoch 187/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8968 - ac
c: 0.3550
Epoch 188/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.7725 - ac
c: 0.3350
Epoch 189/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7810 - ac
c: 0.3410
Epoch 190/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7537 - ac
c: 0.3550
```

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Epoch 191/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8434 - ac
c: 0.3320
Epoch 192/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.7656 - ac
c: 0.3380
Epoch 193/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7928 - ac
c: 0.3280
Epoch 194/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.7879 - ac
c: 0.3160
Epoch 195/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7324 - ac
c: 0.3790
Epoch 196/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.7781 - ac
c: 0.3410
Epoch 197/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.7266 - ac
c: 0.3660
Epoch 198/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7529 - ac
c: 0.3640
Epoch 199/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6999 - ac
c: 0.4010
Epoch 200/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.7016 - ac
c: 0.4220
Epoch 201/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7320 - ac
c: 0.3810
Epoch 202/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.4487 - ac
c: 0.2750
Epoch 203/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9968 - ac
c: 0.3090
Epoch 204/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8732 - ac
c: 0.3670
Epoch 205/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7906 - ac
c: 0.3380
Epoch 206/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7470 - ac
c: 0.3610
Epoch 207/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6678 - ac
c: 0.3900
Epoch 208/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.6859 - ac
c: 0.4000
Epoch 209/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.7002 - ac
c: 0.4000
```

```
Epoch 210/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0361 - ac
c: 0.3130
Epoch 211/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.7501 - ac
c: 0.3580
Epoch 212/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.7237 - ac
c: 0.3750
Epoch 213/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9451 - ac
c: 0.3060
Epoch 214/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9876 - ac
c: 0.3270
Epoch 215/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7578 - ac
c: 0.3550
Epoch 216/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.7181 - ac
c: 0.3470
Epoch 217/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.7149 - ac
c: 0.3990
Epoch 218/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.7296 - ac
c: 0.3770
Epoch 219/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6945 - ac
c: 0.3670
Epoch 220/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6727 - ac
c: 0.4120
Epoch 221/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6613 - ac
c: 0.3980
Epoch 222/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.7109 - ac
c: 0.4100
Epoch 223/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.7720 - ac
c: 0.3500
Epoch 224/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7302 - ac
c: 0.3780
Epoch 225/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7335 - ac
c: 0.3660
Epoch 226/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6771 - ac
c: 0.3930
Epoch 227/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.7533 - ac
c: 0.3990
Epoch 228/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6508 - ac
c: 0.3990
```

```
Epoch 229/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6727 - ac
c: 0.4110
Epoch 230/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.6742 - ac
c: 0.3940
Epoch 231/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6850 - ac
c: 0.4060
Epoch 232/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7605 - ac
c: 0.3780
Epoch 233/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7145 - ac
c: 0.3620
Epoch 234/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7063 - ac
c: 0.3730
Epoch 235/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7414 - ac
c: 0.3960
Epoch 236/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8187 - ac
c: 0.3460
Epoch 237/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7044 - ac
c: 0.3910
Epoch 238/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6657 - ac
c: 0.4080
Epoch 239/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6439 - ac
c: 0.4450
Epoch 240/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6581 - ac
c: 0.4350
Epoch 241/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6371 - ac
c: 0.4320
Epoch 242/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.6673 - ac
c: 0.4360
Epoch 243/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6989 - ac
c: 0.4150
Epoch 244/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.8227 - ac
c: 0.3790
Epoch 245/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.7163 - ac
c: 0.3850
Epoch 246/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6887 - ac
c: 0.4150
Epoch 247/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6240 - ac
c: 0.4030
```

```
Epoch 248/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6981 - ac
c: 0.4040
Epoch 249/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.6237 - ac
c: 0.4170
Epoch 250/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.5687 - ac
c: 0.4610
Epoch 251/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6396 - ac
c: 0.4540
Epoch 252/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6528 - ac
c: 0.4120
Epoch 253/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.6335 - ac
c: 0.4170
Epoch 254/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6149 - ac
c: 0.4460
Epoch 255/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5761 - ac
c: 0.4430
Epoch 256/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5847 - ac
c: 0.4490
Epoch 257/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7920 - ac
c: 0.4220
Epoch 258/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8169 - ac
c: 0.3680
Epoch 259/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8582 - ac
c: 0.3770
Epoch 260/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7990 - ac
c: 0.3560
Epoch 261/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6815 - ac
c: 0.4090
Epoch 262/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5923 - ac
c: 0.4360
Epoch 263/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5914 - ac
c: 0.4680
Epoch 264/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6076 - ac
c: 0.4460
Epoch 265/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5597 - ac
c: 0.4560
Epoch 266/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.6192 - ac
c: 0.4580
```

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Epoch 267/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5593 - ac
c: 0.4670
Epoch 268/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.5904 - ac
c: 0.4710
Epoch 269/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6065 - ac
c: 0.4600
Epoch 270/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5851 - ac
c: 0.4010
Epoch 271/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.5451 - ac
c: 0.4430
Epoch 272/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.5822 - ac
c: 0.4550
Epoch 273/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5871 - ac
c: 0.4260
Epoch 274/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7503 - ac
c: 0.4050
Epoch 275/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.4782 - ac
c: 0.3280
Epoch 276/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.7584 - ac
c: 0.2400
Epoch 277/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8985 - ac
c: 0.3370
Epoch 278/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7715 - ac
c: 0.3620
Epoch 279/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.8218 - ac
c: 0.3920
Epoch 280/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7818 - ac
c: 0.3900
Epoch 281/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7271 - ac
c: 0.3850
Epoch 282/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6056 - ac
c: 0.4480
Epoch 283/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.5705 - ac
c: 0.4400
Epoch 284/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5696 - ac
c: 0.4500
Epoch 285/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5432 - ac
c: 0.4550
```

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Epoch 286/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5179 - ac
c: 0.4930
Epoch 287/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5418 - ac
c: 0.4790
Epoch 288/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5733 - ac
c: 0.4610
Epoch 289/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5322 - ac
c: 0.4840
Epoch 290/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0630 - ac
c: 0.3630
Epoch 291/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5783 - ac
c: 0.4490
Epoch 292/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5497 - ac
c: 0.4480
Epoch 293/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5762 - ac
c: 0.4710
Epoch 294/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4882 - ac
c: 0.5010
Epoch 295/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8060 - ac
c: 0.4430
Epoch 296/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.4938 - ac
c: 0.4670
Epoch 297/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.6278 - ac
c: 0.4410
Epoch 298/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5985 - ac
c: 0.4590
Epoch 299/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.5198 - ac
c: 0.4940
Epoch 300/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4569 - ac
c: 0.5030
Epoch 301/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5154 - ac
c: 0.5040
Epoch 302/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5044 - ac
c: 0.4680
Epoch 303/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5728 - ac
c: 0.4610
Epoch 304/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.5641 - ac
c: 0.4330
```

