Node Classification using Graph Convolutional Networks

This node classification task uses CORA dataset from https://linqs.soe.ucsc.edu/data
The dataset consists of **2708** nodes which correspond to scientific publications.
The nodes are classified into **7** categories indicating the topics of each document.
The edges indicate whether a document is cited by the other or vice versa.
Each node has **1433** features which is described by a 0/1-valued vector, indicating the bag-of-words from the dictionary.

This is an undirected graph problem

In [ ]:
```
#importing dependencies

import numpy as np
import os
import networkx as nx
from keras.utils import to_categorical
from sklearn.preprocessing import LabelEncoder
from sklearn.utils import shuffle
from sklearn.metrics import classification_report

from spektral.layers import GraphConv

from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dropout, Dense
from tensorflow.keras import Sequential
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import TensorBoard, EarlyStopping
import tensorflow as tf
from tensorflow.keras.regularizers import l2

from collections import Counter
from sklearn.manifold import TSNE
import matplotlib.pyplot as plt
```

Data Loading and Preprocessing

We are going to use the edges connecting the (from file **cora.cites**).
The nodes are loaded from file **cora.content**.

In [ ]:
```
#Loading the data

all_data = []
all_edges = []

for root,dirs,files in os.walk('./cora'):
    for file in files:
        if '.content' in file:
            with open(os.path.join(root,file),'r') as f:
                all_data.extend(f.read().splitlines())
        elif 'cites' in file:
            with open(os.path.join(root,file),'r') as f:
                all_edges.extend(f.read().splitlines())


#Shuffle the data because the raw data is ordered based on the label
random_state = 77
all_data = shuffle(all_data,random_state=random_state)
```

In **cora.content** file:
The **first** element indicates the **node name**

The **second** until the last second elements indicate the **node features**
The **last** element indicates the **label of that particular node**

In **cora.cites** file:
Each line indicates the tuple of connected nodes

Parsing the data

In [ ]:
```
#parse the data
labels = []
nodes = []
X = []

for i,data in enumerate(all_data):
    elements = data.split('\t')
    labels.append(elements[-1])
    X.append(elements[1:-1])
    nodes.append(elements[0])

X = np.array(X,dtype=int)
N = X.shape[0] #the number of nodes
F = X.shape[1] #the size of node features
print('X shape: ', X.shape)


#parse the edge
edge_list=[]
for edge in all_edges:
    e = edge.split('\t')
    edge_list.append((e[0],e[1]))

print('\nNumber of nodes (N): ', N)
print('\nNumber of features (F) of each node: ', F)
print('\nCategories: ', set(labels))

num_classes = len(set(labels))
print('\nNumber of classes: ', num_classes)
```

```
X shape:  (2708, 1433)

Number of nodes (N):  2708

Number of features (F) of each node:  1433

Categories:  {'Probabilistic_Methods', 'Reinforcement_Learning', 'Theory', 'Case_Based', 'Neural_Networks',
'Rule_Learning', 'Genetic_Algorithms'}

Number of classes:  7
```

Select examples for training, validation, and test then set the mask

In [ ]:
```
def limit_data(labels,limit=20,val_num=500,test_num=1000):
    '''
    Get the index of train, validation, and test data
    '''
    label_counter = dict((l, 0) for l in labels)
    train_idx = []

    for i in range(len(labels)):
        label = labels[i]
        if label_counter[label]<limit:
            #add the example to the training data
            train_idx.append(i)
            label_counter[label]+=1

        #exit the loop once we found 20 examples for each class
        if all(count == limit for count in label_counter.values()):
            break
```

```
    #get the indices that do not go to traning data
    rest_idx = [x for x in range(len(labels)) if x not in train_idx]
    #get the first val_num
    val_idx = rest_idx[:val_num]
    test_idx = rest_idx[val_num:(val_num+test_num)]
    return train_idx, val_idx,test_idx


train_idx,val_idx,test_idx = limit_data(labels)
```

In [ ]:
```
#set the mask
train_mask = np.zeros((N,),dtype=bool)
train_mask[train_idx] = True

val_mask = np.zeros((N,),dtype=bool)
val_mask[val_idx] = True

test_mask = np.zeros((N,),dtype=bool)
test_mask[test_idx] = True
```

Show Data Distribution

In [ ]:
```
print("All Data Distribution: \n{}".format(Counter(labels)))
```

```
All Data Distribution:
Counter({'Neural_Networks': 818, 'Probabilistic_Methods': 426, 'Genetic_Algorithms': 418, 'Theory': 351, 'Cas
e_Based': 298, 'Reinforcement_Learning': 217, 'Rule_Learning': 180})
```

In [ ]:
```
print("Training Data Distribution: \n{}".format(Counter([labels[i] for i in train_idx])))
```

```
Training Data Distribution:
Counter({'Reinforcement_Learning': 20, 'Probabilistic_Methods': 20, 'Neural_Networks': 20, 'Case_Based': 20,
'Theory': 20, 'Genetic_Algorithms': 20, 'Rule_Learning': 20})
```

In [ ]:
```
print("Validation Data Distribution: \n{}".format(Counter([labels[i] for i in val_idx])))
```

```
Validation Data Distribution:
Counter({'Neural_Networks': 172, 'Genetic_Algorithms': 78, 'Probabilistic_Methods': 72, 'Theory': 63, 'Case_B
ased': 58, 'Reinforcement_Learning': 35, 'Rule_Learning': 22})
```

Convert the labels to one hot encoding

In [ ]:
```
def encode_label(labels):
    label_encoder = LabelEncoder()
    labels = label_encoder.fit_transform(labels)
    labels = to_categorical(labels)
    return labels, label_encoder.classes_

labels_encoded, classes = encode_label(labels)
```

Build a graph on NetworkX using the obtained nodes and edges list

In [ ]:
```
#build the graph
G = nx.Graph()
G.add_nodes_from(nodes)
G.add_edges_from(edge_list)

#obtain the adjacency matrix (A)
A = nx.adjacency_matrix(G)
print('Graph info: ', nx.info(G))
```

```
Graph info:  Name:
Type: Graph
Number of nodes: 2708
Number of edges: 5278
Average degree:   3.8981
```

Building and Training Graph Convolutional Networks

In [ ]:
```
# Parameters
channels = 16           # Number of channels in the first layer
dropout = 0.5           # Dropout rate for the features
l2_reg = 5e-4           # L2 regularization rate
learning_rate = 1e-2    # Learning rate
epochs = 500            # Number of training epochs
es_patience = 250        # Patience for early stopping

# Preprocessing operations
A = GraphConv.preprocess(A).astype('f4')

# Model definition
X_in = Input(shape=(F, ))
fltr_in = Input((N, ), sparse=True)

dropout_1 = Dropout(dropout)(X_in)
graph_conv_1 = GraphConv(channels,
                         activation='relu',
                         kernel_regularizer=l2(l2_reg),
                         use_bias=False)([dropout_1, fltr_in])

dropout_2 = Dropout(dropout)(graph_conv_1)
graph_conv_2 = GraphConv(num_classes,
                         activation='softmax',
                         use_bias=False)([dropout_2, fltr_in])

# Build model
model = Model(inputs=[X_in, fltr_in], outputs=graph_conv_2)
optimizer = Adam(lr=learning_rate)
model.compile(optimizer=optimizer,
              loss='categorical_crossentropy',
              weighted_metrics=['acc'])
model.summary()

tbCallBack_GCN = tf.keras.callbacks.TensorBoard(
    log_dir='./Tensorboard_GCN_cora',
)
callback_GCN = [tbCallBack_GCN]
```

```
Model: "model"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            [(None, 1433)]       0
__________________________________________________________________________________________________
dropout (Dropout)               (None, 1433)         0           input_1[0][0]
__________________________________________________________________________________________________
input_2 (InputLayer)            [(None, 2708)]       0
__________________________________________________________________________________________________
graph_conv (GraphConv)          (None, 16)           22928       dropout[0][0]
                                                                 input_2[0][0]
__________________________________________________________________________________________________
dropout_1 (Dropout)             (None, 16)           0           graph_conv[0][0]
__________________________________________________________________________________________________
graph_conv_1 (GraphConv)        (None, 7)            112         dropout_1[0][0]
                                                                 input_2[0][0]
==================================================================================================
Total params: 23,040
Trainable params: 23,040
Non-trainable params: 0
__________________________________________________________________________________________________
```

In [ ]:
```
# Train model
validation_data = ([X, A], labels_encoded, val_mask)
model.fit([X, A],
          labels_encoded,
          sample_weight=train_mask,
          epochs=epochs,
```

```
        batch_size=N,
        validation_data=validation_data,
        shuffle=False,
        callbacks=[
            EarlyStopping(patience=es_patience,  restore_best_weights=True),
            tbCallBack_GCN
        ])
```

```
Epoch 1/500
1/1 [==============================] - 0s 364ms/step - loss: 0.1162 - acc: 0.1429 - val_loss: 0.3659 - val_ac
c: 0.2660
Epoch 2/500
1/1 [==============================] - ETA: 0s - loss: 0.1088 - acc: 0.3429WARNING:tensorflow:Method (on_trai
n_batch_end) is slow compared to the batch update (0.185897). Check your callbacks.
1/1 [==============================] - 0s 200ms/step - loss: 0.1088 - acc: 0.3429 - val_loss: 0.3568 - val_ac
c: 0.4560
Epoch 3/500
1/1 [==============================] - 0s 192ms/step - loss: 0.1034 - acc: 0.5286 - val_loss: 0.3466 - val_ac
c: 0.5780
Epoch 4/500
1/1 [==============================] - 0s 236ms/step - loss: 0.0973 - acc: 0.6786 - val_loss: 0.3365 - val_ac
c: 0.5920
Epoch 5/500
1/1 [==============================] - 0s 282ms/step - loss: 0.0927 - acc: 0.6643 - val_loss: 0.3281 - val_ac
c: 0.5220
Epoch 6/500
1/1 [==============================] - 0s 239ms/step - loss: 0.0869 - acc: 0.6643 - val_loss: 0.3216 - val_ac
c: 0.4220
Epoch 7/500
1/1 [==============================] - 0s 259ms/step - loss: 0.0838 - acc: 0.6786 - val_loss: 0.3154 - val_ac
c: 0.4020
Epoch 8/500
1/1 [==============================] - 0s 229ms/step - loss: 0.0800 - acc: 0.6714 - val_loss: 0.3084 - val_ac
c: 0.4560
Epoch 9/500
1/1 [==============================] - 0s 234ms/step - loss: 0.0771 - acc: 0.7571 - val_loss: 0.3007 - val_ac
c: 0.5420
Epoch 10/500
1/1 [==============================] - 0s 226ms/step - loss: 0.0763 - acc: 0.7286 - val_loss: 0.2929 - val_ac
c: 0.6020
Epoch 11/500
1/1 [==============================] - 0s 231ms/step - loss: 0.0745 - acc: 0.7786 - val_loss: 0.2852 - val_ac
c: 0.6360
Epoch 12/500
1/1 [==============================] - 0s 292ms/step - loss: 0.0715 - acc: 0.8571 - val_loss: 0.2782 - val_ac
c: 0.6680
Epoch 13/500
1/1 [==============================] - 0s 272ms/step - loss: 0.0705 - acc: 0.8786 - val_loss: 0.2713 - val_ac
c: 0.6900
Epoch 14/500
1/1 [==============================] - 0s 220ms/step - loss: 0.0674 - acc: 0.8714 - val_loss: 0.2647 - val_ac
c: 0.7040
Epoch 15/500
1/1 [==============================] - 0s 235ms/step - loss: 0.0646 - acc: 0.8786 - val_loss: 0.2583 - val_ac
c: 0.7240
Epoch 16/500
1/1 [==============================] - 0s 232ms/step - loss: 0.0629 - acc: 0.8857 - val_loss: 0.2520 - val_ac
c: 0.7380
Epoch 17/500
1/1 [==============================] - 0s 235ms/step - loss: 0.0659 - acc: 0.8500 - val_loss: 0.2459 - val_ac
c: 0.7480
Epoch 18/500
1/1 [==============================] - 0s 244ms/step - loss: 0.0621 - acc: 0.9143 - val_loss: 0.2402 - val_ac
c: 0.7560
Epoch 19/500
1/1 [==============================] - 0s 282ms/step - loss: 0.0589 - acc: 0.9286 - val_loss: 0.2351 - val_ac
c: 0.7600
Epoch 20/500
1/1 [==============================] - 0s 252ms/step - loss: 0.0578 - acc: 0.9000 - val_loss: 0.2305 - val_ac
c: 0.7620
Epoch 21/500
1/1 [==============================] - 0s 224ms/step - loss: 0.0580 - acc: 0.9000 - val_loss: 0.2262 - val_ac
c: 0.7660
Epoch 22/500
1/1 [==============================] - 0s 232ms/step - loss: 0.0554 - acc: 0.9000 - val_loss: 0.2221 - val_ac
c: 0.7680
Epoch 23/500
1/1 [==============================] - 0s 221ms/step - loss: 0.0545 - acc: 0.9143 - val_loss: 0.2183 - val_ac
c: 0.7720
```

```
Epoch 24/500
1/1 [==============================] - 0s 209ms/step - loss: 0.0526 - acc: 0.9500 - val_loss: 0.2146 - val_ac
c: 0.7760
Epoch 25/500
1/1 [==============================] - 0s 232ms/step - loss: 0.0548 - acc: 0.9214 - val_loss: 0.2114 - val_ac
c: 0.7820
Epoch 26/500
1/1 [==============================] - 0s 219ms/step - loss: 0.0536 - acc: 0.9357 - val_loss: 0.2084 - val_ac
c: 0.7900
Epoch 27/500
1/1 [==============================] - 0s 230ms/step - loss: 0.0536 - acc: 0.9071 - val_loss: 0.2053 - val_ac
c: 0.7880
Epoch 28/500
1/1 [==============================] - 0s 233ms/step - loss: 0.0546 - acc: 0.9286 - val_loss: 0.2027 - val_ac
c: 0.7880
Epoch 29/500
1/1 [==============================] - 0s 206ms/step - loss: 0.0510 - acc: 0.9000 - val_loss: 0.2004 - val_ac
c: 0.7920
Epoch 30/500
1/1 [==============================] - 0s 211ms/step - loss: 0.0484 - acc: 0.9571 - val_loss: 0.1986 - val_ac
c: 0.7860
Epoch 31/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0506 - acc: 0.9357 - val_loss: 0.1972 - val_ac
c: 0.7840
Epoch 32/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0494 - acc: 0.9286 - val_loss: 0.1959 - val_ac
c: 0.7760
Epoch 33/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0504 - acc: 0.9000 - val_loss: 0.1946 - val_ac
c: 0.7720
Epoch 34/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0483 - acc: 0.9214 - val_loss: 0.1935 - val_ac
c: 0.7640
Epoch 35/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0458 - acc: 0.9429 - val_loss: 0.1923 - val_ac
c: 0.7600
Epoch 36/500
1/1 [==============================] - 0s 206ms/step - loss: 0.0456 - acc: 0.9429 - val_loss: 0.1913 - val_ac
c: 0.7640
Epoch 37/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0448 - acc: 0.9286 - val_loss: 0.1903 - val_ac
c: 0.7620
Epoch 38/500
1/1 [==============================] - 0s 191ms/step - loss: 0.0439 - acc: 0.9714 - val_loss: 0.1889 - val_ac
c: 0.7660
Epoch 39/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0453 - acc: 0.9571 - val_loss: 0.1870 - val_ac
c: 0.7740
Epoch 40/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0410 - acc: 0.9786 - val_loss: 0.1845 - val_ac
c: 0.7840
Epoch 41/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0432 - acc: 0.9714 - val_loss: 0.1818 - val_ac
c: 0.7960
Epoch 42/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0431 - acc: 0.9357 - val_loss: 0.1792 - val_ac
c: 0.8020
Epoch 43/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0402 - acc: 0.9571 - val_loss: 0.1769 - val_ac
c: 0.8020
Epoch 44/500
1/1 [==============================] - 0s 181ms/step - loss: 0.0410 - acc: 0.9500 - val_loss: 0.1746 - val_ac
c: 0.8100
Epoch 45/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0412 - acc: 0.9429 - val_loss: 0.1721 - val_ac
c: 0.7960
Epoch 46/500
1/1 [==============================] - 0s 191ms/step - loss: 0.0399 - acc: 0.9500 - val_loss: 0.1704 - val_ac
c: 0.7920
Epoch 47/500
1/1 [==============================] - 0s 180ms/step - loss: 0.0400 - acc: 0.9357 - val_loss: 0.1691 - val_ac
```

```
c: 0.7920
Epoch 48/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0408 - acc: 0.9429 - val_loss: 0.1688 - val_ac
c: 0.7840
Epoch 49/500
1/1 [==============================] - 0s 189ms/step - loss: 0.0384 - acc: 0.9500 - val_loss: 0.1685 - val_ac
c: 0.7840
Epoch 50/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0390 - acc: 0.9429 - val_loss: 0.1690 - val_ac
c: 0.7860
Epoch 51/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0417 - acc: 0.9143 - val_loss: 0.1693 - val_ac
c: 0.7860
Epoch 52/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0376 - acc: 0.9500 - val_loss: 0.1689 - val_ac
c: 0.7860
Epoch 53/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0382 - acc: 0.9643 - val_loss: 0.1684 - val_ac
c: 0.7840
Epoch 54/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0402 - acc: 0.9143 - val_loss: 0.1675 - val_ac
c: 0.7840
Epoch 55/500
1/1 [==============================] - 0s 181ms/step - loss: 0.0383 - acc: 0.9429 - val_loss: 0.1667 - val_ac
c: 0.7880
Epoch 56/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0382 - acc: 0.9643 - val_loss: 0.1660 - val_ac
c: 0.7880
Epoch 57/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0389 - acc: 0.9429 - val_loss: 0.1659 - val_ac
c: 0.7820
Epoch 58/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0383 - acc: 0.9429 - val_loss: 0.1660 - val_ac
c: 0.7860
Epoch 59/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0338 - acc: 0.9429 - val_loss: 0.1656 - val_ac
c: 0.7880
Epoch 60/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0353 - acc: 0.9643 - val_loss: 0.1652 - val_ac
c: 0.7920
Epoch 61/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0405 - acc: 0.9429 - val_loss: 0.1642 - val_ac
c: 0.7960
Epoch 62/500
1/1 [==============================] - 0s 187ms/step - loss: 0.0373 - acc: 0.9429 - val_loss: 0.1638 - val_ac
c: 0.7940
Epoch 63/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0374 - acc: 0.9571 - val_loss: 0.1635 - val_ac
c: 0.7900
Epoch 64/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0352 - acc: 0.9786 - val_loss: 0.1634 - val_ac
c: 0.7900
Epoch 65/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0382 - acc: 0.9357 - val_loss: 0.1636 - val_ac
c: 0.7880
Epoch 66/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0362 - acc: 0.9500 - val_loss: 0.1638 - val_ac
c: 0.7860
Epoch 67/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0338 - acc: 0.9714 - val_loss: 0.1639 - val_ac
c: 0.7860
Epoch 68/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0393 - acc: 0.9429 - val_loss: 0.1639 - val_ac
c: 0.7820
Epoch 69/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0341 - acc: 0.9500 - val_loss: 0.1632 - val_ac
c: 0.7820
Epoch 70/500
1/1 [==============================] - 0s 186ms/step - loss: 0.0317 - acc: 0.9929 - val_loss: 0.1628 - val_ac
c: 0.7780
Epoch 71/500
```

```
1/1 [==============================] - 0s 188ms/step - loss: 0.0325 - acc: 0.9714 - val_loss: 0.1620 - val_ac
c: 0.7780
Epoch 72/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0338 - acc: 0.9500 - val_loss: 0.1607 - val_ac
c: 0.7760
Epoch 73/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0367 - acc: 0.9286 - val_loss: 0.1599 - val_ac
c: 0.7800
Epoch 74/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0334 - acc: 0.9500 - val_loss: 0.1595 - val_ac
c: 0.7820
Epoch 75/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0325 - acc: 0.9786 - val_loss: 0.1589 - val_ac
c: 0.7860
Epoch 76/500
1/1 [==============================] - 0s 186ms/step - loss: 0.0321 - acc: 0.9714 - val_loss: 0.1587 - val_ac
c: 0.7840
Epoch 77/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0338 - acc: 0.9714 - val_loss: 0.1590 - val_ac
c: 0.7820
Epoch 78/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0335 - acc: 0.9643 - val_loss: 0.1597 - val_ac
c: 0.7880
Epoch 79/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0319 - acc: 0.9786 - val_loss: 0.1603 - val_ac
c: 0.7840
Epoch 80/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0352 - acc: 0.9000 - val_loss: 0.1601 - val_ac
c: 0.7800
Epoch 81/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0334 - acc: 0.9571 - val_loss: 0.1596 - val_ac
c: 0.7780
Epoch 82/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0307 - acc: 0.9643 - val_loss: 0.1593 - val_ac
c: 0.7720
Epoch 83/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0344 - acc: 0.9429 - val_loss: 0.1597 - val_ac
c: 0.7760
Epoch 84/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0338 - acc: 0.9643 - val_loss: 0.1603 - val_ac
c: 0.7760
Epoch 85/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0320 - acc: 0.9857 - val_loss: 0.1604 - val_ac
c: 0.7760
Epoch 86/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0327 - acc: 0.9429 - val_loss: 0.1605 - val_ac
c: 0.7740
Epoch 87/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0330 - acc: 0.9786 - val_loss: 0.1605 - val_ac
c: 0.7720
Epoch 88/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0299 - acc: 0.9714 - val_loss: 0.1590 - val_ac
c: 0.7720
Epoch 89/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0342 - acc: 0.9500 - val_loss: 0.1584 - val_ac
c: 0.7760
Epoch 90/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0292 - acc: 0.9857 - val_loss: 0.1579 - val_ac
c: 0.7800
Epoch 91/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0323 - acc: 0.9714 - val_loss: 0.1577 - val_ac
c: 0.7780
Epoch 92/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0300 - acc: 0.9857 - val_loss: 0.1579 - val_ac
c: 0.7820
Epoch 93/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0309 - acc: 0.9714 - val_loss: 0.1580 - val_ac
c: 0.7700
Epoch 94/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0298 - acc: 0.9643 - val_loss: 0.1579 - val_ac
c: 0.7700
```