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Epoch 305/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5679 - ac
c: 0.4580
Epoch 306/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.4626 - ac
c: 0.5070
Epoch 307/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4844 - ac
c: 0.4980
Epoch 308/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.4199 - ac
c: 0.4960
Epoch 309/1000
1000/1000 [==============================] - 0s 18us/step - loss: 1.4547 - ac
c: 0.5080
Epoch 310/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.5064 - ac
c: 0.4750
Epoch 311/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4914 - ac
c: 0.4870
Epoch 312/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6033 - ac
c: 0.4950
Epoch 313/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5605 - ac
c: 0.4800
Epoch 314/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5441 - ac
c: 0.4970
Epoch 315/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.5328 - ac
c: 0.4680
Epoch 316/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5308 - ac
c: 0.4970
Epoch 317/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5411 - ac
c: 0.4990
Epoch 318/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4766 - ac
c: 0.4860
Epoch 319/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6935 - ac
c: 0.4560
Epoch 320/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5358 - ac
c: 0.4450
Epoch 321/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5418 - ac
c: 0.4610
Epoch 322/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6673 - ac
c: 0.4550
Epoch 323/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.5315 - ac
c: 0.4850
```

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Epoch 324/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6176 - ac
c: 0.4650
Epoch 325/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.2141 - ac
c: 0.3920
Epoch 326/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.3747 - ac
c: 0.4120
Epoch 327/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8330 - ac
c: 0.4190
Epoch 328/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5007 - ac
c: 0.4850
Epoch 329/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4820 - ac
c: 0.4750
Epoch 330/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4168 - ac
c: 0.5000
Epoch 331/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3881 - ac
c: 0.5440
Epoch 332/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4296 - ac
c: 0.5320
Epoch 333/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.3613 - ac
c: 0.5350
Epoch 334/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4096 - ac
c: 0.5190
Epoch 335/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3951 - ac
c: 0.5460
Epoch 336/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9034 - ac
c: 0.4550
Epoch 337/1000
1000/1000 [==============================] - 0s 14us/step - loss: 3.6464 - ac
c: 0.3210
Epoch 338/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.4262 - ac
c: 0.4040
Epoch 339/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.4382 - ac
c: 0.3790
Epoch 340/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.8801 - ac
c: 0.4480
Epoch 341/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.5117 - ac
c: 0.4730
Epoch 342/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.4707 - ac
c: 0.4910
```

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Epoch 343/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4873 - ac
c: 0.5020
Epoch 344/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4597 - ac
c: 0.5060
Epoch 345/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3723 - ac
c: 0.5350
Epoch 346/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4275 - ac
c: 0.5100
Epoch 347/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4352 - ac
c: 0.5440
Epoch 348/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.3753 - ac
c: 0.5460
Epoch 349/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4829 - ac
c: 0.5130
Epoch 350/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4288 - ac
c: 0.5200
Epoch 351/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5654 - ac
c: 0.4750
Epoch 352/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5160 - ac
c: 0.5210
Epoch 353/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.4422 - ac
c: 0.5280
Epoch 354/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.4404 - ac
c: 0.5250
Epoch 355/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3989 - ac
c: 0.5470
Epoch 356/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4838 - ac
c: 0.4930
Epoch 357/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4412 - ac
c: 0.5360
Epoch 358/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4200 - ac
c: 0.5330
Epoch 359/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.5883 - ac
c: 0.4700
Epoch 360/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5412 - ac
c: 0.5030
Epoch 361/1000
1000/1000 [==============================] - 0s 18us/step - loss: 2.7143 - ac
c: 0.4010
```

```
Epoch 362/1000
1000/1000 [==============================] - 0s 17us/step - loss: 2.0156 - ac
c: 0.4110
Epoch 363/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.7149 - ac
c: 0.4490
Epoch 364/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4970 - ac
c: 0.4960
Epoch 365/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.4394 - ac
c: 0.5290
Epoch 366/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4154 - ac
c: 0.5690
Epoch 367/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4024 - ac
c: 0.5250
Epoch 368/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3828 - ac
c: 0.5400
Epoch 369/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3733 - ac
c: 0.5480
Epoch 370/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4709 - ac
c: 0.5490
Epoch 371/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4097 - ac
c: 0.5610
Epoch 372/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.3442 - ac
c: 0.5590
Epoch 373/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3974 - ac
c: 0.5590
Epoch 374/1000
1000/1000 [==============================] - 0s 16us/step - loss: 4.9181 - ac
c: 0.3050
Epoch 375/1000
1000/1000 [==============================] - 0s 14us/step - loss: 3.6087 - ac
c: 0.3560
Epoch 376/1000
1000/1000 [==============================] - 0s 15us/step - loss: 3.2816 - ac
c: 0.3530
Epoch 377/1000
1000/1000 [==============================] - 0s 15us/step - loss: 4.3127 - ac
c: 0.3000
Epoch 378/1000
1000/1000 [==============================] - 0s 15us/step - loss: 3.2866 - ac
c: 0.3360
Epoch 379/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.7691 - ac
c: 0.3720
Epoch 380/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.3268 - ac
c: 0.3690
```

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Epoch 381/1000
1000/1000 [==============================] - 0s 17us/step - loss: 2.1892 - ac
c: 0.4170
Epoch 382/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.0470 - ac
c: 0.4150
Epoch 383/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.7859 - ac
c: 0.4410
Epoch 384/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8142 - ac
c: 0.4450
Epoch 385/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6865 - ac
c: 0.4600
Epoch 386/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6379 - ac
c: 0.4550
Epoch 387/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.6116 - ac
c: 0.4790
Epoch 388/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6073 - ac
c: 0.4870
Epoch 389/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.5066 - ac
c: 0.4620
Epoch 390/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5544 - ac
c: 0.4570
Epoch 391/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5207 - ac
c: 0.5020
Epoch 392/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5462 - ac
c: 0.4750
Epoch 393/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4526 - ac
c: 0.5040
Epoch 394/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.4714 - ac
c: 0.4980
Epoch 395/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4200 - ac
c: 0.5270
Epoch 396/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.4489 - ac
c: 0.5100
Epoch 397/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4312 - ac
c: 0.5120
Epoch 398/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4861 - ac
c: 0.5140
Epoch 399/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5205 - ac
c: 0.4670
```

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Epoch 400/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.3904 - ac
c: 0.5310
Epoch 401/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.4531 - ac
c: 0.5090
Epoch 402/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5240 - ac
c: 0.4840
Epoch 403/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6241 - ac
c: 0.4820
Epoch 404/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5475 - ac
c: 0.4570
Epoch 405/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4735 - ac
c: 0.5070
Epoch 406/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4520 - ac
c: 0.5060
Epoch 407/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.5429 - ac
c: 0.4890
Epoch 408/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4054 - ac
c: 0.5100
Epoch 409/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4565 - ac
c: 0.5150
Epoch 410/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7077 - ac
c: 0.4410
Epoch 411/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5408 - ac
c: 0.4470
Epoch 412/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4360 - ac
c: 0.5060
Epoch 413/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4514 - ac
c: 0.5150
Epoch 414/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.4040 - ac
c: 0.5520
Epoch 415/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.3821 - ac
c: 0.5520
Epoch 416/1000
1000/1000 [==============================] - 0s 19us/step - loss: 1.3425 - ac
c: 0.5500
Epoch 417/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4340 - ac
c: 0.5050
Epoch 418/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.4037 - ac
c: 0.5310
```