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Epoch 95/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0296 - acc: 0.9714 - val_loss: 0.1574 - val_ac
c: 0.7720
Epoch 96/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0324 - acc: 0.9357 - val_loss: 0.1566 - val_ac
c: 0.7720
Epoch 97/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0305 - acc: 0.9643 - val_loss: 0.1566 - val_ac
c: 0.7720
Epoch 98/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0301 - acc: 0.9643 - val_loss: 0.1560 - val_ac
c: 0.7700
Epoch 99/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0315 - acc: 0.9500 - val_loss: 0.1556 - val_ac
c: 0.7680
Epoch 100/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0312 - acc: 0.9500 - val_loss: 0.1556 - val_ac
c: 0.7680
Epoch 101/500
1/1 [==============================] - 0s 192ms/step - loss: 0.0326 - acc: 0.9500 - val_loss: 0.1566 - val_ac
c: 0.7740
Epoch 102/500
1/1 [==============================] - 0s 217ms/step - loss: 0.0299 - acc: 0.9500 - val_loss: 0.1567 - val_ac
c: 0.7760
Epoch 103/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0265 - acc: 0.9786 - val_loss: 0.1558 - val_ac
c: 0.7800
Epoch 104/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0303 - acc: 0.9500 - val_loss: 0.1541 - val_ac
c: 0.7780
Epoch 105/500
1/1 [==============================] - 0s 250ms/step - loss: 0.0309 - acc: 0.9786 - val_loss: 0.1524 - val_ac
c: 0.7760
Epoch 106/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0279 - acc: 0.9786 - val_loss: 0.1512 - val_ac
c: 0.7740
Epoch 107/500
1/1 [==============================] - 0s 190ms/step - loss: 0.0302 - acc: 0.9643 - val_loss: 0.1509 - val_ac
c: 0.7700
Epoch 108/500
1/1 [==============================] - 0s 197ms/step - loss: 0.0279 - acc: 0.9786 - val_loss: 0.1506 - val_ac
c: 0.7700
Epoch 109/500
1/1 [==============================] - 0s 197ms/step - loss: 0.0298 - acc: 0.9786 - val_loss: 0.1512 - val_ac
c: 0.7740
Epoch 110/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0294 - acc: 0.9857 - val_loss: 0.1516 - val_ac
c: 0.7780
Epoch 111/500
1/1 [==============================] - 0s 211ms/step - loss: 0.0289 - acc: 0.9786 - val_loss: 0.1510 - val_ac
c: 0.7840
Epoch 112/500
1/1 [==============================] - 0s 202ms/step - loss: 0.0271 - acc: 0.9714 - val_loss: 0.1504 - val_ac
c: 0.7820
Epoch 113/500
1/1 [==============================] - 0s 189ms/step - loss: 0.0282 - acc: 0.9786 - val_loss: 0.1508 - val_ac
c: 0.7800
Epoch 114/500
1/1 [==============================] - 0s 212ms/step - loss: 0.0301 - acc: 0.9571 - val_loss: 0.1510 - val_ac
c: 0.7840
Epoch 115/500
1/1 [==============================] - 0s 189ms/step - loss: 0.0292 - acc: 0.9357 - val_loss: 0.1526 - val_ac
c: 0.7820
Epoch 116/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0306 - acc: 0.9357 - val_loss: 0.1529 - val_ac
c: 0.7840
Epoch 117/500
1/1 [==============================] - 0s 196ms/step - loss: 0.0308 - acc: 0.9571 - val_loss: 0.1512 - val_ac
c: 0.7800
Epoch 118/500
1/1 [==============================] - 0s 206ms/step - loss: 0.0287 - acc: 0.9571 - val_loss: 0.1500 - val_ac
```

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c: 0.7780
Epoch 119/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0261 - acc: 0.9786 - val_loss: 0.1503 - val_ac
c: 0.7760
Epoch 120/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0283 - acc: 0.9643 - val_loss: 0.1515 - val_ac
c: 0.7780
Epoch 121/500
1/1 [==============================] - 0s 190ms/step - loss: 0.0292 - acc: 0.9643 - val_loss: 0.1518 - val_ac
c: 0.7860
Epoch 122/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0257 - acc: 0.9857 - val_loss: 0.1508 - val_ac
c: 0.7840
Epoch 123/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0278 - acc: 0.9714 - val_loss: 0.1494 - val_ac
c: 0.7860
Epoch 124/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0298 - acc: 0.9786 - val_loss: 0.1488 - val_ac
c: 0.7880
Epoch 125/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0283 - acc: 0.9643 - val_loss: 0.1504 - val_ac
c: 0.7860
Epoch 126/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0259 - acc: 0.9786 - val_loss: 0.1515 - val_ac
c: 0.7820
Epoch 127/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0262 - acc: 0.9786 - val_loss: 0.1511 - val_ac
c: 0.7800
Epoch 128/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0261 - acc: 0.9643 - val_loss: 0.1492 - val_ac
c: 0.7840
Epoch 129/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0257 - acc: 0.9857 - val_loss: 0.1477 - val_ac
c: 0.7840
Epoch 130/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0271 - acc: 0.9571 - val_loss: 0.1468 - val_ac
c: 0.7820
Epoch 131/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0274 - acc: 0.9571 - val_loss: 0.1471 - val_ac
c: 0.7820
Epoch 132/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0284 - acc: 0.9500 - val_loss: 0.1482 - val_ac
c: 0.7800
Epoch 133/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0264 - acc: 0.9786 - val_loss: 0.1489 - val_ac
c: 0.7820
Epoch 134/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0255 - acc: 0.9714 - val_loss: 0.1502 - val_ac
c: 0.7800
Epoch 135/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0259 - acc: 0.9786 - val_loss: 0.1514 - val_ac
c: 0.7800
Epoch 136/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0256 - acc: 0.9857 - val_loss: 0.1531 - val_ac
c: 0.7820
Epoch 137/500
1/1 [==============================] - 0s 224ms/step - loss: 0.0278 - acc: 0.9286 - val_loss: 0.1535 - val_ac
c: 0.7760
Epoch 138/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0263 - acc: 0.9714 - val_loss: 0.1533 - val_ac
c: 0.7740
Epoch 139/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0269 - acc: 0.9714 - val_loss: 0.1523 - val_ac
c: 0.7720
Epoch 140/500
1/1 [==============================] - 0s 197ms/step - loss: 0.0271 - acc: 0.9500 - val_loss: 0.1513 - val_ac
c: 0.7760
Epoch 141/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0236 - acc: 0.9857 - val_loss: 0.1513 - val_ac
c: 0.7700
Epoch 142/500
```

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1/1 [==============================] - 0s 165ms/step - loss: 0.0299 - acc: 0.9214 - val_loss: 0.1504 - val_ac
c: 0.7640
Epoch 143/500
1/1 [==============================] - 0s 162ms/step - loss: 0.0253 - acc: 0.9714 - val_loss: 0.1481 - val_ac
c: 0.7720
Epoch 144/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0254 - acc: 0.9500 - val_loss: 0.1466 - val_ac
c: 0.7720
Epoch 145/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0249 - acc: 0.9786 - val_loss: 0.1453 - val_ac
c: 0.7840
Epoch 146/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0254 - acc: 0.9643 - val_loss: 0.1447 - val_ac
c: 0.7780
Epoch 147/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0252 - acc: 0.9857 - val_loss: 0.1445 - val_ac
c: 0.7780
Epoch 148/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0240 - acc: 0.9857 - val_loss: 0.1456 - val_ac
c: 0.7820
Epoch 149/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0248 - acc: 0.9929 - val_loss: 0.1476 - val_ac
c: 0.7820
Epoch 150/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0261 - acc: 0.9786 - val_loss: 0.1503 - val_ac
c: 0.7740
Epoch 151/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0240 - acc: 0.9714 - val_loss: 0.1520 - val_ac
c: 0.7700
Epoch 152/500
1/1 [==============================] - 0s 162ms/step - loss: 0.0257 - acc: 0.9786 - val_loss: 0.1529 - val_ac
c: 0.7680
Epoch 153/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0271 - acc: 0.9571 - val_loss: 0.1524 - val_ac
c: 0.7660
Epoch 154/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0244 - acc: 0.9714 - val_loss: 0.1509 - val_ac
c: 0.7700
Epoch 155/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0261 - acc: 0.9571 - val_loss: 0.1478 - val_ac
c: 0.7760
Epoch 156/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0235 - acc: 0.9929 - val_loss: 0.1455 - val_ac
c: 0.7760
Epoch 157/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0255 - acc: 0.9714 - val_loss: 0.1440 - val_ac
c: 0.7820
Epoch 158/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0251 - acc: 0.9643 - val_loss: 0.1444 - val_ac
c: 0.7920
Epoch 159/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0239 - acc: 0.9857 - val_loss: 0.1455 - val_ac
c: 0.7920
Epoch 160/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0251 - acc: 0.9643 - val_loss: 0.1476 - val_ac
c: 0.7860
Epoch 161/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0254 - acc: 0.9786 - val_loss: 0.1488 - val_ac
c: 0.7840
Epoch 162/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0236 - acc: 0.9929 - val_loss: 0.1502 - val_ac
c: 0.7800
Epoch 163/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0255 - acc: 0.9571 - val_loss: 0.1517 - val_ac
c: 0.7820
Epoch 164/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0224 - acc: 1.0000 - val_loss: 0.1523 - val_ac
c: 0.7720
Epoch 165/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0235 - acc: 0.9714 - val_loss: 0.1511 - val_ac
c: 0.7740
```

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Epoch 166/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0252 - acc: 0.9786 - val_loss: 0.1487 - val_ac
c: 0.7780
Epoch 167/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0266 - acc: 0.9857 - val_loss: 0.1483 - val_ac
c: 0.7780
Epoch 168/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0238 - acc: 0.9929 - val_loss: 0.1483 - val_ac
c: 0.7720
Epoch 169/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0244 - acc: 0.9929 - val_loss: 0.1471 - val_ac
c: 0.7680
Epoch 170/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0244 - acc: 0.9857 - val_loss: 0.1450 - val_ac
c: 0.7720
Epoch 171/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0253 - acc: 0.9643 - val_loss: 0.1429 - val_ac
c: 0.7760
Epoch 172/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0241 - acc: 0.9714 - val_loss: 0.1423 - val_ac
c: 0.7900
Epoch 173/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0251 - acc: 0.9500 - val_loss: 0.1436 - val_ac
c: 0.7880
Epoch 174/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0247 - acc: 0.9714 - val_loss: 0.1454 - val_ac
c: 0.7840
Epoch 175/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0237 - acc: 0.9929 - val_loss: 0.1464 - val_ac
c: 0.7820
Epoch 176/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0261 - acc: 0.9571 - val_loss: 0.1466 - val_ac
c: 0.7780
Epoch 177/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0241 - acc: 0.9643 - val_loss: 0.1465 - val_ac
c: 0.7780
Epoch 178/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0241 - acc: 0.9714 - val_loss: 0.1453 - val_ac
c: 0.7800
Epoch 179/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0238 - acc: 0.9786 - val_loss: 0.1447 - val_ac
c: 0.7780
Epoch 180/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0244 - acc: 0.9500 - val_loss: 0.1452 - val_ac
c: 0.7760
Epoch 181/500
1/1 [==============================] - 0s 160ms/step - loss: 0.0225 - acc: 0.9929 - val_loss: 0.1458 - val_ac
c: 0.7760
Epoch 182/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0255 - acc: 0.9571 - val_loss: 0.1454 - val_ac
c: 0.7800
Epoch 183/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0255 - acc: 0.9500 - val_loss: 0.1446 - val_ac
c: 0.7840
Epoch 184/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0239 - acc: 0.9714 - val_loss: 0.1442 - val_ac
c: 0.7780
Epoch 185/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0247 - acc: 0.9714 - val_loss: 0.1438 - val_ac
c: 0.7760
Epoch 186/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0239 - acc: 0.9714 - val_loss: 0.1445 - val_ac
c: 0.7680
Epoch 187/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0246 - acc: 0.9714 - val_loss: 0.1443 - val_ac
c: 0.7600
Epoch 188/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0249 - acc: 0.9714 - val_loss: 0.1428 - val_ac
c: 0.7680
Epoch 189/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0232 - acc: 0.9714 - val_loss: 0.1418 - val_ac
```

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c: 0.7720
Epoch 190/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0247 - acc: 0.9571 - val_loss: 0.1416 - val_ac
c: 0.7720
Epoch 191/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0232 - acc: 0.9714 - val_loss: 0.1429 - val_ac
c: 0.7740
Epoch 192/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0240 - acc: 0.9714 - val_loss: 0.1453 - val_ac
c: 0.7700
Epoch 193/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0254 - acc: 0.9429 - val_loss: 0.1468 - val_ac
c: 0.7760
Epoch 194/500
1/1 [==============================] - 0s 162ms/step - loss: 0.0238 - acc: 0.9786 - val_loss: 0.1454 - val_ac
c: 0.7760
Epoch 195/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0232 - acc: 0.9714 - val_loss: 0.1438 - val_ac
c: 0.7820
Epoch 196/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0228 - acc: 0.9643 - val_loss: 0.1421 - val_ac
c: 0.7880
Epoch 197/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0235 - acc: 0.9643 - val_loss: 0.1403 - val_ac
c: 0.7820
Epoch 198/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0225 - acc: 0.9643 - val_loss: 0.1405 - val_ac
c: 0.7760
Epoch 199/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0233 - acc: 0.9786 - val_loss: 0.1408 - val_ac
c: 0.7660
Epoch 200/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0226 - acc: 0.9857 - val_loss: 0.1420 - val_ac
c: 0.7680
Epoch 201/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0235 - acc: 0.9571 - val_loss: 0.1436 - val_ac
c: 0.7680
Epoch 202/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0226 - acc: 0.9857 - val_loss: 0.1440 - val_ac
c: 0.7680
Epoch 203/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0248 - acc: 0.9500 - val_loss: 0.1430 - val_ac
c: 0.7680
Epoch 204/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0209 - acc: 0.9714 - val_loss: 0.1417 - val_ac
c: 0.7760
Epoch 205/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0258 - acc: 0.9571 - val_loss: 0.1396 - val_ac
c: 0.7820
Epoch 206/500
1/1 [==============================] - 0s 181ms/step - loss: 0.0208 - acc: 0.9643 - val_loss: 0.1389 - val_ac
c: 0.7780
Epoch 207/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0228 - acc: 0.9714 - val_loss: 0.1402 - val_ac
c: 0.7740
Epoch 208/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0235 - acc: 0.9571 - val_loss: 0.1431 - val_ac
c: 0.7740
Epoch 209/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0263 - acc: 0.9500 - val_loss: 0.1466 - val_ac
c: 0.7600
Epoch 210/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0221 - acc: 0.9929 - val_loss: 0.1490 - val_ac
c: 0.7560
Epoch 211/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0225 - acc: 0.9786 - val_loss: 0.1505 - val_ac
c: 0.7500
Epoch 212/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0224 - acc: 0.9857 - val_loss: 0.1526 - val_ac
c: 0.7540
Epoch 213/500
```

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1/1 [==============================] - 0s 165ms/step - loss: 0.0229 - acc: 0.9786 - val_loss: 0.1528 - val_ac
c: 0.7520
Epoch 214/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0227 - acc: 0.9643 - val_loss: 0.1500 - val_ac
c: 0.7680
Epoch 215/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0219 - acc: 0.9786 - val_loss: 0.1467 - val_ac
c: 0.7820
Epoch 216/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0240 - acc: 0.9786 - val_loss: 0.1448 - val_ac
c: 0.7800
Epoch 217/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0221 - acc: 0.9714 - val_loss: 0.1457 - val_ac
c: 0.7700
Epoch 218/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0216 - acc: 0.9929 - val_loss: 0.1458 - val_ac
c: 0.7700
Epoch 219/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0240 - acc: 0.9571 - val_loss: 0.1470 - val_ac
c: 0.7680
Epoch 220/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0226 - acc: 0.9571 - val_loss: 0.1488 - val_ac
c: 0.7580
Epoch 221/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0241 - acc: 0.9429 - val_loss: 0.1493 - val_ac
c: 0.7620
Epoch 222/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0205 - acc: 0.9857 - val_loss: 0.1495 - val_ac
c: 0.7580
Epoch 223/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0205 - acc: 0.9929 - val_loss: 0.1494 - val_ac
c: 0.7620
Epoch 224/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0217 - acc: 0.9786 - val_loss: 0.1489 - val_ac
c: 0.7660
Epoch 225/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0212 - acc: 0.9786 - val_loss: 0.1475 - val_ac
c: 0.7640
Epoch 226/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0229 - acc: 0.9786 - val_loss: 0.1479 - val_ac
c: 0.7640
Epoch 227/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0221 - acc: 0.9786 - val_loss: 0.1476 - val_ac
c: 0.7660
Epoch 228/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0228 - acc: 0.9714 - val_loss: 0.1460 - val_ac
c: 0.7640
Epoch 229/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0220 - acc: 0.9643 - val_loss: 0.1443 - val_ac
c: 0.7680
Epoch 230/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0234 - acc: 0.9500 - val_loss: 0.1427 - val_ac
c: 0.7700
Epoch 231/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0217 - acc: 0.9786 - val_loss: 0.1415 - val_ac
c: 0.7700
Epoch 232/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0218 - acc: 0.9786 - val_loss: 0.1419 - val_ac
c: 0.7660
Epoch 233/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0190 - acc: 0.9857 - val_loss: 0.1423 - val_ac
c: 0.7700
Epoch 234/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0217 - acc: 0.9929 - val_loss: 0.1434 - val_ac
c: 0.7720
Epoch 235/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0227 - acc: 0.9643 - val_loss: 0.1457 - val_ac
c: 0.7680
Epoch 236/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0214 - acc: 0.9857 - val_loss: 0.1483 - val_ac
c: 0.7560
```

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Epoch 237/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0212 - acc: 0.9857 - val_loss: 0.1488 - val_ac
c: 0.7520
Epoch 238/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0225 - acc: 0.9643 - val_loss: 0.1481 - val_ac
c: 0.7540
Epoch 239/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0226 - acc: 0.9643 - val_loss: 0.1458 - val_ac
c: 0.7580
Epoch 240/500
1/1 [==============================] - 0s 180ms/step - loss: 0.0191 - acc: 1.0000 - val_loss: 0.1451 - val_ac
c: 0.7800
Epoch 241/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0214 - acc: 0.9714 - val_loss: 0.1455 - val_ac
c: 0.7780
Epoch 242/500
1/1 [==============================] - 0s 162ms/step - loss: 0.0218 - acc: 0.9714 - val_loss: 0.1457 - val_ac
c: 0.7820
Epoch 243/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0215 - acc: 0.9857 - val_loss: 0.1443 - val_ac
c: 0.7800
Epoch 244/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0232 - acc: 0.9643 - val_loss: 0.1444 - val_ac
c: 0.7740
Epoch 245/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0208 - acc: 0.9786 - val_loss: 0.1433 - val_ac
c: 0.7740
Epoch 246/500
1/1 [==============================] - 0s 162ms/step - loss: 0.0213 - acc: 0.9714 - val_loss: 0.1427 - val_ac
c: 0.7700
Epoch 247/500
1/1 [==============================] - 0s 180ms/step - loss: 0.0215 - acc: 0.9786 - val_loss: 0.1423 - val_ac
c: 0.7660
Epoch 248/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0222 - acc: 0.9714 - val_loss: 0.1392 - val_ac
c: 0.7740
Epoch 249/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0209 - acc: 0.9929 - val_loss: 0.1395 - val_ac
c: 0.7720
Epoch 250/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0211 - acc: 0.9714 - val_loss: 0.1382 - val_ac
c: 0.7740
Epoch 251/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0234 - acc: 0.9643 - val_loss: 0.1383 - val_ac
c: 0.7720
Epoch 252/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0215 - acc: 0.9714 - val_loss: 0.1405 - val_ac
c: 0.7720
Epoch 253/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0222 - acc: 0.9857 - val_loss: 0.1428 - val_ac
c: 0.7740
Epoch 254/500
1/1 [==============================] - 0s 161ms/step - loss: 0.0231 - acc: 0.9714 - val_loss: 0.1448 - val_ac
c: 0.7720
Epoch 255/500
1/1 [==============================] - 0s 159ms/step - loss: 0.0226 - acc: 0.9714 - val_loss: 0.1474 - val_ac
c: 0.7700
Epoch 256/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0209 - acc: 0.9929 - val_loss: 0.1495 - val_ac
c: 0.7640
Epoch 257/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0202 - acc: 0.9857 - val_loss: 0.1497 - val_ac
c: 0.7620
Epoch 258/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0213 - acc: 0.9929 - val_loss: 0.1484 - val_ac
c: 0.7660
Epoch 259/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0211 - acc: 0.9714 - val_loss: 0.1460 - val_ac
c: 0.7700
Epoch 260/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0193 - acc: 1.0000 - val_loss: 0.1435 - val_ac
```

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c: 0.7720
Epoch 261/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0229 - acc: 0.9714 - val_loss: 0.1416 - val_ac
c: 0.7780
Epoch 262/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0229 - acc: 0.9500 - val_loss: 0.1400 - val_ac
c: 0.7860
Epoch 263/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0208 - acc: 0.9643 - val_loss: 0.1392 - val_ac
c: 0.7920
Epoch 264/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0231 - acc: 0.9286 - val_loss: 0.1399 - val_ac
c: 0.7740
Epoch 265/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0211 - acc: 0.9857 - val_loss: 0.1406 - val_ac
c: 0.7760
Epoch 266/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0184 - acc: 0.9857 - val_loss: 0.1417 - val_ac
c: 0.7740
Epoch 267/500
1/1 [==============================] - 0s 180ms/step - loss: 0.0191 - acc: 1.0000 - val_loss: 0.1419 - val_ac
c: 0.7780
Epoch 268/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0202 - acc: 0.9786 - val_loss: 0.1415 - val_ac
c: 0.7760
Epoch 269/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0211 - acc: 0.9786 - val_loss: 0.1408 - val_ac
c: 0.7760
Epoch 270/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0215 - acc: 0.9714 - val_loss: 0.1403 - val_ac
c: 0.7860
Epoch 271/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0196 - acc: 0.9786 - val_loss: 0.1383 - val_ac
c: 0.7840
Epoch 272/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0209 - acc: 0.9857 - val_loss: 0.1390 - val_ac
c: 0.7860
Epoch 273/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0181 - acc: 0.9929 - val_loss: 0.1405 - val_ac
c: 0.7880
Epoch 274/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0181 - acc: 0.9857 - val_loss: 0.1418 - val_ac
c: 0.7840
Epoch 275/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0210 - acc: 0.9714 - val_loss: 0.1420 - val_ac
c: 0.7760
Epoch 276/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0207 - acc: 0.9857 - val_loss: 0.1413 - val_ac
c: 0.7740
Epoch 277/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0211 - acc: 0.9714 - val_loss: 0.1433 - val_ac
c: 0.7720
Epoch 278/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0204 - acc: 0.9571 - val_loss: 0.1442 - val_ac
c: 0.7740
Epoch 279/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0209 - acc: 0.9714 - val_loss: 0.1452 - val_ac
c: 0.7780
Epoch 280/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0221 - acc: 0.9714 - val_loss: 0.1456 - val_ac
c: 0.7740
Epoch 281/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0215 - acc: 0.9643 - val_loss: 0.1436 - val_ac
c: 0.7720
Epoch 282/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0204 - acc: 0.9857 - val_loss: 0.1411 - val_ac
c: 0.7700
Epoch 283/500
1/1 [==============================] - 0s 190ms/step - loss: 0.0207 - acc: 0.9714 - val_loss: 0.1391 - val_ac
c: 0.7700
Epoch 284/500
```