```
Epoch 419/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3945 - ac
c: 0.5300
Epoch 420/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.3763 - ac
c: 0.5380
Epoch 421/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4031 - ac
c: 0.5430
Epoch 422/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3968 - ac
c: 0.5560
Epoch 423/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.4305 - ac
c: 0.5390
Epoch 424/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.4223 - ac
c: 0.5180
Epoch 425/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4238 - ac
c: 0.5170
Epoch 426/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.4003 - ac
c: 0.5330
Epoch 427/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3983 - ac
c: 0.5350
Epoch 428/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4163 - ac
c: 0.4990
Epoch 429/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4841 - ac
c: 0.5190
Epoch 430/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4052 - ac
c: 0.5000
Epoch 431/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3569 - ac
c: 0.5550
Epoch 432/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.3777 - ac
c: 0.5410
Epoch 433/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3625 - ac
c: 0.5550
Epoch 434/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3706 - ac
c: 0.5550
Epoch 435/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.3907 - ac
c: 0.5320
Epoch 436/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4557 - ac
c: 0.5530
Epoch 437/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3442 - ac
c: 0.5330
```

```
Epoch 438/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2961 - ac
c: 0.5640
Epoch 439/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2828 - ac
c: 0.5820
Epoch 440/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4448 - ac
c: 0.5550
Epoch 441/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3994 - ac
c: 0.5020
Epoch 442/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3583 - ac
c: 0.5610
Epoch 443/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3087 - ac
c: 0.5770
Epoch 444/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3513 - ac
c: 0.5880
Epoch 445/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3259 - ac
c: 0.5440
Epoch 446/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4085 - ac
c: 0.5450
Epoch 447/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9971 - ac
c: 0.4010
Epoch 448/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.0241 - ac
c: 0.4060
Epoch 449/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5169 - ac
c: 0.4940
Epoch 450/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5172 - ac
c: 0.5060
Epoch 451/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.4563 - ac
c: 0.5230
Epoch 452/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2772 - ac
c: 0.5780
Epoch 453/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2747 - ac
c: 0.5750
Epoch 454/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3625 - ac
c: 0.5830
Epoch 455/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3240 - ac
c: 0.5780
Epoch 456/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3308 - ac
c: 0.5520
```

```
Epoch 457/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2508 - ac
c: 0.5840
Epoch 458/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2219 - ac
c: 0.6110
Epoch 459/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.4660 - ac
c: 0.5340
Epoch 460/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.3086 - ac
c: 0.5590
Epoch 461/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2537 - ac
c: 0.5870
Epoch 462/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2780 - ac
c: 0.5750
Epoch 463/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3143 - ac
c: 0.5930
Epoch 464/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.4592 - ac
c: 0.4380
Epoch 465/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.5302 - ac
c: 0.4150
Epoch 466/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.6605 - ac
c: 0.4210
Epoch 467/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8863 - ac
c: 0.4870
Epoch 468/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.8330 - ac
c: 0.4790
Epoch 469/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4743 - ac
c: 0.5300
Epoch 470/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3112 - ac
c: 0.5830
Epoch 471/1000
1000/1000 [==============================] - 0s 18us/step - loss: 1.2919 - ac
c: 0.5830
Epoch 472/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.3031 - ac
c: 0.5850
Epoch 473/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2967 - ac
c: 0.5920
Epoch 474/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5116 - ac
c: 0.5250
Epoch 475/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4091 - ac
c: 0.5430
```

```
Epoch 476/1000
1000/1000 [==============================] - 0s 11us/step - loss: 1.3056 - ac
c: 0.5590
Epoch 477/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9772 - ac
c: 0.4920
Epoch 478/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5141 - ac
c: 0.5380
Epoch 479/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2913 - ac
c: 0.5810
Epoch 480/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2135 - ac
c: 0.6060
Epoch 481/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3618 - ac
c: 0.5890
Epoch 482/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2541 - ac
c: 0.5710
Epoch 483/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2281 - ac
c: 0.6040
Epoch 484/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3014 - ac
c: 0.5840
Epoch 485/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2707 - ac
c: 0.6140
Epoch 486/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2897 - ac
c: 0.5870
Epoch 487/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2597 - ac
c: 0.6010
Epoch 488/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2024 - ac
c: 0.6210
Epoch 489/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2353 - ac
c: 0.6230
Epoch 490/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2182 - ac
c: 0.6040
Epoch 491/1000
1000/1000 [==============================] - 0s 18us/step - loss: 1.3405 - ac
c: 0.5510
Epoch 492/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3983 - ac
c: 0.5310
Epoch 493/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.3487 - ac
c: 0.5800
Epoch 494/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2783 - ac
c: 0.5540
```

```
Epoch 495/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.2394 - ac
c: 0.6020
Epoch 496/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1886 - ac
c: 0.6210
Epoch 497/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1928 - ac
c: 0.6330
Epoch 498/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1849 - ac
c: 0.6250
Epoch 499/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2101 - ac
c: 0.6120
Epoch 500/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2290 - ac
c: 0.6250
Epoch 501/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.2068 - ac
c: 0.6240
Epoch 502/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4103 - ac
c: 0.5700
Epoch 503/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.0260 - ac
c: 0.5010
Epoch 504/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.8950 - ac
c: 0.4590
Epoch 505/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.9892 - ac
c: 0.3510
Epoch 506/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.1435 - ac
c: 0.4500
Epoch 507/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3663 - ac
c: 0.5410
Epoch 508/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.2626 - ac
c: 0.5820
Epoch 509/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1749 - ac
c: 0.6200
Epoch 510/1000
1000/1000 [==============================] - 0s 18us/step - loss: 1.2206 - ac
c: 0.6250
Epoch 511/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.1378 - ac
c: 0.6470
Epoch 512/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1550 - ac
c: 0.6460
Epoch 513/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1575 - ac
c: 0.6400
```