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1/1 [==============================] - 0s 191ms/step - loss: 0.0210 - acc: 0.9714 - val_loss: 0.1393 - val_ac
c: 0.7760
Epoch 285/500
1/1 [==============================] - 0s 187ms/step - loss: 0.0197 - acc: 0.9929 - val_loss: 0.1384 - val_ac
c: 0.7820
Epoch 286/500
1/1 [==============================] - 0s 199ms/step - loss: 0.0201 - acc: 0.9857 - val_loss: 0.1385 - val_ac
c: 0.7820
Epoch 287/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0203 - acc: 0.9857 - val_loss: 0.1403 - val_ac
c: 0.7800
Epoch 288/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0212 - acc: 0.9571 - val_loss: 0.1409 - val_ac
c: 0.7740
Epoch 289/500
1/1 [==============================] - 0s 200ms/step - loss: 0.0210 - acc: 0.9786 - val_loss: 0.1419 - val_ac
c: 0.7780
Epoch 290/500
1/1 [==============================] - 0s 185ms/step - loss: 0.0191 - acc: 0.9786 - val_loss: 0.1414 - val_ac
c: 0.7800
Epoch 291/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0189 - acc: 0.9786 - val_loss: 0.1387 - val_ac
c: 0.7820
Epoch 292/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0192 - acc: 0.9857 - val_loss: 0.1363 - val_ac
c: 0.7800
Epoch 293/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0202 - acc: 0.9714 - val_loss: 0.1354 - val_ac
c: 0.7740
Epoch 294/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0210 - acc: 0.9714 - val_loss: 0.1355 - val_ac
c: 0.7720
Epoch 295/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0193 - acc: 0.9786 - val_loss: 0.1352 - val_ac
c: 0.7760
Epoch 296/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0199 - acc: 0.9857 - val_loss: 0.1359 - val_ac
c: 0.7700
Epoch 297/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0198 - acc: 0.9643 - val_loss: 0.1360 - val_ac
c: 0.7720
Epoch 298/500
1/1 [==============================] - 0s 191ms/step - loss: 0.0196 - acc: 0.9857 - val_loss: 0.1384 - val_ac
c: 0.7760
Epoch 299/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0193 - acc: 0.9786 - val_loss: 0.1405 - val_ac
c: 0.7760
Epoch 300/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0200 - acc: 0.9786 - val_loss: 0.1411 - val_ac
c: 0.7760
Epoch 301/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0208 - acc: 0.9643 - val_loss: 0.1390 - val_ac
c: 0.7760
Epoch 302/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0204 - acc: 0.9714 - val_loss: 0.1380 - val_ac
c: 0.7740
Epoch 303/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0208 - acc: 0.9643 - val_loss: 0.1362 - val_ac
c: 0.7820
Epoch 304/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0185 - acc: 1.0000 - val_loss: 0.1353 - val_ac
c: 0.7820
Epoch 305/500
1/1 [==============================] - 0s 187ms/step - loss: 0.0209 - acc: 0.9643 - val_loss: 0.1337 - val_ac
c: 0.7880
Epoch 306/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0203 - acc: 0.9643 - val_loss: 0.1349 - val_ac
c: 0.7820
Epoch 307/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0193 - acc: 0.9786 - val_loss: 0.1376 - val_ac
c: 0.7760
```

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Epoch 308/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0186 - acc: 0.9929 - val_loss: 0.1399 - val_ac
c: 0.7700
Epoch 309/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0206 - acc: 0.9714 - val_loss: 0.1439 - val_ac
c: 0.7540
Epoch 310/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0225 - acc: 0.9429 - val_loss: 0.1452 - val_ac
c: 0.7460
Epoch 311/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0191 - acc: 0.9786 - val_loss: 0.1448 - val_ac
c: 0.7640
Epoch 312/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0206 - acc: 0.9857 - val_loss: 0.1442 - val_ac
c: 0.7640
Epoch 313/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0210 - acc: 0.9500 - val_loss: 0.1441 - val_ac
c: 0.7700
Epoch 314/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0177 - acc: 0.9929 - val_loss: 0.1425 - val_ac
c: 0.7720
Epoch 315/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0203 - acc: 0.9929 - val_loss: 0.1401 - val_ac
c: 0.7720
Epoch 316/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0197 - acc: 0.9857 - val_loss: 0.1382 - val_ac
c: 0.7740
Epoch 317/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0197 - acc: 1.0000 - val_loss: 0.1375 - val_ac
c: 0.7780
Epoch 318/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0201 - acc: 0.9857 - val_loss: 0.1365 - val_ac
c: 0.7740
Epoch 319/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0170 - acc: 1.0000 - val_loss: 0.1361 - val_ac
c: 0.7740
Epoch 320/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0195 - acc: 0.9929 - val_loss: 0.1364 - val_ac
c: 0.7820
Epoch 321/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0179 - acc: 1.0000 - val_loss: 0.1366 - val_ac
c: 0.7820
Epoch 322/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0169 - acc: 1.0000 - val_loss: 0.1363 - val_ac
c: 0.7880
Epoch 323/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0194 - acc: 0.9714 - val_loss: 0.1382 - val_ac
c: 0.7840
Epoch 324/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0218 - acc: 0.9643 - val_loss: 0.1408 - val_ac
c: 0.7820
Epoch 325/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0187 - acc: 0.9714 - val_loss: 0.1437 - val_ac
c: 0.7740
Epoch 326/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0187 - acc: 0.9786 - val_loss: 0.1441 - val_ac
c: 0.7680
Epoch 327/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0187 - acc: 0.9786 - val_loss: 0.1436 - val_ac
c: 0.7680
Epoch 328/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0218 - acc: 0.9571 - val_loss: 0.1408 - val_ac
c: 0.7800
Epoch 329/500
1/1 [==============================] - 0s 180ms/step - loss: 0.0192 - acc: 0.9786 - val_loss: 0.1401 - val_ac
c: 0.7720
Epoch 330/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0174 - acc: 0.9714 - val_loss: 0.1402 - val_ac
c: 0.7640
Epoch 331/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0166 - acc: 1.0000 - val_loss: 0.1408 - val_ac
```

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c: 0.7660
Epoch 332/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0178 - acc: 0.9857 - val_loss: 0.1403 - val_ac
c: 0.7760
Epoch 333/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0198 - acc: 0.9714 - val_loss: 0.1401 - val_ac
c: 0.7800
Epoch 334/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0179 - acc: 0.9929 - val_loss: 0.1405 - val_ac
c: 0.7800
Epoch 335/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0190 - acc: 0.9714 - val_loss: 0.1424 - val_ac
c: 0.7660
Epoch 336/500
1/1 [==============================] - 0s 161ms/step - loss: 0.0193 - acc: 0.9786 - val_loss: 0.1438 - val_ac
c: 0.7680
Epoch 337/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0183 - acc: 0.9857 - val_loss: 0.1442 - val_ac
c: 0.7620
Epoch 338/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0194 - acc: 0.9857 - val_loss: 0.1419 - val_ac
c: 0.7660
Epoch 339/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0178 - acc: 0.9714 - val_loss: 0.1398 - val_ac
c: 0.7700
Epoch 340/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0199 - acc: 0.9571 - val_loss: 0.1381 - val_ac
c: 0.7800
Epoch 341/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0217 - acc: 0.9571 - val_loss: 0.1362 - val_ac
c: 0.7840
Epoch 342/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0201 - acc: 0.9714 - val_loss: 0.1369 - val_ac
c: 0.7780
Epoch 343/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0176 - acc: 1.0000 - val_loss: 0.1375 - val_ac
c: 0.7700
Epoch 344/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0198 - acc: 0.9786 - val_loss: 0.1378 - val_ac
c: 0.7820
Epoch 345/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0192 - acc: 0.9786 - val_loss: 0.1383 - val_ac
c: 0.7760
Epoch 346/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0211 - acc: 0.9500 - val_loss: 0.1389 - val_ac
c: 0.7740
Epoch 347/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0201 - acc: 0.9714 - val_loss: 0.1388 - val_ac
c: 0.7740
Epoch 348/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0196 - acc: 0.9714 - val_loss: 0.1373 - val_ac
c: 0.7680
Epoch 349/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0190 - acc: 0.9714 - val_loss: 0.1361 - val_ac
c: 0.7600
Epoch 350/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0179 - acc: 0.9857 - val_loss: 0.1356 - val_ac
c: 0.7720
Epoch 351/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0196 - acc: 0.9786 - val_loss: 0.1362 - val_ac
c: 0.7760
Epoch 352/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0175 - acc: 0.9857 - val_loss: 0.1361 - val_ac
c: 0.7800
Epoch 353/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0183 - acc: 0.9786 - val_loss: 0.1357 - val_ac
c: 0.7780
Epoch 354/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0179 - acc: 0.9929 - val_loss: 0.1361 - val_ac
c: 0.7720
Epoch 355/500
```

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1/1 [==============================] - 0s 167ms/step - loss: 0.0193 - acc: 0.9857 - val_loss: 0.1379 - val_ac
c: 0.7660
Epoch 356/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0173 - acc: 0.9786 - val_loss: 0.1388 - val_ac
c: 0.7760
Epoch 357/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0197 - acc: 0.9643 - val_loss: 0.1423 - val_ac
c: 0.7620
Epoch 358/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0175 - acc: 0.9786 - val_loss: 0.1441 - val_ac
c: 0.7680
Epoch 359/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0189 - acc: 0.9857 - val_loss: 0.1424 - val_ac
c: 0.7720
Epoch 360/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0188 - acc: 0.9643 - val_loss: 0.1418 - val_ac
c: 0.7740
Epoch 361/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0203 - acc: 0.9500 - val_loss: 0.1413 - val_ac
c: 0.7800
Epoch 362/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0163 - acc: 1.0000 - val_loss: 0.1405 - val_ac
c: 0.7740
Epoch 363/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0196 - acc: 0.9714 - val_loss: 0.1414 - val_ac
c: 0.7820
Epoch 364/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0169 - acc: 0.9929 - val_loss: 0.1423 - val_ac
c: 0.7860
Epoch 365/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0169 - acc: 0.9857 - val_loss: 0.1425 - val_ac
c: 0.7820
Epoch 366/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0167 - acc: 0.9929 - val_loss: 0.1408 - val_ac
c: 0.7800
Epoch 367/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0187 - acc: 0.9786 - val_loss: 0.1389 - val_ac
c: 0.7820
Epoch 368/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0172 - acc: 0.9857 - val_loss: 0.1382 - val_ac
c: 0.7900
Epoch 369/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0180 - acc: 0.9857 - val_loss: 0.1399 - val_ac
c: 0.7840
Epoch 370/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0182 - acc: 0.9786 - val_loss: 0.1413 - val_ac
c: 0.7820
Epoch 371/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0182 - acc: 0.9714 - val_loss: 0.1387 - val_ac
c: 0.7840
Epoch 372/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0199 - acc: 0.9786 - val_loss: 0.1363 - val_ac
c: 0.7780
Epoch 373/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0181 - acc: 1.0000 - val_loss: 0.1352 - val_ac
c: 0.7800
Epoch 374/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0168 - acc: 0.9786 - val_loss: 0.1353 - val_ac
c: 0.7800
Epoch 375/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0177 - acc: 0.9929 - val_loss: 0.1369 - val_ac
c: 0.7740
Epoch 376/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0176 - acc: 0.9857 - val_loss: 0.1390 - val_ac
c: 0.7740
Epoch 377/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0178 - acc: 0.9857 - val_loss: 0.1397 - val_ac
c: 0.7780
Epoch 378/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0179 - acc: 0.9786 - val_loss: 0.1401 - val_ac
c: 0.7840
```

```
Epoch 379/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0193 - acc: 0.9643 - val_loss: 0.1407 - val_ac
c: 0.7820
Epoch 380/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0206 - acc: 0.9786 - val_loss: 0.1402 - val_ac
c: 0.7820
Epoch 381/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0184 - acc: 0.9929 - val_loss: 0.1410 - val_ac
c: 0.7740
Epoch 382/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0195 - acc: 0.9500 - val_loss: 0.1400 - val_ac
c: 0.7720
Epoch 383/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0199 - acc: 0.9714 - val_loss: 0.1389 - val_ac
c: 0.7640
Epoch 384/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0178 - acc: 0.9929 - val_loss: 0.1400 - val_ac
c: 0.7600
Epoch 385/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0200 - acc: 0.9786 - val_loss: 0.1418 - val_ac
c: 0.7600
Epoch 386/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0198 - acc: 0.9786 - val_loss: 0.1408 - val_ac
c: 0.7720
Epoch 387/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0183 - acc: 0.9786 - val_loss: 0.1405 - val_ac
c: 0.7740
Epoch 388/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0178 - acc: 0.9857 - val_loss: 0.1417 - val_ac
c: 0.7740
Epoch 389/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0181 - acc: 0.9929 - val_loss: 0.1423 - val_ac
c: 0.7700
Epoch 390/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0199 - acc: 0.9643 - val_loss: 0.1419 - val_ac
c: 0.7760
Epoch 391/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0170 - acc: 0.9714 - val_loss: 0.1406 - val_ac
c: 0.7700
Epoch 392/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0180 - acc: 0.9929 - val_loss: 0.1384 - val_ac
c: 0.7640
Epoch 393/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0204 - acc: 0.9643 - val_loss: 0.1372 - val_ac
c: 0.7680
Epoch 394/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0180 - acc: 0.9929 - val_loss: 0.1375 - val_ac
c: 0.7680
Epoch 395/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0175 - acc: 0.9786 - val_loss: 0.1374 - val_ac
c: 0.7640
Epoch 396/500
1/1 [==============================] - 0s 162ms/step - loss: 0.0168 - acc: 0.9929 - val_loss: 0.1378 - val_ac
c: 0.7620
Epoch 397/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0206 - acc: 0.9500 - val_loss: 0.1384 - val_ac
c: 0.7680
Epoch 398/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0183 - acc: 0.9714 - val_loss: 0.1377 - val_ac
c: 0.7660
Epoch 399/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0185 - acc: 0.9857 - val_loss: 0.1389 - val_ac
c: 0.7620
Epoch 400/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0183 - acc: 0.9786 - val_loss: 0.1405 - val_ac
c: 0.7640
Epoch 401/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0191 - acc: 0.9643 - val_loss: 0.1410 - val_ac
c: 0.7560
Epoch 402/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0160 - acc: 1.0000 - val_loss: 0.1416 - val_ac
```

```
c: 0.7520
Epoch 403/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0166 - acc: 0.9786 - val_loss: 0.1441 - val_ac
c: 0.7540
Epoch 404/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0167 - acc: 0.9929 - val_loss: 0.1442 - val_ac
c: 0.7600
Epoch 405/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0163 - acc: 0.9857 - val_loss: 0.1442 - val_ac
c: 0.7680
Epoch 406/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0170 - acc: 0.9857 - val_loss: 0.1416 - val_ac
c: 0.7740
Epoch 407/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0175 - acc: 0.9857 - val_loss: 0.1412 - val_ac
c: 0.7760
Epoch 408/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0173 - acc: 0.9643 - val_loss: 0.1415 - val_ac
c: 0.7700
Epoch 409/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0179 - acc: 0.9857 - val_loss: 0.1423 - val_ac
c: 0.7700
Epoch 410/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0180 - acc: 0.9643 - val_loss: 0.1430 - val_ac
c: 0.7780
Epoch 411/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0178 - acc: 0.9929 - val_loss: 0.1450 - val_ac
c: 0.7680
Epoch 412/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0187 - acc: 0.9786 - val_loss: 0.1457 - val_ac
c: 0.7680
Epoch 413/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0172 - acc: 0.9786 - val_loss: 0.1433 - val_ac
c: 0.7660
Epoch 414/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0158 - acc: 0.9857 - val_loss: 0.1430 - val_ac
c: 0.7580
Epoch 415/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0170 - acc: 0.9786 - val_loss: 0.1419 - val_ac
c: 0.7720
Epoch 416/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0181 - acc: 0.9786 - val_loss: 0.1409 - val_ac
c: 0.7840
Epoch 417/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0159 - acc: 0.9857 - val_loss: 0.1396 - val_ac
c: 0.7880
Epoch 418/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0181 - acc: 0.9786 - val_loss: 0.1397 - val_ac
c: 0.7860
Epoch 419/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0192 - acc: 0.9714 - val_loss: 0.1428 - val_ac
c: 0.7740
Epoch 420/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0171 - acc: 0.9857 - val_loss: 0.1474 - val_ac
c: 0.7660
Epoch 421/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0181 - acc: 0.9786 - val_loss: 0.1501 - val_ac
c: 0.7720
Epoch 422/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0168 - acc: 0.9857 - val_loss: 0.1516 - val_ac
c: 0.7660
Epoch 423/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0211 - acc: 0.9714 - val_loss: 0.1521 - val_ac
c: 0.7580
Epoch 424/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0186 - acc: 0.9786 - val_loss: 0.1491 - val_ac
c: 0.7600
Epoch 425/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0169 - acc: 0.9786 - val_loss: 0.1464 - val_ac
c: 0.7620
Epoch 426/500
```

```
1/1 [==============================] - 0s 175ms/step - loss: 0.0177 - acc: 1.0000 - val_loss: 0.1429 - val_ac
c: 0.7620
Epoch 427/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0184 - acc: 0.9714 - val_loss: 0.1400 - val_ac
c: 0.7740
Epoch 428/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0165 - acc: 1.0000 - val_loss: 0.1384 - val_ac
c: 0.7760
Epoch 429/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0171 - acc: 0.9857 - val_loss: 0.1371 - val_ac
c: 0.7740
Epoch 430/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0154 - acc: 0.9929 - val_loss: 0.1380 - val_ac
c: 0.7720
Epoch 431/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0197 - acc: 0.9714 - val_loss: 0.1411 - val_ac
c: 0.7640
Epoch 432/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0188 - acc: 0.9786 - val_loss: 0.1433 - val_ac
c: 0.7620
Epoch 433/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0181 - acc: 0.9786 - val_loss: 0.1424 - val_ac
c: 0.7620
Epoch 434/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0189 - acc: 0.9643 - val_loss: 0.1408 - val_ac
c: 0.7640
Epoch 435/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0177 - acc: 0.9857 - val_loss: 0.1398 - val_ac
c: 0.7640
Epoch 436/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0169 - acc: 0.9857 - val_loss: 0.1392 - val_ac
c: 0.7660
Epoch 437/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0168 - acc: 0.9857 - val_loss: 0.1420 - val_ac
c: 0.7580
Epoch 438/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0164 - acc: 0.9857 - val_loss: 0.1458 - val_ac
c: 0.7500
Epoch 439/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0185 - acc: 0.9643 - val_loss: 0.1475 - val_ac
c: 0.7500
Epoch 440/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0185 - acc: 0.9786 - val_loss: 0.1491 - val_ac
c: 0.7520
Epoch 441/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0172 - acc: 0.9857 - val_loss: 0.1502 - val_ac
c: 0.7540
Epoch 442/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0156 - acc: 0.9929 - val_loss: 0.1479 - val_ac
c: 0.7620
Epoch 443/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0185 - acc: 0.9714 - val_loss: 0.1434 - val_ac
c: 0.7660
Epoch 444/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0159 - acc: 0.9929 - val_loss: 0.1392 - val_ac
c: 0.7720
Epoch 445/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0177 - acc: 0.9857 - val_loss: 0.1367 - val_ac
c: 0.7840
Epoch 446/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0167 - acc: 0.9857 - val_loss: 0.1360 - val_ac
c: 0.7840
Epoch 447/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0170 - acc: 0.9786 - val_loss: 0.1373 - val_ac
c: 0.7800
Epoch 448/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0165 - acc: 0.9929 - val_loss: 0.1386 - val_ac
c: 0.7740
Epoch 449/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0186 - acc: 0.9714 - val_loss: 0.1402 - val_ac
c: 0.7660
```

```
Epoch 450/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0171 - acc: 0.9929 - val_loss: 0.1405 - val_ac
c: 0.7720
Epoch 451/500
1/1 [==============================] - 0s 162ms/step - loss: 0.0184 - acc: 0.9857 - val_loss: 0.1409 - val_ac
c: 0.7700
Epoch 452/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0175 - acc: 0.9786 - val_loss: 0.1426 - val_ac
c: 0.7680
Epoch 453/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0180 - acc: 0.9786 - val_loss: 0.1453 - val_ac
c: 0.7600
Epoch 454/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0179 - acc: 0.9786 - val_loss: 0.1448 - val_ac
c: 0.7620
Epoch 455/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0176 - acc: 0.9929 - val_loss: 0.1430 - val_ac
c: 0.7660
Epoch 456/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0176 - acc: 0.9857 - val_loss: 0.1401 - val_ac
c: 0.7640
Epoch 457/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0176 - acc: 0.9786 - val_loss: 0.1403 - val_ac
c: 0.7620
Epoch 458/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0175 - acc: 0.9857 - val_loss: 0.1407 - val_ac
c: 0.7700
Epoch 459/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0179 - acc: 1.0000 - val_loss: 0.1432 - val_ac
c: 0.7660
Epoch 460/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0188 - acc: 0.9643 - val_loss: 0.1482 - val_ac
c: 0.7580
Epoch 461/500
1/1 [==============================] - 0s 162ms/step - loss: 0.0168 - acc: 1.0000 - val_loss: 0.1529 - val_ac
c: 0.7460
Epoch 462/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0166 - acc: 0.9929 - val_loss: 0.1541 - val_ac
c: 0.7440
Epoch 463/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0169 - acc: 0.9929 - val_loss: 0.1521 - val_ac
c: 0.7540
Epoch 464/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0170 - acc: 0.9786 - val_loss: 0.1506 - val_ac
c: 0.7600
Epoch 465/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0173 - acc: 0.9857 - val_loss: 0.1488 - val_ac
c: 0.7660
Epoch 466/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0198 - acc: 0.9714 - val_loss: 0.1448 - val_ac
c: 0.7700
Epoch 467/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0197 - acc: 0.9571 - val_loss: 0.1423 - val_ac
c: 0.7760
Epoch 468/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0164 - acc: 0.9786 - val_loss: 0.1412 - val_ac
c: 0.7800
Epoch 469/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0165 - acc: 1.0000 - val_loss: 0.1409 - val_ac
c: 0.7840
Epoch 470/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0186 - acc: 0.9714 - val_loss: 0.1434 - val_ac
c: 0.7720
Epoch 471/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0169 - acc: 0.9857 - val_loss: 0.1480 - val_ac
c: 0.7660
Epoch 472/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0170 - acc: 0.9643 - val_loss: 0.1553 - val_ac
c: 0.7560
Epoch 473/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0178 - acc: 0.9929 - val_loss: 0.1604 - val_ac
```

```
c: 0.7500
Epoch 474/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0180 - acc: 0.9714 - val_loss: 0.1588 - val_ac
c: 0.7540
Epoch 475/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0175 - acc: 0.9929 - val_loss: 0.1525 - val_ac
c: 0.7680
Epoch 476/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0153 - acc: 1.0000 - val_loss: 0.1477 - val_ac
c: 0.7680
Epoch 477/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0166 - acc: 0.9857 - val_loss: 0.1435 - val_ac
c: 0.7760
Epoch 478/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0173 - acc: 0.9929 - val_loss: 0.1399 - val_ac
c: 0.7800
Epoch 479/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0187 - acc: 0.9857 - val_loss: 0.1403 - val_ac
c: 0.7820
Epoch 480/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0169 - acc: 0.9714 - val_loss: 0.1416 - val_ac
c: 0.7840
Epoch 481/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0170 - acc: 0.9714 - val_loss: 0.1415 - val_ac
c: 0.7780
Epoch 482/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0169 - acc: 0.9857 - val_loss: 0.1428 - val_ac
c: 0.7760
Epoch 483/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0171 - acc: 0.9929 - val_loss: 0.1444 - val_ac
c: 0.7620
Epoch 484/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0171 - acc: 0.9714 - val_loss: 0.1442 - val_ac
c: 0.7580
Epoch 485/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0185 - acc: 0.9643 - val_loss: 0.1429 - val_ac
c: 0.7700
Epoch 486/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0159 - acc: 0.9929 - val_loss: 0.1425 - val_ac
c: 0.7700
Epoch 487/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0181 - acc: 0.9714 - val_loss: 0.1438 - val_ac
c: 0.7780
Epoch 488/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0171 - acc: 0.9857 - val_loss: 0.1448 - val_ac
c: 0.7760
Epoch 489/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0177 - acc: 0.9857 - val_loss: 0.1438 - val_ac
c: 0.7760
Epoch 490/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0185 - acc: 0.9714 - val_loss: 0.1429 - val_ac
c: 0.7720
Epoch 491/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0180 - acc: 0.9857 - val_loss: 0.1395 - val_ac
c: 0.7660
Epoch 492/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0171 - acc: 0.9786 - val_loss: 0.1400 - val_ac
c: 0.7700
Epoch 493/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0166 - acc: 0.9857 - val_loss: 0.1431 - val_ac
c: 0.7600
Epoch 494/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0158 - acc: 0.9857 - val_loss: 0.1447 - val_ac
c: 0.7580
Epoch 495/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0170 - acc: 0.9786 - val_loss: 0.1418 - val_ac
c: 0.7580
Epoch 496/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0169 - acc: 0.9643 - val_loss: 0.1371 - val_ac
c: 0.7860
Epoch 497/500
```

```
1/1 [==============================] - 0s 166ms/step - loss: 0.0174 - acc: 0.9786 - val_loss: 0.1342 - val_ac
c: 0.7900
Epoch 498/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0163 - acc: 0.9929 - val_loss: 0.1335 - val_ac
c: 0.7880
Epoch 499/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0155 - acc: 0.9929 - val_loss: 0.1350 - val_ac
c: 0.7800
Epoch 500/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0170 - acc: 0.9643 - val_loss: 0.1347 - val_ac
c: 0.7720
```

Out[ ]: <tensorflow.python.keras.callbacks.History at 0x22329b937c8>

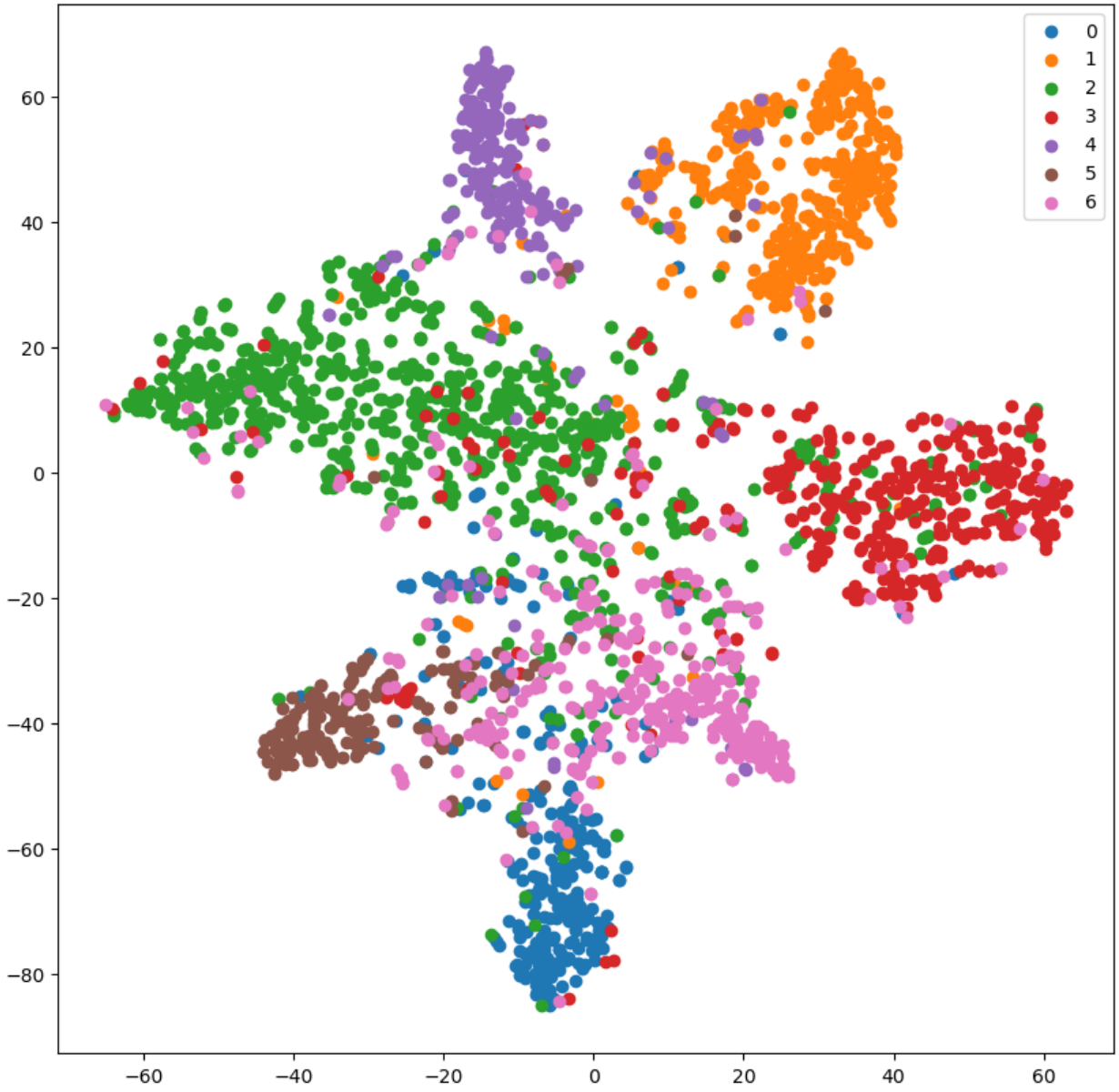
In [ ]:
```
# Evaluate model
X_te = X[test_mask]
A_te = A[test_mask,:][:,test_mask]
y_te = labels_encoded[test_mask]

y_pred = model.predict([X_te, A_te], batch_size=N)
report = classification_report(np.argmax(y_te,axis=1), np.argmax(y_pred,axis=1), target_names=classes)
print('GCN Classification Report: \n {}'.format(report))
```

```
GCN Classification Report:
                        precision    recall  f1-score   support

            Case_Based       0.80      0.72      0.76       114
    Genetic_Algorithms       0.90      0.85      0.87       156
       Neural_Networks       0.77      0.71      0.74       290
 Probabilistic_Methods       0.76      0.70      0.73       172
Reinforcement_Learning       0.70      0.76      0.73        85
         Rule_Learning       0.52      0.87      0.65        60
                Theory       0.58      0.62      0.60       123

              accuracy                           0.73      1000
             macro avg       0.72      0.75      0.73      1000
          weighted avg       0.75      0.73      0.74      1000
```

Get hidden layer representation for GCN

In [ ]:
```
layer_outputs = [layer.output for layer in model.layers]
activation_model = Model(inputs=model.input, outputs=layer_outputs)
activations = activation_model.predict([X,A],batch_size=N)

#Get t-SNE Representation
#get the hidden layer representation after the first GCN layer
x_tsne = TSNE(n_components=2).fit_transform(activations[3])
```

In [ ]:
```
def plot_tSNE(labels_encoded,x_tsne):
    color_map = np.argmax(labels_encoded, axis=1)
    plt.figure(figsize=(10,10))
    for cl in range(num_classes):
        indices = np.where(color_map==cl)
        indices = indices[0]
        plt.scatter(x_tsne[indices,0], x_tsne[indices, 1], label=cl)
    plt.legend()
    plt.show()

plot_tSNE(labels_encoded,x_tsne)
```