```
Epoch 514/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1522 - ac
c: 0.6380
Epoch 515/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1775 - ac
c: 0.6150
Epoch 516/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2094 - ac
c: 0.6190
Epoch 517/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2201 - ac
c: 0.6230
Epoch 518/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2146 - ac
c: 0.6170
Epoch 519/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2474 - ac
c: 0.6040
Epoch 520/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8611 - ac
c: 0.5190
Epoch 521/1000
1000/1000 [==============================] - 0s 14us/step - loss: 3.4136 - ac
c: 0.3880
Epoch 522/1000
1000/1000 [==============================] - 0s 12us/step - loss: 2.3594 - ac
c: 0.4670
Epoch 523/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.2088 - ac
c: 0.4380
Epoch 524/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.3258 - ac
c: 0.5560
Epoch 525/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1798 - ac
c: 0.6370
Epoch 526/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1558 - ac
c: 0.6080
Epoch 527/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1790 - ac
c: 0.6340
Epoch 528/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.1662 - ac
c: 0.6310
Epoch 529/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1198 - ac
c: 0.6550
Epoch 530/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1246 - ac
c: 0.6620
Epoch 531/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1489 - ac
c: 0.6130
Epoch 532/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1859 - ac
c: 0.6500
```

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Epoch 533/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1146 - ac
c: 0.6510
Epoch 534/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0899 - ac
c: 0.6610
Epoch 535/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1570 - ac
c: 0.6340
Epoch 536/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.4969 - ac
c: 0.5840
Epoch 537/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.2577 - ac
c: 0.4930
Epoch 538/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6644 - ac
c: 0.4820
Epoch 539/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4289 - ac
c: 0.5410
Epoch 540/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7366 - ac
c: 0.5080
Epoch 541/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2701 - ac
c: 0.5910
Epoch 542/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.2085 - ac
c: 0.6040
Epoch 543/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1849 - ac
c: 0.6180
Epoch 544/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1585 - ac
c: 0.6340
Epoch 545/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0770 - ac
c: 0.6790
Epoch 546/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1337 - ac
c: 0.6480
Epoch 547/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1735 - ac
c: 0.6320
Epoch 548/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1548 - ac
c: 0.6530
Epoch 549/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0997 - ac
c: 0.6670
Epoch 550/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0858 - ac
c: 0.6750
Epoch 551/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1647 - ac
c: 0.6510
```

```
Epoch 552/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4874 - ac
c: 0.5410
Epoch 553/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3181 - ac
c: 0.6150
Epoch 554/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.9909 - ac
c: 0.4000
Epoch 555/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.5395 - ac
c: 0.4420
Epoch 556/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6087 - ac
c: 0.5240
Epoch 557/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.2186 - ac
c: 0.5870
Epoch 558/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1696 - ac
c: 0.6570
Epoch 559/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2120 - ac
c: 0.6330
Epoch 560/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1278 - ac
c: 0.6370
Epoch 561/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1190 - ac
c: 0.6690
Epoch 562/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.3103 - ac
c: 0.5440
Epoch 563/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2836 - ac
c: 0.6050
Epoch 564/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2168 - ac
c: 0.5940
Epoch 565/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.1221 - ac
c: 0.6490
Epoch 566/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2007 - ac
c: 0.6210
Epoch 567/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2109 - ac
c: 0.6400
Epoch 568/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1438 - ac
c: 0.6410
Epoch 569/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0862 - ac
c: 0.6800
Epoch 570/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0993 - ac
c: 0.6480
```

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Epoch 571/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1482 - ac
c: 0.6580
Epoch 572/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3383 - ac
c: 0.6150
Epoch 573/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2753 - ac
c: 0.6250
Epoch 574/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.3375 - ac
c: 0.5860
Epoch 575/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2778 - ac
c: 0.6060
Epoch 576/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2206 - ac
c: 0.6260
Epoch 577/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2222 - ac
c: 0.6180
Epoch 578/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1667 - ac
c: 0.6500
Epoch 579/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1855 - ac
c: 0.6580
Epoch 580/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.2471 - ac
c: 0.6080
Epoch 581/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.8507 - ac
c: 0.4610
Epoch 582/1000
1000/1000 [==============================] - 0s 12us/step - loss: 2.7625 - ac
c: 0.4450
Epoch 583/1000
1000/1000 [==============================] - 0s 13us/step - loss: 4.1393 - ac
c: 0.3870
Epoch 584/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6676 - ac
c: 0.5160
Epoch 585/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2277 - ac
c: 0.6040
Epoch 586/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1772 - ac
c: 0.6310
Epoch 587/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0603 - ac
c: 0.6710
Epoch 588/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0972 - ac
c: 0.6520
Epoch 589/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1121 - ac
c: 0.6670
```

```
Epoch 590/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1348 - ac
c: 0.6590
Epoch 591/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1413 - ac
c: 0.6680
Epoch 592/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1390 - ac
c: 0.6320
Epoch 593/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0640 - ac
c: 0.6650
Epoch 594/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1161 - ac
c: 0.6430
Epoch 595/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8386 - ac
c: 0.5270
Epoch 596/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.2434 - ac
c: 0.4830
Epoch 597/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.2886 - ac
c: 0.4790
Epoch 598/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5648 - ac
c: 0.5080
Epoch 599/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2751 - ac
c: 0.5860
Epoch 600/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2038 - ac
c: 0.6010
Epoch 601/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1692 - ac
c: 0.6310
Epoch 602/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1734 - ac
c: 0.6330
Epoch 603/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2269 - ac
c: 0.6210
Epoch 604/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.9429 - ac
c: 0.5540
Epoch 605/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8202 - ac
c: 0.5150
Epoch 606/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1817 - ac
c: 0.6200
Epoch 607/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2866 - ac
c: 0.6030
Epoch 608/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1764 - ac
c: 0.6270
```

```
Epoch 609/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2113 - ac
c: 0.6570
Epoch 610/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1677 - ac
c: 0.6260
Epoch 611/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1485 - ac
c: 0.6560
Epoch 612/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1663 - ac
c: 0.6190
Epoch 613/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0959 - ac
c: 0.6540
Epoch 614/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0743 - ac
c: 0.6580
Epoch 615/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1035 - ac
c: 0.6500
Epoch 616/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0495 - ac
c: 0.6720
Epoch 617/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1054 - ac
c: 0.6730
Epoch 618/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0350 - ac
c: 0.6850
Epoch 619/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.1565 - ac
c: 0.6610
Epoch 620/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1970 - ac
c: 0.6450
Epoch 621/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1391 - ac
c: 0.6630
Epoch 622/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.2816 - ac
c: 0.5980
Epoch 623/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1552 - ac
c: 0.6270
Epoch 624/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1349 - ac
c: 0.6410
Epoch 625/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0295 - ac
c: 0.6930
Epoch 626/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0122 - ac
c: 0.6810
Epoch 627/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0238 - ac
c: 0.7030
```

```
Epoch 628/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2736 - ac
c: 0.6180
Epoch 629/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.4598 - ac
c: 0.5890
Epoch 630/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.1647 - ac
c: 0.4850
Epoch 631/1000
1000/1000 [==============================] - 0s 18us/step - loss: 1.2920 - ac
c: 0.6200
Epoch 632/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1567 - ac
c: 0.6440
Epoch 633/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1121 - ac
c: 0.6510
Epoch 634/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1011 - ac
c: 0.6580
Epoch 635/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2201 - ac
c: 0.6310
Epoch 636/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2022 - ac
c: 0.6570
Epoch 637/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0977 - ac
c: 0.6500
Epoch 638/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.7577 - ac
c: 0.4770
Epoch 639/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.7574 - ac
c: 0.5350
Epoch 640/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5837 - ac
c: 0.5910
Epoch 641/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3092 - ac
c: 0.5810
Epoch 642/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1895 - ac
c: 0.6600
Epoch 643/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0717 - ac
c: 0.6460
Epoch 644/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0515 - ac
c: 0.6700
Epoch 645/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0248 - ac
c: 0.6830
Epoch 646/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.0381 - ac
c: 0.6950
```