Comparison to Fully-Connected Neural Networks

Building and Training FNN

In [ ]:
```
es_patience = 250
optimizer = Adam(lr=1e-2)
l2_reg = 5e-4
epochs = 500

#Compare with FNN
#Construct the model
model_fnn = Sequential()
model_fnn.add(Dense(
                    128,
                    input_dim=X.shape[1],
                    activation=tf.nn.relu,
                    kernel_regularizer=tf.keras.regularizers.l2(l2_reg))
              )
model_fnn.add(Dropout(0.5))
model_fnn.add(Dense(256, activation=tf.nn.relu))
model_fnn.add(Dropout(0.5))
model_fnn.add(Dense(num_classes, activation=tf.keras.activations.softmax))
```

```
model_fnn.compile(optimizer=optimizer,
              loss='categorical_crossentropy',
              weighted_metrics=['acc'])


#define TensorBoard
tbCallBack_FNN = TensorBoard(
    log_dir='./Tensorboard_FNN_cora',
)

#Train model
validation_data_fnn = (X, labels_encoded, val_mask)
model_fnn.fit(
                X,labels_encoded,
                sample_weight=train_mask,
                epochs=epochs,
                batch_size=N,
                validation_data=validation_data_fnn,
                shuffle=False,
                callbacks=[
                  EarlyStopping(patience=es_patience,  restore_best_weights=True),
                  tbCallBack_FNN
          ])
```

```
Epoch 1/500
1/1 [==============================] - 0s 252ms/step - loss: 0.2186 - acc: 0.1643 - val_loss: 0.4349 - val_ac
c: 0.2120
Epoch 2/500
1/1 [==============================] - ETA: 0s - loss: 0.1745 - acc: 0.4071WARNING:tensorflow:Method (on_trai
n_batch_end) is slow compared to the batch update (0.140708). Check your callbacks.
1/1 [==============================] - 0s 173ms/step - loss: 0.1745 - acc: 0.4071 - val_loss: 0.4012 - val_ac
c: 0.3360
Epoch 3/500
1/1 [==============================] - 0s 175ms/step - loss: 0.1413 - acc: 0.5000 - val_loss: 0.3704 - val_ac
c: 0.4500
Epoch 4/500
1/1 [==============================] - 0s 190ms/step - loss: 0.1129 - acc: 0.6857 - val_loss: 0.3394 - val_ac
c: 0.5280
Epoch 5/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0876 - acc: 0.8500 - val_loss: 0.3044 - val_ac
c: 0.5620
Epoch 6/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0680 - acc: 0.8500 - val_loss: 0.2739 - val_ac
c: 0.5720
Epoch 7/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0522 - acc: 0.9143 - val_loss: 0.2588 - val_ac
c: 0.5680
Epoch 8/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0458 - acc: 0.9286 - val_loss: 0.2684 - val_ac
c: 0.5660
Epoch 9/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0434 - acc: 0.9571 - val_loss: 0.2902 - val_ac
c: 0.5420
Epoch 10/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0427 - acc: 0.9786 - val_loss: 0.3191 - val_ac
c: 0.5120
Epoch 11/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0423 - acc: 0.9929 - val_loss: 0.3531 - val_ac
c: 0.5100
Epoch 12/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0427 - acc: 0.9786 - val_loss: 0.3845 - val_ac
c: 0.5200
Epoch 13/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0406 - acc: 1.0000 - val_loss: 0.4083 - val_ac
c: 0.5220
Epoch 14/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0397 - acc: 0.9857 - val_loss: 0.4298 - val_ac
c: 0.5300
Epoch 15/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0374 - acc: 0.9857 - val_loss: 0.4379 - val_ac
c: 0.5300
Epoch 16/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0343 - acc: 0.9929 - val_loss: 0.4304 - val_ac
c: 0.5240
Epoch 17/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0311 - acc: 0.9929 - val_loss: 0.4155 - val_ac
c: 0.5360
Epoch 18/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0283 - acc: 1.0000 - val_loss: 0.4007 - val_ac
c: 0.5640
Epoch 19/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0271 - acc: 0.9929 - val_loss: 0.3938 - val_ac
c: 0.5660
Epoch 20/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0241 - acc: 0.9929 - val_loss: 0.3923 - val_ac
c: 0.5580
Epoch 21/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0287 - acc: 0.9714 - val_loss: 0.3971 - val_ac
c: 0.5320
Epoch 22/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0213 - acc: 0.9857 - val_loss: 0.4238 - val_ac
c: 0.5140
Epoch 23/500
1/1 [==============================] - 0s 180ms/step - loss: 0.0226 - acc: 0.9714 - val_loss: 0.4685 - val_ac
c: 0.4740
```

```
Epoch 24/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0201 - acc: 0.9857 - val_loss: 0.4912 - val_ac
c: 0.4700
Epoch 25/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0240 - acc: 0.9429 - val_loss: 0.4222 - val_ac
c: 0.4940
Epoch 26/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0193 - acc: 0.9857 - val_loss: 0.3774 - val_ac
c: 0.5120
Epoch 27/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0192 - acc: 0.9857 - val_loss: 0.3632 - val_ac
c: 0.5220
Epoch 28/500
1/1 [==============================] - 0s 192ms/step - loss: 0.0220 - acc: 0.9643 - val_loss: 0.3598 - val_ac
c: 0.5380
Epoch 29/500
1/1 [==============================] - 0s 214ms/step - loss: 0.0212 - acc: 0.9857 - val_loss: 0.3597 - val_ac
c: 0.5280
Epoch 30/500
1/1 [==============================] - 0s 247ms/step - loss: 0.0214 - acc: 0.9857 - val_loss: 0.3475 - val_ac
c: 0.5220
Epoch 31/500
1/1 [==============================] - 0s 227ms/step - loss: 0.0208 - acc: 0.9857 - val_loss: 0.3412 - val_ac
c: 0.5120
Epoch 32/500
1/1 [==============================] - 0s 239ms/step - loss: 0.0202 - acc: 1.0000 - val_loss: 0.3374 - val_ac
c: 0.5300
Epoch 33/500
1/1 [==============================] - 0s 275ms/step - loss: 0.0207 - acc: 1.0000 - val_loss: 0.3347 - val_ac
c: 0.5340
Epoch 34/500
1/1 [==============================] - 0s 285ms/step - loss: 0.0227 - acc: 0.9786 - val_loss: 0.3333 - val_ac
c: 0.5360
Epoch 35/500
1/1 [==============================] - 0s 225ms/step - loss: 0.0227 - acc: 0.9857 - val_loss: 0.3353 - val_ac
c: 0.5400
Epoch 36/500
1/1 [==============================] - 0s 230ms/step - loss: 0.0233 - acc: 0.9929 - val_loss: 0.3470 - val_ac
c: 0.5260
Epoch 37/500
1/1 [==============================] - 0s 211ms/step - loss: 0.0231 - acc: 0.9857 - val_loss: 0.3491 - val_ac
c: 0.5320
Epoch 38/500
1/1 [==============================] - 0s 243ms/step - loss: 0.0224 - acc: 1.0000 - val_loss: 0.3409 - val_ac
c: 0.5380
Epoch 39/500
1/1 [==============================] - 0s 225ms/step - loss: 0.0225 - acc: 0.9929 - val_loss: 0.3328 - val_ac
c: 0.5360
Epoch 40/500
1/1 [==============================] - 0s 228ms/step - loss: 0.0214 - acc: 1.0000 - val_loss: 0.3262 - val_ac
c: 0.5540
Epoch 41/500
1/1 [==============================] - 0s 243ms/step - loss: 0.0220 - acc: 0.9786 - val_loss: 0.3255 - val_ac
c: 0.5540
Epoch 42/500
1/1 [==============================] - 0s 244ms/step - loss: 0.0222 - acc: 0.9857 - val_loss: 0.3253 - val_ac
c: 0.5540
Epoch 43/500
1/1 [==============================] - 0s 226ms/step - loss: 0.0202 - acc: 1.0000 - val_loss: 0.3266 - val_ac
c: 0.5600
Epoch 44/500
1/1 [==============================] - 0s 270ms/step - loss: 0.0210 - acc: 0.9857 - val_loss: 0.3267 - val_ac
c: 0.5580
Epoch 45/500
1/1 [==============================] - 0s 240ms/step - loss: 0.0202 - acc: 0.9929 - val_loss: 0.3338 - val_ac
c: 0.5580
Epoch 46/500
1/1 [==============================] - 0s 205ms/step - loss: 0.0199 - acc: 0.9857 - val_loss: 0.3441 - val_ac
c: 0.5380
Epoch 47/500
1/1 [==============================] - 0s 227ms/step - loss: 0.0184 - acc: 1.0000 - val_loss: 0.3594 - val_ac
```

```
c: 0.5380
Epoch 48/500
1/1 [==============================] - 0s 256ms/step - loss: 0.0177 - acc: 1.0000 - val_loss: 0.3708 - val_ac
c: 0.5280
Epoch 49/500
1/1 [==============================] - 0s 239ms/step - loss: 0.0179 - acc: 0.9929 - val_loss: 0.3734 - val_ac
c: 0.5100
Epoch 50/500
1/1 [==============================] - 0s 227ms/step - loss: 0.0173 - acc: 1.0000 - val_loss: 0.3691 - val_ac
c: 0.5100
Epoch 51/500
1/1 [==============================] - 0s 220ms/step - loss: 0.0169 - acc: 0.9929 - val_loss: 0.3649 - val_ac
c: 0.5160
Epoch 52/500
1/1 [==============================] - 0s 201ms/step - loss: 0.0162 - acc: 0.9929 - val_loss: 0.3625 - val_ac
c: 0.5140
Epoch 53/500
1/1 [==============================] - 0s 234ms/step - loss: 0.0170 - acc: 0.9857 - val_loss: 0.3647 - val_ac
c: 0.5100
Epoch 54/500
1/1 [==============================] - 0s 232ms/step - loss: 0.0173 - acc: 0.9857 - val_loss: 0.3618 - val_ac
c: 0.5200
Epoch 55/500
1/1 [==============================] - 0s 251ms/step - loss: 0.0170 - acc: 0.9786 - val_loss: 0.3646 - val_ac
c: 0.5180
Epoch 56/500
1/1 [==============================] - 0s 202ms/step - loss: 0.0163 - acc: 0.9929 - val_loss: 0.3653 - val_ac
c: 0.5100
Epoch 57/500
1/1 [==============================] - 0s 214ms/step - loss: 0.0167 - acc: 0.9857 - val_loss: 0.3693 - val_ac
c: 0.5000
Epoch 58/500
1/1 [==============================] - 0s 206ms/step - loss: 0.0178 - acc: 0.9786 - val_loss: 0.3596 - val_ac
c: 0.5000
Epoch 59/500
1/1 [==============================] - 0s 210ms/step - loss: 0.0176 - acc: 0.9714 - val_loss: 0.3552 - val_ac
c: 0.5000
Epoch 60/500
1/1 [==============================] - 0s 208ms/step - loss: 0.0157 - acc: 0.9929 - val_loss: 0.3565 - val_ac
c: 0.5000
Epoch 61/500
1/1 [==============================] - 0s 192ms/step - loss: 0.0168 - acc: 0.9929 - val_loss: 0.3593 - val_ac
c: 0.5100
Epoch 62/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0170 - acc: 0.9929 - val_loss: 0.3717 - val_ac
c: 0.5060
Epoch 63/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0180 - acc: 0.9786 - val_loss: 0.3651 - val_ac
c: 0.5220
Epoch 64/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0185 - acc: 0.9786 - val_loss: 0.3598 - val_ac
c: 0.5160
Epoch 65/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0188 - acc: 0.9714 - val_loss: 0.3581 - val_ac
c: 0.5280
Epoch 66/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0189 - acc: 0.9786 - val_loss: 0.3755 - val_ac
c: 0.5160
Epoch 67/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0208 - acc: 0.9643 - val_loss: 0.3781 - val_ac
c: 0.5160
Epoch 68/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0206 - acc: 0.9786 - val_loss: 0.3862 - val_ac
c: 0.4920
Epoch 69/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0188 - acc: 1.0000 - val_loss: 0.3926 - val_ac
c: 0.4940
Epoch 70/500
1/1 [==============================] - 0s 163ms/step - loss: 0.0238 - acc: 0.9786 - val_loss: 0.3936 - val_ac
c: 0.4900
Epoch 71/500
```

```
1/1 [==============================] - 0s 174ms/step - loss: 0.0208 - acc: 0.9929 - val_loss: 0.3805 - val_ac
c: 0.5260
Epoch 72/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0239 - acc: 0.9643 - val_loss: 0.3703 - val_ac
c: 0.5540
Epoch 73/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0221 - acc: 0.9786 - val_loss: 0.3670 - val_ac
c: 0.5560
Epoch 74/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0219 - acc: 0.9929 - val_loss: 0.3675 - val_ac
c: 0.5600
Epoch 75/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0219 - acc: 1.0000 - val_loss: 0.3692 - val_ac
c: 0.5560
Epoch 76/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0261 - acc: 0.9857 - val_loss: 0.3738 - val_ac
c: 0.5540
Epoch 77/500
1/1 [==============================] - 0s 171ms/step - loss: 0.0294 - acc: 0.9643 - val_loss: 0.3632 - val_ac
c: 0.5500
Epoch 78/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0252 - acc: 0.9857 - val_loss: 0.3638 - val_ac
c: 0.5340
Epoch 79/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0237 - acc: 0.9929 - val_loss: 0.3670 - val_ac
c: 0.5320
Epoch 80/500
1/1 [==============================] - 0s 167ms/step - loss: 0.0253 - acc: 0.9929 - val_loss: 0.3758 - val_ac
c: 0.5300
Epoch 81/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0301 - acc: 0.9786 - val_loss: 0.3793 - val_ac
c: 0.5120
Epoch 82/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0245 - acc: 1.0000 - val_loss: 0.3871 - val_ac
c: 0.5120
Epoch 83/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0276 - acc: 0.9643 - val_loss: 0.3965 - val_ac
c: 0.5060
Epoch 84/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0252 - acc: 1.0000 - val_loss: 0.4022 - val_ac
c: 0.5040
Epoch 85/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0285 - acc: 0.9857 - val_loss: 0.4069 - val_ac
c: 0.5000
Epoch 86/500
1/1 [==============================] - 0s 166ms/step - loss: 0.0264 - acc: 0.9714 - val_loss: 0.4010 - val_ac
c: 0.5140
Epoch 87/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0262 - acc: 0.9786 - val_loss: 0.3946 - val_ac
c: 0.5160
Epoch 88/500
1/1 [==============================] - 0s 168ms/step - loss: 0.0263 - acc: 0.9857 - val_loss: 0.3835 - val_ac
c: 0.5340
Epoch 89/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0262 - acc: 0.9857 - val_loss: 0.3805 - val_ac
c: 0.5260
Epoch 90/500
1/1 [==============================] - 0s 164ms/step - loss: 0.0261 - acc: 1.0000 - val_loss: 0.3843 - val_ac
c: 0.5100
Epoch 91/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0273 - acc: 0.9786 - val_loss: 0.3775 - val_ac
c: 0.5240
Epoch 92/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0270 - acc: 0.9786 - val_loss: 0.3737 - val_ac
c: 0.5260
Epoch 93/500
1/1 [==============================] - 0s 165ms/step - loss: 0.0280 - acc: 0.9714 - val_loss: 0.3719 - val_ac
c: 0.5140
Epoch 94/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0268 - acc: 0.9786 - val_loss: 0.3823 - val_ac
c: 0.5040
```

```
Epoch 95/500
1/1 [==============================] - 0s 169ms/step - loss: 0.0278 - acc: 0.9714 - val_loss: 0.3794 - val_ac
c: 0.4800
Epoch 96/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0258 - acc: 0.9929 - val_loss: 0.3746 - val_ac
c: 0.4820
Epoch 97/500
1/1 [==============================] - 0s 223ms/step - loss: 0.0261 - acc: 0.9857 - val_loss: 0.3727 - val_ac
c: 0.4980
Epoch 98/500
1/1 [==============================] - 0s 205ms/step - loss: 0.0273 - acc: 0.9714 - val_loss: 0.3770 - val_ac
c: 0.5140
Epoch 99/500
1/1 [==============================] - 0s 206ms/step - loss: 0.0265 - acc: 0.9857 - val_loss: 0.3917 - val_ac
c: 0.5060
Epoch 100/500
1/1 [==============================] - 0s 181ms/step - loss: 0.0273 - acc: 0.9857 - val_loss: 0.4095 - val_ac
c: 0.4980
Epoch 101/500
1/1 [==============================] - 0s 195ms/step - loss: 0.0252 - acc: 1.0000 - val_loss: 0.4236 - val_ac
c: 0.4920
Epoch 102/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0274 - acc: 0.9786 - val_loss: 0.4299 - val_ac
c: 0.4880
Epoch 103/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0273 - acc: 0.9786 - val_loss: 0.4247 - val_ac
c: 0.4840
Epoch 104/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0291 - acc: 0.9857 - val_loss: 0.4326 - val_ac
c: 0.4820
Epoch 105/500
1/1 [==============================] - 0s 185ms/step - loss: 0.0253 - acc: 0.9929 - val_loss: 0.4460 - val_ac
c: 0.4720
Epoch 106/500
1/1 [==============================] - 0s 197ms/step - loss: 0.0301 - acc: 0.9714 - val_loss: 0.4489 - val_ac
c: 0.4700
Epoch 107/500
1/1 [==============================] - 0s 181ms/step - loss: 0.0259 - acc: 0.9929 - val_loss: 0.4564 - val_ac
c: 0.4680
Epoch 108/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0282 - acc: 0.9571 - val_loss: 0.4505 - val_ac
c: 0.4700
Epoch 109/500
1/1 [==============================] - 0s 185ms/step - loss: 0.0275 - acc: 0.9786 - val_loss: 0.4521 - val_ac
c: 0.4660
Epoch 110/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0268 - acc: 0.9929 - val_loss: 0.4362 - val_ac
c: 0.4700
Epoch 111/500
1/1 [==============================] - 0s 199ms/step - loss: 0.0276 - acc: 0.9714 - val_loss: 0.4333 - val_ac
c: 0.4800
Epoch 112/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0259 - acc: 1.0000 - val_loss: 0.4429 - val_ac
c: 0.4780
Epoch 113/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0274 - acc: 0.9929 - val_loss: 0.4474 - val_ac
c: 0.4720
Epoch 114/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0259 - acc: 0.9857 - val_loss: 0.4549 - val_ac
c: 0.4740
Epoch 115/500
1/1 [==============================] - 0s 186ms/step - loss: 0.0307 - acc: 0.9643 - val_loss: 0.4526 - val_ac
c: 0.4840
Epoch 116/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0264 - acc: 0.9857 - val_loss: 0.4426 - val_ac
c: 0.4860
Epoch 117/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0268 - acc: 0.9929 - val_loss: 0.4343 - val_ac
c: 0.4820
Epoch 118/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0284 - acc: 0.9786 - val_loss: 0.4357 - val_ac
```

```
c: 0.4820
Epoch 119/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0287 - acc: 0.9786 - val_loss: 0.4360 - val_ac
c: 0.5000
Epoch 120/500
1/1 [==============================] - 0s 181ms/step - loss: 0.0297 - acc: 0.9929 - val_loss: 0.4322 - val_ac
c: 0.5000
Epoch 121/500
1/1 [==============================] - 0s 205ms/step - loss: 0.0278 - acc: 0.9929 - val_loss: 0.4337 - val_ac
c: 0.5060
Epoch 122/500
1/1 [==============================] - 0s 170ms/step - loss: 0.0273 - acc: 0.9857 - val_loss: 0.4340 - val_ac
c: 0.5040
Epoch 123/500
1/1 [==============================] - 0s 180ms/step - loss: 0.0305 - acc: 0.9714 - val_loss: 0.4305 - val_ac
c: 0.4980
Epoch 124/500
1/1 [==============================] - 0s 225ms/step - loss: 0.0264 - acc: 1.0000 - val_loss: 0.4273 - val_ac
c: 0.5040
Epoch 125/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0293 - acc: 0.9643 - val_loss: 0.4234 - val_ac