```
Epoch 647/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0304 - ac
c: 0.7080
Epoch 648/1000
1000/1000 [==============================] - 0s 12us/step - loss: 0.9651 - ac
c: 0.7070
Epoch 649/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0820 - ac
c: 0.6680
Epoch 650/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2612 - ac
c: 0.6400
Epoch 651/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2409 - ac
c: 0.6390
Epoch 652/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9763 - ac
c: 0.5210
Epoch 653/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4823 - ac
c: 0.5860
Epoch 654/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.3049 - ac
c: 0.5140
Epoch 655/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1550 - ac
c: 0.6340
Epoch 656/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1115 - ac
c: 0.6560
Epoch 657/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0640 - ac
c: 0.6520
Epoch 658/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1039 - ac
c: 0.6530
Epoch 659/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.4953 - ac
c: 0.6010
Epoch 660/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3467 - ac
c: 0.5920
Epoch 661/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.4530 - ac
c: 0.4520
Epoch 662/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.1433 - ac
c: 0.4800
Epoch 663/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4152 - ac
c: 0.5490
Epoch 664/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2903 - ac
c: 0.5660
Epoch 665/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1870 - ac
c: 0.6210
```

```
Epoch 666/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2083 - ac
c: 0.6510
Epoch 667/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1473 - ac
c: 0.6400
Epoch 668/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.0850 - ac
c: 0.6620
Epoch 669/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1016 - ac
c: 0.6650
Epoch 670/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9888 - ac
c: 0.6800
Epoch 671/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0200 - ac
c: 0.7120
Epoch 672/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0318 - ac
c: 0.7020
Epoch 673/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0280 - ac
c: 0.6800
Epoch 674/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0352 - ac
c: 0.6760
Epoch 675/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0731 - ac
c: 0.6770
Epoch 676/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1559 - ac
c: 0.6480
Epoch 677/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1402 - ac
c: 0.6510
Epoch 678/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1266 - ac
c: 0.6710
Epoch 679/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0542 - ac
c: 0.6950
Epoch 680/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0428 - ac
c: 0.7020
Epoch 681/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9836 - ac
c: 0.7040
Epoch 682/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.7571 - ac
c: 0.5710
Epoch 683/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.4229 - ac
c: 0.6260
Epoch 684/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9713 - ac
c: 0.5450
```

```
Epoch 685/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.6910 - ac
c: 0.5180
Epoch 686/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.7883 - ac
c: 0.4780
Epoch 687/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5054 - ac
c: 0.5510
Epoch 688/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1857 - ac
c: 0.6480
Epoch 689/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0703 - ac
c: 0.6540
Epoch 690/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0428 - ac
c: 0.6920
Epoch 691/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0472 - ac
c: 0.7010
Epoch 692/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.1072 - ac
c: 0.6850
Epoch 693/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0314 - ac
c: 0.6800
Epoch 694/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0175 - ac
c: 0.6940
Epoch 695/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1639 - ac
c: 0.6540
Epoch 696/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0869 - ac
c: 0.6880
Epoch 697/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0966 - ac
c: 0.6740
Epoch 698/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2305 - ac
c: 0.6420
Epoch 699/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1094 - ac
c: 0.6430
Epoch 700/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0774 - ac
c: 0.6540
Epoch 701/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0103 - ac
c: 0.6980
Epoch 702/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9855 - ac
c: 0.6870
Epoch 703/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0151 - ac
c: 0.6950
```

```
Epoch 704/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9912 - ac
c: 0.7240
Epoch 705/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9736 - ac
c: 0.6890
Epoch 706/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9890 - ac
c: 0.6880
Epoch 707/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0145 - ac
c: 0.7170
Epoch 708/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0275 - ac
c: 0.6770
Epoch 709/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.0242 - ac
c: 0.7050
Epoch 710/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0291 - ac
c: 0.6950
Epoch 711/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0182 - ac
c: 0.6780
Epoch 712/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1478 - ac
c: 0.7020
Epoch 713/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1254 - ac
c: 0.6750
Epoch 714/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.5020 - ac
c: 0.5970
Epoch 715/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8744 - ac
c: 0.5130
Epoch 716/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.2679 - ac
c: 0.5950
Epoch 717/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.4768 - ac
c: 0.4810
Epoch 718/1000
1000/1000 [==============================] - 0s 15us/step - loss: 3.1970 - ac
c: 0.4580
Epoch 719/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2133 - ac
c: 0.5980
Epoch 720/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1316 - ac
c: 0.6530
Epoch 721/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0560 - ac
c: 0.6810
Epoch 722/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1029 - ac
c: 0.6570
```

```
Epoch 723/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.9778 - ac
c: 0.6720
Epoch 724/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.9977 - ac
c: 0.7050
Epoch 725/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9989 - ac
c: 0.7250
Epoch 726/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9951 - ac
c: 0.7220
Epoch 727/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9895 - ac
c: 0.6960
Epoch 728/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9803 - ac
c: 0.7140
Epoch 729/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9482 - ac
c: 0.7160
Epoch 730/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.0812 - ac
c: 0.5950
Epoch 731/1000
1000/1000 [==============================] - 0s 16us/step - loss: 5.2620 - ac
c: 0.4010
Epoch 732/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.2398 - ac
c: 0.5310
Epoch 733/1000
1000/1000 [==============================] - 0s 17us/step - loss: 2.6644 - ac
c: 0.5290
Epoch 734/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.0079 - ac
c: 0.5780
Epoch 735/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.2581 - ac
c: 0.6240
Epoch 736/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9808 - ac
c: 0.7180
Epoch 737/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0080 - ac
c: 0.7020
Epoch 738/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9356 - ac
c: 0.6970
Epoch 739/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.9767 - ac
c: 0.7280
Epoch 740/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9691 - ac
c: 0.7080
Epoch 741/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8830 - ac
c: 0.7280
```