c: 0.5160
Epoch 126/500
1/1 [==============================] - 0s 202ms/step - loss: 0.0266 - acc: 1.0000 - val_loss: 0.4171 - val_ac
c: 0.5300
Epoch 127/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0302 - acc: 0.9714 - val_loss: 0.4074 - val_ac
c: 0.5260
Epoch 128/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0286 - acc: 0.9714 - val_loss: 0.3865 - val_ac
c: 0.5600
Epoch 129/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0282 - acc: 0.9786 - val_loss: 0.3722 - val_ac
c: 0.5740
Epoch 130/500
1/1 [==============================] - 0s 210ms/step - loss: 0.0279 - acc: 0.9786 - val_loss: 0.3665 - val_ac
c: 0.5720
Epoch 131/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0270 - acc: 0.9929 - val_loss: 0.3649 - val_ac
c: 0.5740
Epoch 132/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0346 - acc: 0.9429 - val_loss: 0.3742 - val_ac
c: 0.5680
Epoch 133/500
1/1 [==============================] - 0s 178ms/step - loss: 0.0298 - acc: 0.9714 - val_loss: 0.3890 - val_ac
c: 0.5420
Epoch 134/500
1/1 [==============================] - 0s 195ms/step - loss: 0.0290 - acc: 0.9643 - val_loss: 0.4135 - val_ac
c: 0.5220
Epoch 135/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0300 - acc: 0.9786 - val_loss: 0.4380 - val_ac
c: 0.4800
Epoch 136/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0316 - acc: 0.9714 - val_loss: 0.4466 - val_ac
c: 0.4760
Epoch 137/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0316 - acc: 0.9571 - val_loss: 0.4449 - val_ac
c: 0.4820
Epoch 138/500
1/1 [==============================] - 0s 208ms/step - loss: 0.0321 - acc: 0.9714 - val_loss: 0.4299 - val_ac
c: 0.4880
Epoch 139/500
1/1 [==============================] - 0s 192ms/step - loss: 0.0296 - acc: 0.9929 - val_loss: 0.4166 - val_ac
c: 0.5040
Epoch 140/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0320 - acc: 0.9643 - val_loss: 0.3958 - val_ac
c: 0.5220
Epoch 141/500
1/1 [==============================] - 0s 285ms/step - loss: 0.0338 - acc: 0.9786 - val_loss: 0.3837 - val_ac
c: 0.5340
Epoch 142/500
```

```
1/1 [==============================] - 0s 187ms/step - loss: 0.0367 - acc: 0.9857 - val_loss: 0.3810 - val_ac
c: 0.5520
Epoch 143/500
1/1 [==============================] - 0s 181ms/step - loss: 0.0338 - acc: 0.9786 - val_loss: 0.3784 - val_ac
c: 0.5460
Epoch 144/500
1/1 [==============================] - 0s 264ms/step - loss: 0.0346 - acc: 0.9857 - val_loss: 0.3783 - val_ac
c: 0.5500
Epoch 145/500
1/1 [==============================] - 0s 214ms/step - loss: 0.0383 - acc: 0.9643 - val_loss: 0.3839 - val_ac
c: 0.5560
Epoch 146/500
1/1 [==============================] - 0s 195ms/step - loss: 0.0389 - acc: 0.9571 - val_loss: 0.3898 - val_ac
c: 0.5340
Epoch 147/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0346 - acc: 0.9857 - val_loss: 0.3947 - val_ac
c: 0.5180
Epoch 148/500
1/1 [==============================] - 0s 235ms/step - loss: 0.0328 - acc: 1.0000 - val_loss: 0.4000 - val_ac
c: 0.5060
Epoch 149/500
1/1 [==============================] - 0s 200ms/step - loss: 0.0351 - acc: 0.9857 - val_loss: 0.4107 - val_ac
c: 0.5000
Epoch 150/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0348 - acc: 0.9857 - val_loss: 0.4201 - val_ac
c: 0.5000
Epoch 151/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0368 - acc: 0.9714 - val_loss: 0.4328 - val_ac
c: 0.4920
Epoch 152/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0367 - acc: 0.9643 - val_loss: 0.4307 - val_ac
c: 0.4900
Epoch 153/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0365 - acc: 0.9786 - val_loss: 0.4250 - val_ac
c: 0.4980
Epoch 154/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0383 - acc: 0.9714 - val_loss: 0.4153 - val_ac
c: 0.5200
Epoch 155/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0354 - acc: 0.9929 - val_loss: 0.4057 - val_ac
c: 0.5280
Epoch 156/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0361 - acc: 0.9857 - val_loss: 0.4037 - val_ac
c: 0.5380
Epoch 157/500
1/1 [==============================] - 0s 198ms/step - loss: 0.0335 - acc: 0.9929 - val_loss: 0.4035 - val_ac
c: 0.5360
Epoch 158/500
1/1 [==============================] - 0s 186ms/step - loss: 0.0351 - acc: 0.9714 - val_loss: 0.3961 - val_ac
c: 0.5400
Epoch 159/500
1/1 [==============================] - 0s 180ms/step - loss: 0.0386 - acc: 0.9714 - val_loss: 0.3921 - val_ac
c: 0.5480
Epoch 160/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0367 - acc: 0.9714 - val_loss: 0.3935 - val_ac
c: 0.5520
Epoch 161/500
1/1 [==============================] - 0s 186ms/step - loss: 0.0367 - acc: 0.9786 - val_loss: 0.3926 - val_ac
c: 0.5500
Epoch 162/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0359 - acc: 0.9857 - val_loss: 0.3942 - val_ac
c: 0.5240
Epoch 163/500
1/1 [==============================] - 0s 199ms/step - loss: 0.0344 - acc: 0.9857 - val_loss: 0.4001 - val_ac
c: 0.5140
Epoch 164/500
1/1 [==============================] - 0s 204ms/step - loss: 0.0388 - acc: 0.9857 - val_loss: 0.4121 - val_ac
c: 0.5160
Epoch 165/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0358 - acc: 0.9786 - val_loss: 0.4295 - val_ac
c: 0.4920
```

```
Epoch 166/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0397 - acc: 0.9643 - val_loss: 0.4264 - val_ac
c: 0.4980
Epoch 167/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0381 - acc: 0.9714 - val_loss: 0.4074 - val_ac
c: 0.5100
Epoch 168/500
1/1 [==============================] - 0s 227ms/step - loss: 0.0354 - acc: 0.9714 - val_loss: 0.3951 - val_ac
c: 0.5260
Epoch 169/500
1/1 [==============================] - 0s 238ms/step - loss: 0.0343 - acc: 0.9857 - val_loss: 0.3842 - val_ac
c: 0.5200
Epoch 170/500
1/1 [==============================] - 0s 211ms/step - loss: 0.0355 - acc: 0.9643 - val_loss: 0.3903 - val_ac
c: 0.5220
Epoch 171/500
1/1 [==============================] - 0s 213ms/step - loss: 0.0348 - acc: 0.9714 - val_loss: 0.3969 - val_ac
c: 0.5180
Epoch 172/500
1/1 [==============================] - 0s 205ms/step - loss: 0.0370 - acc: 0.9786 - val_loss: 0.3976 - val_ac
c: 0.5240
Epoch 173/500
1/1 [==============================] - 0s 225ms/step - loss: 0.0359 - acc: 0.9714 - val_loss: 0.3997 - val_ac
c: 0.5300
Epoch 174/500
1/1 [==============================] - 0s 225ms/step - loss: 0.0408 - acc: 0.9714 - val_loss: 0.4038 - val_ac
c: 0.5380
Epoch 175/500
1/1 [==============================] - 0s 223ms/step - loss: 0.0334 - acc: 0.9929 - val_loss: 0.4120 - val_ac
c: 0.5380
Epoch 176/500
1/1 [==============================] - 0s 205ms/step - loss: 0.0396 - acc: 0.9643 - val_loss: 0.4315 - val_ac
c: 0.5280
Epoch 177/500
1/1 [==============================] - 0s 203ms/step - loss: 0.0398 - acc: 0.9500 - val_loss: 0.4214 - val_ac
c: 0.5220
Epoch 178/500
1/1 [==============================] - 0s 230ms/step - loss: 0.0375 - acc: 0.9786 - val_loss: 0.3990 - val_ac
c: 0.5320
Epoch 179/500
1/1 [==============================] - 0s 204ms/step - loss: 0.0333 - acc: 1.0000 - val_loss: 0.3873 - val_ac
c: 0.5260
Epoch 180/500
1/1 [==============================] - 0s 198ms/step - loss: 0.0381 - acc: 0.9786 - val_loss: 0.3814 - val_ac
c: 0.5140
Epoch 181/500
1/1 [==============================] - 0s 210ms/step - loss: 0.0365 - acc: 0.9786 - val_loss: 0.3903 - val_ac
c: 0.5160
Epoch 182/500
1/1 [==============================] - 0s 211ms/step - loss: 0.0370 - acc: 0.9857 - val_loss: 0.4045 - val_ac
c: 0.4840
Epoch 183/500
1/1 [==============================] - 0s 216ms/step - loss: 0.0380 - acc: 0.9643 - val_loss: 0.4098 - val_ac
c: 0.4820
Epoch 184/500
1/1 [==============================] - 0s 202ms/step - loss: 0.0360 - acc: 0.9857 - val_loss: 0.4056 - val_ac
c: 0.5000
Epoch 185/500
1/1 [==============================] - 0s 199ms/step - loss: 0.0378 - acc: 0.9643 - val_loss: 0.3999 - val_ac
c: 0.5040
Epoch 186/500
1/1 [==============================] - 0s 207ms/step - loss: 0.0365 - acc: 0.9714 - val_loss: 0.3943 - val_ac
c: 0.5060
Epoch 187/500
1/1 [==============================] - 0s 224ms/step - loss: 0.0370 - acc: 0.9786 - val_loss: 0.3886 - val_ac
c: 0.5140
Epoch 188/500
1/1 [==============================] - 0s 271ms/step - loss: 0.0404 - acc: 0.9429 - val_loss: 0.3928 - val_ac
c: 0.5180
Epoch 189/500
1/1 [==============================] - 0s 216ms/step - loss: 0.0448 - acc: 0.9500 - val_loss: 0.3947 - val_ac
```

```
c: 0.5140
Epoch 190/500
1/1 [==============================] - 0s 203ms/step - loss: 0.0362 - acc: 0.9714 - val_loss: 0.4028 - val_ac
c: 0.5200
Epoch 191/500
1/1 [==============================] - 0s 212ms/step - loss: 0.0350 - acc: 0.9929 - val_loss: 0.4086 - val_ac
c: 0.5000
Epoch 192/500
1/1 [==============================] - 0s 198ms/step - loss: 0.0365 - acc: 0.9786 - val_loss: 0.4113 - val_ac
c: 0.5040
Epoch 193/500
1/1 [==============================] - 0s 190ms/step - loss: 0.0356 - acc: 1.0000 - val_loss: 0.4157 - val_ac
c: 0.5040
Epoch 194/500
1/1 [==============================] - 0s 190ms/step - loss: 0.0413 - acc: 0.9714 - val_loss: 0.4290 - val_ac
c: 0.4900
Epoch 195/500
1/1 [==============================] - 0s 224ms/step - loss: 0.0379 - acc: 0.9857 - val_loss: 0.4360 - val_ac
c: 0.4920
Epoch 196/500
1/1 [==============================] - 0s 209ms/step - loss: 0.0398 - acc: 0.9786 - val_loss: 0.4447 - val_ac
c: 0.4900
Epoch 197/500
1/1 [==============================] - 0s 212ms/step - loss: 0.0387 - acc: 0.9714 - val_loss: 0.4510 - val_ac
c: 0.4960
Epoch 198/500
1/1 [==============================] - 0s 243ms/step - loss: 0.0391 - acc: 0.9643 - val_loss: 0.4427 - val_ac
c: 0.5080
Epoch 199/500
1/1 [==============================] - 0s 205ms/step - loss: 0.0442 - acc: 0.9500 - val_loss: 0.4228 - val_ac
c: 0.5240
Epoch 200/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0388 - acc: 0.9571 - val_loss: 0.4059 - val_ac
c: 0.5400
Epoch 201/500
1/1 [==============================] - 0s 208ms/step - loss: 0.0397 - acc: 0.9786 - val_loss: 0.3932 - val_ac
c: 0.5440
Epoch 202/500
1/1 [==============================] - 0s 199ms/step - loss: 0.0389 - acc: 0.9714 - val_loss: 0.3847 - val_ac
c: 0.5440
Epoch 203/500
1/1 [==============================] - 0s 206ms/step - loss: 0.0408 - acc: 0.9857 - val_loss: 0.3791 - val_ac
c: 0.5480
Epoch 204/500
1/1 [==============================] - 0s 221ms/step - loss: 0.0402 - acc: 0.9857 - val_loss: 0.3788 - val_ac
c: 0.5420
Epoch 205/500
1/1 [==============================] - 0s 209ms/step - loss: 0.0406 - acc: 0.9714 - val_loss: 0.3819 - val_ac
c: 0.5380
Epoch 206/500
1/1 [==============================] - 0s 203ms/step - loss: 0.0404 - acc: 0.9786 - val_loss: 0.3854 - val_ac
c: 0.5280
Epoch 207/500
1/1 [==============================] - 0s 186ms/step - loss: 0.0391 - acc: 0.9786 - val_loss: 0.3929 - val_ac
c: 0.5300
Epoch 208/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0365 - acc: 0.9929 - val_loss: 0.4036 - val_ac
c: 0.5280
Epoch 209/500
1/1 [==============================] - 0s 190ms/step - loss: 0.0462 - acc: 0.9571 - val_loss: 0.4071 - val_ac
c: 0.5180
Epoch 210/500
1/1 [==============================] - 0s 199ms/step - loss: 0.0402 - acc: 0.9786 - val_loss: 0.4154 - val_ac
c: 0.5180
Epoch 211/500
1/1 [==============================] - 0s 195ms/step - loss: 0.0375 - acc: 0.9857 - val_loss: 0.4276 - val_ac
c: 0.5140
Epoch 212/500
1/1 [==============================] - 0s 181ms/step - loss: 0.0386 - acc: 0.9857 - val_loss: 0.4340 - val_ac
c: 0.5160
Epoch 213/500
```

```
1/1 [==============================] - 0s 185ms/step - loss: 0.0468 - acc: 0.9571 - val_loss: 0.4335 - val_ac
c: 0.5120
Epoch 214/500
1/1 [==============================] - 0s 197ms/step - loss: 0.0375 - acc: 0.9786 - val_loss: 0.4273 - val_ac
c: 0.5200
Epoch 215/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0376 - acc: 0.9857 - val_loss: 0.4190 - val_ac
c: 0.5260
Epoch 216/500
1/1 [==============================] - 0s 180ms/step - loss: 0.0423 - acc: 0.9571 - val_loss: 0.3981 - val_ac
c: 0.5380
Epoch 217/500
1/1 [==============================] - 0s 206ms/step - loss: 0.0367 - acc: 0.9857 - val_loss: 0.3880 - val_ac
c: 0.5520
Epoch 218/500
1/1 [==============================] - 0s 233ms/step - loss: 0.0410 - acc: 0.9643 - val_loss: 0.3772 - val_ac
c: 0.5500
Epoch 219/500
1/1 [==============================] - 0s 208ms/step - loss: 0.0402 - acc: 0.9714 - val_loss: 0.3663 - val_ac
c: 0.5500
Epoch 220/500
1/1 [==============================] - 0s 187ms/step - loss: 0.0373 - acc: 0.9714 - val_loss: 0.3602 - val_ac
c: 0.5380
Epoch 221/500
1/1 [==============================] - 0s 206ms/step - loss: 0.0384 - acc: 0.9643 - val_loss: 0.3726 - val_ac
c: 0.5300
Epoch 222/500
1/1 [==============================] - 0s 221ms/step - loss: 0.0393 - acc: 0.9643 - val_loss: 0.3843 - val_ac
c: 0.5140
Epoch 223/500
1/1 [==============================] - 0s 175ms/step - loss: 0.0351 - acc: 0.9929 - val_loss: 0.3988 - val_ac
c: 0.5020
Epoch 224/500
1/1 [==============================] - 0s 176ms/step - loss: 0.0385 - acc: 0.9857 - val_loss: 0.4086 - val_ac
c: 0.4920
Epoch 225/500
1/1 [==============================] - 0s 217ms/step - loss: 0.0370 - acc: 0.9786 - val_loss: 0.4175 - val_ac
c: 0.4920
Epoch 226/500
1/1 [==============================] - 0s 209ms/step - loss: 0.0356 - acc: 0.9857 - val_loss: 0.4230 - val_ac
c: 0.4820
Epoch 227/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0392 - acc: 0.9571 - val_loss: 0.4184 - val_ac
c: 0.4720
Epoch 228/500
1/1 [==============================] - 0s 182ms/step - loss: 0.0381 - acc: 0.9714 - val_loss: 0.4128 - val_ac
c: 0.4840
Epoch 229/500
1/1 [==============================] - 0s 199ms/step - loss: 0.0363 - acc: 0.9714 - val_loss: 0.3946 - val_ac
c: 0.4960
Epoch 230/500
1/1 [==============================] - 0s 203ms/step - loss: 0.0361 - acc: 0.9714 - val_loss: 0.3791 - val_ac
c: 0.5040
Epoch 231/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0345 - acc: 0.9857 - val_loss: 0.3687 - val_ac
c: 0.4960
Epoch 232/500
1/1 [==============================] - 0s 174ms/step - loss: 0.0337 - acc: 0.9857 - val_loss: 0.3657 - val_ac
c: 0.5040
Epoch 233/500
1/1 [==============================] - 0s 172ms/step - loss: 0.0348 - acc: 0.9714 - val_loss: 0.3720 - val_ac
c: 0.4960
Epoch 234/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0360 - acc: 0.9643 - val_loss: 0.3811 - val_ac
c: 0.4980
Epoch 235/500
1/1 [==============================] - 0s 191ms/step - loss: 0.0330 - acc: 0.9857 - val_loss: 0.3883 - val_ac
c: 0.4940
Epoch 236/500
1/1 [==============================] - 0s 223ms/step - loss: 0.0326 - acc: 0.9929 - val_loss: 0.3912 - val_ac
c: 0.5000
```

```
Epoch 237/500
1/1 [==============================] - 0s 211ms/step - loss: 0.0346 - acc: 0.9571 - val_loss: 0.3934 - val_ac
c: 0.4820
Epoch 238/500
1/1 [==============================] - 0s 202ms/step - loss: 0.0374 - acc: 0.9714 - val_loss: 0.4052 - val_ac
c: 0.4700
Epoch 239/500
1/1 [==============================] - 0s 192ms/step - loss: 0.0348 - acc: 0.9857 - val_loss: 0.4154 - val_ac
c: 0.4560
Epoch 240/500
1/1 [==============================] - 0s 197ms/step - loss: 0.0353 - acc: 0.9786 - val_loss: 0.4280 - val_ac
c: 0.4500
Epoch 241/500
1/1 [==============================] - 0s 225ms/step - loss: 0.0335 - acc: 0.9786 - val_loss: 0.4294 - val_ac
c: 0.4600
Epoch 242/500
1/1 [==============================] - 0s 202ms/step - loss: 0.0333 - acc: 0.9857 - val_loss: 0.4262 - val_ac
c: 0.4600
Epoch 243/500
1/1 [==============================] - 0s 177ms/step - loss: 0.0314 - acc: 0.9929 - val_loss: 0.4252 - val_ac
c: 0.4660
Epoch 244/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0326 - acc: 0.9786 - val_loss: 0.4165 - val_ac
c: 0.4720
Epoch 245/500
1/1 [==============================] - 0s 192ms/step - loss: 0.0353 - acc: 0.9786 - val_loss: 0.3947 - val_ac
c: 0.4820
Epoch 246/500
1/1 [==============================] - 0s 183ms/step - loss: 0.0314 - acc: 0.9786 - val_loss: 0.3812 - val_ac
c: 0.4900
Epoch 247/500
1/1 [==============================] - 0s 194ms/step - loss: 0.0312 - acc: 0.9857 - val_loss: 0.3708 - val_ac
c: 0.5020
Epoch 248/500
1/1 [==============================] - 0s 181ms/step - loss: 0.0325 - acc: 0.9643 - val_loss: 0.3599 - val_ac
c: 0.5120
Epoch 249/500
1/1 [==============================] - 0s 187ms/step - loss: 0.0301 - acc: 0.9929 - val_loss: 0.3535 - val_ac
c: 0.5240
Epoch 250/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0343 - acc: 0.9571 - val_loss: 0.3496 - val_ac
c: 0.5260
Epoch 251/500
1/1 [==============================] - 0s 179ms/step - loss: 0.0318 - acc: 0.9857 - val_loss: 0.3495 - val_ac
c: 0.5220
Epoch 252/500
1/1 [==============================] - 0s 184ms/step - loss: 0.0323 - acc: 0.9857 - val_loss: 0.3580 - val_ac
c: 0.5200
Epoch 253/500
1/1 [==============================] - 0s 199ms/step - loss: 0.0300 - acc: 0.9929 - val_loss: 0.3665 - val_ac
c: 0.5120
Epoch 254/500
1/1 [==============================] - 0s 188ms/step - loss: 0.0314 - acc: 0.9714 - val_loss: 0.3823 - val_ac
c: 0.5000
Epoch 255/500
1/1 [==============================] - 0s 186ms/step - loss: 0.0310 - acc: 0.9714 - val_loss: 0.3891 - val_ac
c: 0.4900
Epoch 256/500
1/1 [==============================] - 0s 185ms/step - loss: 0.0321 - acc: 0.9714 - val_loss: 0.4057 - val_ac
c: 0.4740
Epoch 257/500
1/1 [==============================] - 0s 173ms/step - loss: 0.0351 - acc: 0.9500 - val_loss: 0.4083 - val_ac
c: 0.4860
```

Out[ ]: <tensorflow.python.keras.callbacks.History at 0x22338badf08>

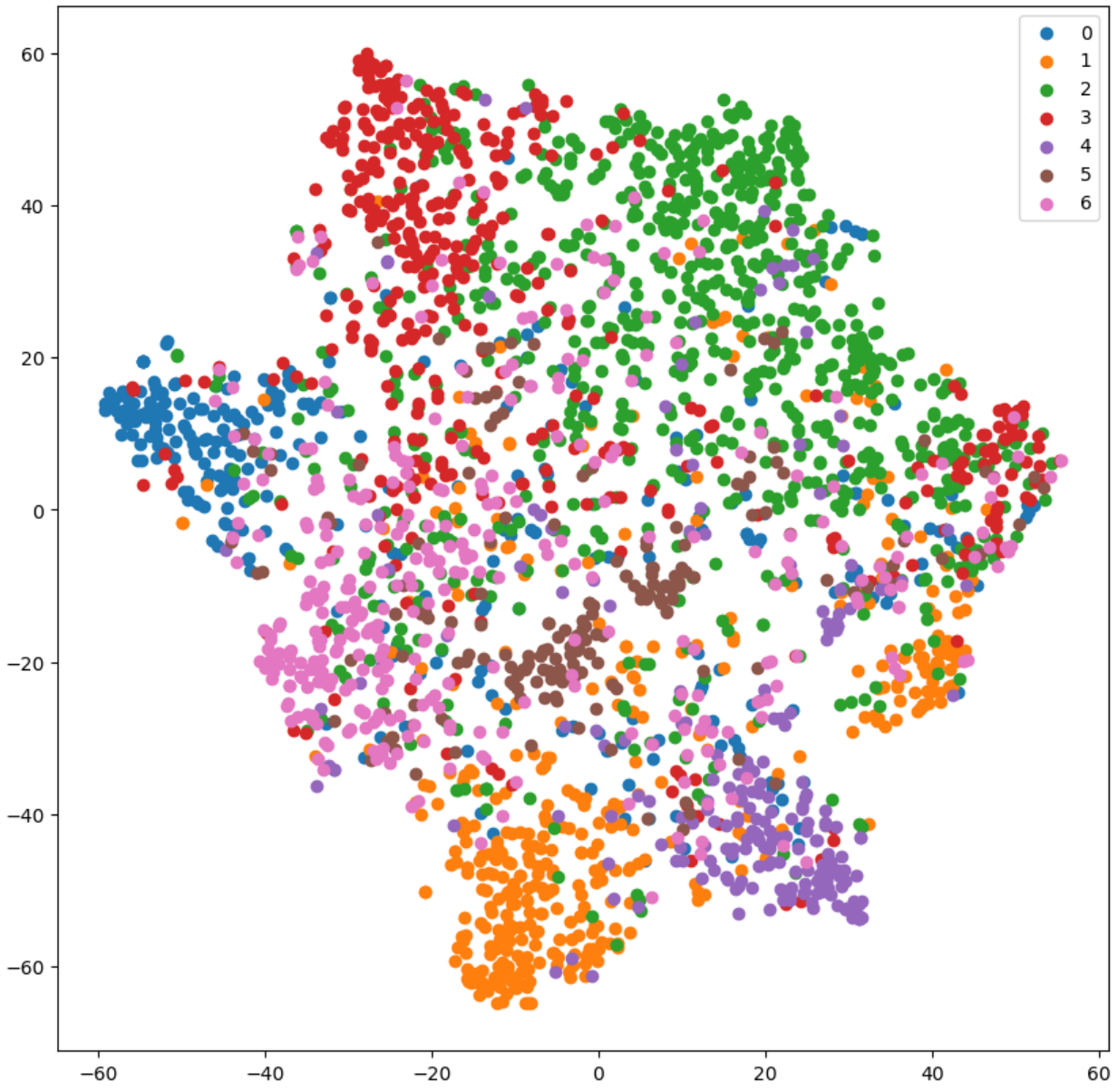
In [ ]:
```
# Evaluate model
y_pred = model_fnn.predict(X_te)
report = classification_report(np.argmax(y_te,axis=1), np.argmax(y_pred,axis=1), target_names=classes)
print('FCNN Classification Report: \n {}'.format(report))
```

```
FCNN Classification Report:
                        precision    recall  f1-score   support

           Case_Based       0.50      0.58      0.54       114
    Genetic_Algorithms       0.69      0.72      0.70       156
      Neural_Networks       0.73      0.50      0.60       290
Probabilistic_Methods       0.62      0.56      0.59       172
Reinforcement_Learning       0.46      0.62      0.53        85
        Rule_Learning       0.41      0.63      0.50        60
               Theory       0.41      0.49      0.45       123

             accuracy                           0.57      1000
            macro avg       0.55      0.59      0.56      1000
         weighted avg       0.60      0.57      0.58      1000
```

Get hidden layer representation for FNN

In [ ]:
```
layer_outputs = [layer.output for layer in model_fnn.layers]
activation_model = Model(inputs=model_fnn.input, outputs=layer_outputs)
activations = activation_model.predict([X])
```

In [ ]:
```
x_tsne = TSNE(n_components=2).fit_transform(activations[3])
plot_tSNE(labels_encoded,x_tsne)
```



In [ ]:
```
### END OF NOTEBOOK ###
```