```
Epoch 742/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9483 - ac
c: 0.7150
Epoch 743/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9351 - ac
c: 0.7290
Epoch 744/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9673 - ac
c: 0.7190
Epoch 745/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9126 - ac
c: 0.7320
Epoch 746/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8906 - ac
c: 0.7390
Epoch 747/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9814 - ac
c: 0.7300
Epoch 748/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1513 - ac
c: 0.6860
Epoch 749/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9341 - ac
c: 0.7400
Epoch 750/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.0045 - ac
c: 0.7100
Epoch 751/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9105 - ac
c: 0.7400
Epoch 752/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9629 - ac
c: 0.7380
Epoch 753/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0981 - ac
c: 0.7150
Epoch 754/1000
1000/1000 [==============================] - 0s 12us/step - loss: 0.9373 - ac
c: 0.7010
Epoch 755/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1005 - ac
c: 0.7280
Epoch 756/1000
1000/1000 [==============================] - 0s 12us/step - loss: 0.9285 - ac
c: 0.7420
Epoch 757/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9102 - ac
c: 0.7360
Epoch 758/1000
1000/1000 [==============================] - 0s 12us/step - loss: 0.9727 - ac
c: 0.7140
Epoch 759/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0545 - ac
c: 0.6670
Epoch 760/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9300 - ac
c: 0.7340
```

```
Epoch 761/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.0222 - ac
c: 0.7220
Epoch 762/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0332 - ac
c: 0.7170
Epoch 763/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1022 - ac
c: 0.6680
Epoch 764/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0840 - ac
c: 0.7030
Epoch 765/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0626 - ac
c: 0.6730
Epoch 766/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9220 - ac
c: 0.7460
Epoch 767/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0231 - ac
c: 0.6750
Epoch 768/1000
1000/1000 [==============================] - 0s 12us/step - loss: 0.8778 - ac
c: 0.7380
Epoch 769/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9620 - ac
c: 0.7130
Epoch 770/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9369 - ac
c: 0.7500
Epoch 771/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0431 - ac
c: 0.7020
Epoch 772/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3093 - ac
c: 0.6790
Epoch 773/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.9697 - ac
c: 0.5150
Epoch 774/1000
1000/1000 [==============================] - 0s 13us/step - loss: 3.3601 - ac
c: 0.4890
Epoch 775/1000
1000/1000 [==============================] - 0s 15us/step - loss: 3.4951 - ac
c: 0.4760
Epoch 776/1000
1000/1000 [==============================] - 0s 14us/step - loss: 5.7053 - ac
c: 0.3740
Epoch 777/1000
1000/1000 [==============================] - 0s 16us/step - loss: 3.5092 - ac
c: 0.4820
Epoch 778/1000
1000/1000 [==============================] - 0s 14us/step - loss: 4.5136 - ac
c: 0.4210
Epoch 779/1000
1000/1000 [==============================] - 0s 15us/step - loss: 8.0293 - ac
c: 0.2910
```

```
Epoch 780/1000
1000/1000 [==============================] - 0s 13us/step - loss: 4.6587 - ac
c: 0.4270
Epoch 781/1000
1000/1000 [==============================] - 0s 16us/step - loss: 3.8626 - ac
c: 0.4460
Epoch 782/1000
1000/1000 [==============================] - 0s 14us/step - loss: 3.2789 - ac
c: 0.5000
Epoch 783/1000
1000/1000 [==============================] - 0s 16us/step - loss: 2.5258 - ac
c: 0.5220
Epoch 784/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.1761 - ac
c: 0.5510
Epoch 785/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.3843 - ac
c: 0.5260
Epoch 786/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.6634 - ac
c: 0.5750
Epoch 787/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.6631 - ac
c: 0.5900
Epoch 788/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.4301 - ac
c: 0.6060
Epoch 789/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.3583 - ac
c: 0.6100
Epoch 790/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1345 - ac
c: 0.6430
Epoch 791/1000
1000/1000 [==============================] - 0s 17us/step - loss: 1.1071 - ac
c: 0.6690
Epoch 792/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0971 - ac
c: 0.6640
Epoch 793/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0722 - ac
c: 0.6840
Epoch 794/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0275 - ac
c: 0.6950
Epoch 795/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0705 - ac
c: 0.6990
Epoch 796/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.9810 - ac
c: 0.7150
Epoch 797/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.9795 - ac
c: 0.7330
Epoch 798/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0360 - ac
c: 0.7120
```

```
Epoch 799/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0169 - ac
c: 0.6890
Epoch 800/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0078 - ac
c: 0.7300
Epoch 801/1000
1000/1000 [==============================] - 0s 12us/step - loss: 0.9836 - ac
c: 0.7160
Epoch 802/1000
1000/1000 [==============================] - 0s 12us/step - loss: 0.9688 - ac
c: 0.7060
Epoch 803/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0210 - ac
c: 0.7220
Epoch 804/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9139 - ac
c: 0.7290
Epoch 805/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8804 - ac
c: 0.7540
Epoch 806/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9048 - ac
c: 0.7390
Epoch 807/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9852 - ac
c: 0.7260
Epoch 808/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9020 - ac
c: 0.7220
Epoch 809/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9535 - ac
c: 0.7450
Epoch 810/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9301 - ac
c: 0.7210
Epoch 811/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9654 - ac
c: 0.7440
Epoch 812/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9964 - ac
c: 0.7210
Epoch 813/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8990 - ac
c: 0.7310
Epoch 814/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9253 - ac
c: 0.7580
Epoch 815/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9251 - ac
c: 0.7190
Epoch 816/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9807 - ac
c: 0.7280
Epoch 817/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1565 - ac
c: 0.6840
```

```
Epoch 818/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1056 - ac
c: 0.7100
Epoch 819/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9330 - ac
c: 0.7330
Epoch 820/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9322 - ac
c: 0.7270
Epoch 821/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2703 - ac
c: 0.6740
Epoch 822/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1522 - ac
c: 0.6720
Epoch 823/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.9560 - ac
c: 0.7090
Epoch 824/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8678 - ac
c: 0.7430
Epoch 825/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8498 - ac
c: 0.7570
Epoch 826/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.8745 - ac
c: 0.7430
Epoch 827/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8523 - ac
c: 0.7530
Epoch 828/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.9279 - ac
c: 0.7450
Epoch 829/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0440 - ac
c: 0.7000
Epoch 830/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0135 - ac
c: 0.7150
Epoch 831/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0610 - ac
c: 0.6970
Epoch 832/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9757 - ac
c: 0.7090
Epoch 833/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0134 - ac
c: 0.6950
Epoch 834/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.9978 - ac
c: 0.7110
Epoch 835/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9404 - ac
c: 0.7300
Epoch 836/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9050 - ac
c: 0.7370
```

```
Epoch 837/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9853 - ac
c: 0.7400
Epoch 838/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8854 - ac
c: 0.7480
Epoch 839/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0352 - ac
c: 0.7220
Epoch 840/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8876 - ac
c: 0.7440
Epoch 841/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.4709 - ac
c: 0.5580
Epoch 842/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.2497 - ac
c: 0.5450
Epoch 843/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.9385 - ac
c: 0.5470
Epoch 844/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.8442 - ac
c: 0.5650
Epoch 845/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.6167 - ac
c: 0.5180
Epoch 846/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6483 - ac
c: 0.6110
Epoch 847/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0477 - ac
c: 0.6800
Epoch 848/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9270 - ac
c: 0.7080
Epoch 849/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8812 - ac
c: 0.7390
Epoch 850/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.9203 - ac
c: 0.7390
Epoch 851/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9440 - ac
c: 0.7200
Epoch 852/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.9582 - ac
c: 0.7030
Epoch 853/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.8639 - ac
c: 0.7390
Epoch 854/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9370 - ac
c: 0.7370
Epoch 855/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8812 - ac
c: 0.7640
```

```
Epoch 856/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8491 - ac
c: 0.7690
Epoch 857/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8570 - ac
c: 0.7650
Epoch 858/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8292 - ac
c: 0.7530
Epoch 859/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.9016 - ac
c: 0.7780
Epoch 860/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.9217 - ac
c: 0.7250
Epoch 861/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8717 - ac
c: 0.7800
Epoch 862/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8787 - ac
c: 0.7340
Epoch 863/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9665 - ac
c: 0.7350
Epoch 864/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1753 - ac
c: 0.7120
Epoch 865/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1224 - ac
c: 0.6670
Epoch 866/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1277 - ac
c: 0.6890
Epoch 867/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0212 - ac
c: 0.7140
Epoch 868/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8986 - ac
c: 0.7430
Epoch 869/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9321 - ac
c: 0.7450
Epoch 870/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.0474 - ac
c: 0.6660
Epoch 871/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9642 - ac
c: 0.7030
Epoch 872/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.9856 - ac
c: 0.7220
Epoch 873/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8609 - ac
c: 0.7590
Epoch 874/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8351 - ac
c: 0.7600
```

```
Epoch 875/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8126 - ac
c: 0.7690
Epoch 876/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8220 - ac
c: 0.7920
Epoch 877/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8061 - ac
c: 0.7730
Epoch 878/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8681 - ac
c: 0.7510
Epoch 879/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9137 - ac
c: 0.7380
Epoch 880/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.3138 - ac
c: 0.6710
Epoch 881/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.3489 - ac
c: 0.6700
Epoch 882/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.4339 - ac
c: 0.6370
Epoch 883/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3410 - ac
c: 0.6730
Epoch 884/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1440 - ac
c: 0.6890
Epoch 885/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.5780 - ac
c: 0.6220
Epoch 886/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9631 - ac
c: 0.7160
Epoch 887/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8856 - ac
c: 0.7570
Epoch 888/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8610 - ac
c: 0.7580
Epoch 889/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8112 - ac
c: 0.7740
Epoch 890/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8430 - ac
c: 0.7800
Epoch 891/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8186 - ac
c: 0.7710
Epoch 892/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9202 - ac
c: 0.7390
Epoch 893/1000
1000/1000 [==============================] - 0s 15us/step - loss: 2.1973 - ac
c: 0.6310
```

```
Epoch 894/1000
1000/1000 [==============================] - 0s 14us/step - loss: 3.8549 - ac
c: 0.5010
Epoch 895/1000
1000/1000 [==============================] - 0s 13us/step - loss: 5.0932 - ac
c: 0.4400
Epoch 896/1000
1000/1000 [==============================] - 0s 13us/step - loss: 3.6691 - ac
c: 0.5410
Epoch 897/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.2171 - ac
c: 0.6260
Epoch 898/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0064 - ac
c: 0.6970
Epoch 899/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8782 - ac
c: 0.7440
Epoch 900/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8497 - ac
c: 0.7520
Epoch 901/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8757 - ac
c: 0.7500
Epoch 902/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8392 - ac
c: 0.7640
Epoch 903/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8997 - ac
c: 0.7500
Epoch 904/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8700 - ac
c: 0.7450
Epoch 905/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8878 - ac
c: 0.7620
Epoch 906/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8551 - ac
c: 0.7480
Epoch 907/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8359 - ac
c: 0.7610
Epoch 908/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.8872 - ac
c: 0.6200
Epoch 909/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.6545 - ac
c: 0.6810
Epoch 910/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.2150 - ac
c: 0.6900
Epoch 911/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0693 - ac
c: 0.7130
Epoch 912/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9911 - ac
c: 0.6950
```

```
Epoch 913/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8390 - ac
c: 0.7450
Epoch 914/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8420 - ac
c: 0.7520
Epoch 915/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8361 - ac
c: 0.7800
Epoch 916/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8163 - ac
c: 0.7490
Epoch 917/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.7538 - ac
c: 0.8090
Epoch 918/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.7781 - ac
c: 0.7820
Epoch 919/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.7740 - ac
c: 0.7770
Epoch 920/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8383 - ac
c: 0.7920
Epoch 921/1000
1000/1000 [==============================] - 0s 18us/step - loss: 0.7893 - ac
c: 0.7790
Epoch 922/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.7340 - ac
c: 0.8060
Epoch 923/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8327 - ac
c: 0.7790
Epoch 924/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8944 - ac
c: 0.7600
Epoch 925/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.7211 - ac
c: 0.8010
Epoch 926/1000
1000/1000 [==============================] - 0s 17us/step - loss: 0.8357 - ac
c: 0.7550
Epoch 927/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8974 - ac
c: 0.7590
Epoch 928/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8357 - ac
c: 0.7870
Epoch 929/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.0998 - ac
c: 0.7060
Epoch 930/1000
1000/1000 [==============================] - 0s 12us/step - loss: 1.7523 - ac
c: 0.6560
Epoch 931/1000
1000/1000 [==============================] - 0s 12us/step - loss: 3.0409 - ac
c: 0.5580
```

```
Epoch 932/1000
1000/1000 [==============================] - 0s 13us/step - loss: 3.6508 - ac
c: 0.5470
Epoch 933/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.6684 - ac
c: 0.6430
Epoch 934/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.4573 - ac
c: 0.6150
Epoch 935/1000
1000/1000 [==============================] - 0s 13us/step - loss: 2.4198 - ac
c: 0.5880
Epoch 936/1000
1000/1000 [==============================] - 0s 18us/step - loss: 2.1375 - ac
c: 0.5580
Epoch 937/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1117 - ac
c: 0.7140
Epoch 938/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9349 - ac
c: 0.7340
Epoch 939/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8235 - ac
c: 0.7790
Epoch 940/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8038 - ac
c: 0.7890
Epoch 941/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.9825 - ac
c: 0.6460
Epoch 942/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1782 - ac
c: 0.7110
Epoch 943/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8595 - ac
c: 0.7650
Epoch 944/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8110 - ac
c: 0.7760
Epoch 945/1000
1000/1000 [==============================] - 0s 12us/step - loss: 0.7959 - ac
c: 0.7960
Epoch 946/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8504 - ac
c: 0.7650
Epoch 947/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.7799 - ac
c: 0.7930
Epoch 948/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.7776 - ac
c: 0.7990
Epoch 949/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8279 - ac
c: 0.7830
Epoch 950/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8096 - ac
c: 0.7870
```

```
Epoch 951/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8213 - ac
c: 0.7940
Epoch 952/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.7439 - ac
c: 0.8100
Epoch 953/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8426 - ac
c: 0.7710
Epoch 954/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.9855 - ac
c: 0.7660
Epoch 955/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.9462 - ac
c: 0.7430
Epoch 956/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9942 - ac
c: 0.7380
Epoch 957/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9410 - ac
c: 0.7510
Epoch 958/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8459 - ac
c: 0.7660
Epoch 959/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8754 - ac
c: 0.7680
Epoch 960/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9606 - ac
c: 0.7810
Epoch 961/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9967 - ac
c: 0.7480
Epoch 962/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.3309 - ac
c: 0.6840
Epoch 963/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1255 - ac
c: 0.6590
Epoch 964/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.9741 - ac
c: 0.7440
Epoch 965/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.9141 - ac
c: 0.7540
Epoch 966/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.8119 - ac
c: 0.7560
Epoch 967/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8693 - ac
c: 0.7530
Epoch 968/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8486 - ac
c: 0.7790
Epoch 969/1000
1000/1000 [==============================] - 0s 14us/step - loss: 2.9475 - ac
c: 0.5680
```

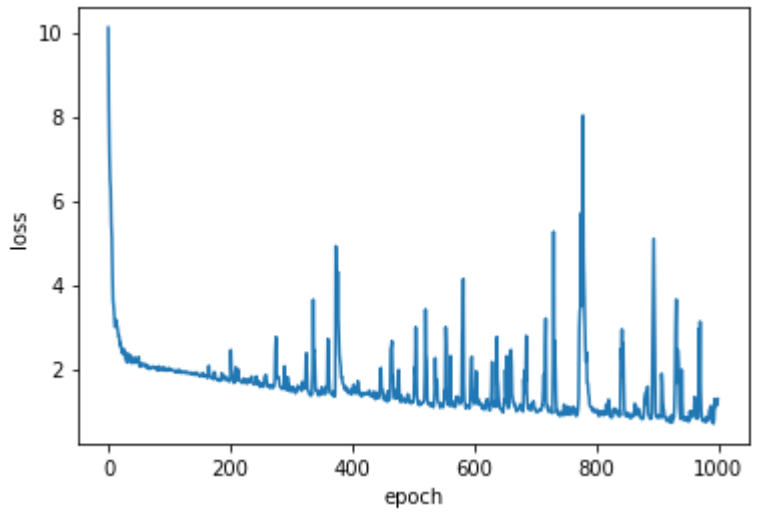
```
Epoch 970/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.7821 - ac
c: 0.6470
Epoch 971/1000
1000/1000 [==============================] - 0s 14us/step - loss: 3.1250 - ac
c: 0.5380
Epoch 972/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.5372 - ac
c: 0.6430
Epoch 973/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0082 - ac
c: 0.6800
Epoch 974/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8452 - ac
c: 0.7520
Epoch 975/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.7870 - ac
c: 0.7990
Epoch 976/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.7577 - ac
c: 0.7750
Epoch 977/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8127 - ac
c: 0.7650
Epoch 978/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.7604 - ac
c: 0.7910
Epoch 979/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.7811 - ac
c: 0.7940
Epoch 980/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.7793 - ac
c: 0.7860
Epoch 981/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.7319 - ac
c: 0.7990
Epoch 982/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8579 - ac
c: 0.7610
Epoch 983/1000
1000/1000 [==============================] - 0s 16us/step - loss: 0.8156 - ac
c: 0.7790
Epoch 984/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8045 - ac
c: 0.8020
Epoch 985/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.7744 - ac
c: 0.7690
Epoch 986/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.9908 - ac
c: 0.7390
Epoch 987/1000
1000/1000 [==============================] - 0s 16us/step - loss: 1.0402 - ac
c: 0.7200
Epoch 988/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0981 - ac
c: 0.7470
```

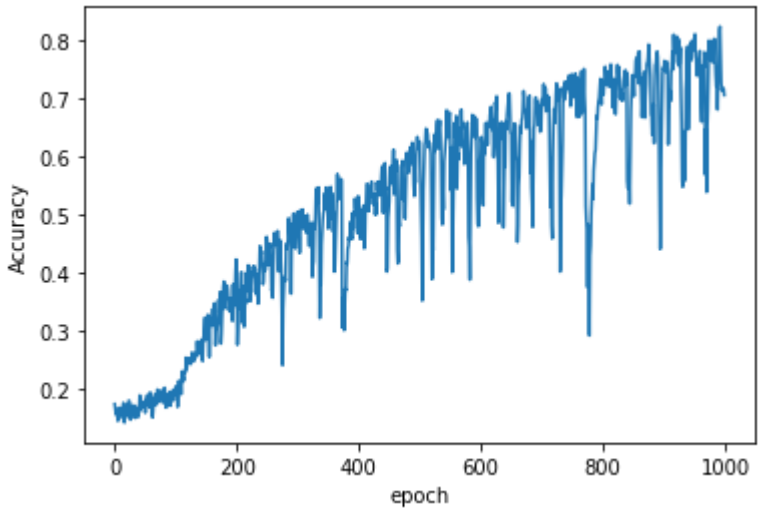
```
Epoch 989/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1219 - ac
c: 0.6800
Epoch 990/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8476 - ac
c: 0.7390
Epoch 991/1000
1000/1000 [==============================] - 0s 14us/step - loss: 0.8062 - ac
c: 0.7770
Epoch 992/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.7379 - ac
c: 0.8170
Epoch 993/1000
1000/1000 [==============================] - 0s 15us/step - loss: 0.6980 - ac
c: 0.8230
Epoch 994/1000
1000/1000 [==============================] - 0s 13us/step - loss: 0.8087 - ac
c: 0.7690
Epoch 995/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2830 - ac
c: 0.7260
Epoch 996/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.0933 - ac
c: 0.7130
Epoch 997/1000
1000/1000 [==============================] - 0s 15us/step - loss: 1.1747 - ac
c: 0.7170
Epoch 998/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.1300 - ac
c: 0.7120
Epoch 999/1000
1000/1000 [==============================] - 0s 13us/step - loss: 1.1440 - ac
c: 0.7160
Epoch 1000/1000
1000/1000 [==============================] - 0s 14us/step - loss: 1.2846 - ac
c: 0.7050
```

In [103]:
```
plt.xlabel('epoch')
plt.ylabel('loss')
plt.plot(history.history['loss'])

plt.figure()
plt.xlabel('epoch')
plt.ylabel('Accuracy')
plt.plot(history.history['acc'])
```

Out[103]: [<matplotlib.lines.Line2D at 0x7fc20c5bf710>]





In [105]:
```
test_loss, test_acc = FNN_network_featuresNetwork.evaluate(test_data_X_2D_HOG,
test_data_y[0:100])
print('test_acc: ', test_acc)

test_loss, val_acc = FNN_network_featuresNetwork.evaluate(val_data_X_2D_HOG, v
al_data_y[0:100])
print('val_acc: ', val_acc)
```

```
100/100 [==============================] - 1s 10ms/step
test_acc:  0.29
100/100 [==============================] - 0s 135us/step
val_acc:  0.3
```